Behavioural patterns of university students during the COVID-19 pandemic: A cross-sectional study of the effects of active transportation, uninterrupted sitting time, and screen use on physical activity and sitting time

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Abstract

Background

The closure of universities due to the coronavirus disease 2019 (COVID-19) pandemic significantly affected students' behaviours, particularly regarding physical activity, sitting time, and screen use. This study aimed to determine the effect of active transportation duration, uninterrupted sitting time, and screen time to study on physical activity and sitting time during the confinement.

Methods

This was a cross-sectional study based on data collected via an online questionnaire for university students during the second confinement in France (between October and December 2020). The questionnaire assessed physical activity and sedentary behaviour, and contained questions about modes of transport, and perception of uninterrupted sitting time and screen time to study prior to confinement and during
confinement. Participants (N=2873) completed the International Physical Activity Questionnaire (IPAQ) in an average time of around 15 minutes, after providing digital informed consent. Multiple regression models assessed how time duration of active transportation, uninterrupted sitting time, and screen time studying increased or reduced confinement effects on physical activity and sitting time.

Results

The regression models showed that physical activity decreased during confinement for students who engaged in more prolonged periods of active transportation prior to confinement. Moreover, the perception of long, uninterrupted sitting time and high screen time prior to confinement significantly increased sitting time during confinement. Students who adopted the most active transport time prior to confinement were the least likely to increase their screen time during confinement.

Conclusions

Confinement reduced physical activity levels and increased sitting time, mainly among students who adopted active transport and accumulated longer uninterrupted sitting time prior to confinement. Students who combined-long periods of uninterrupted sitting time with high screen use could be a riskier profile for health. Analysis of physical activity time and sitting position should include its accumulation patterns.

Keywords
Universities, sitting position, transportation, lifestyle, young people

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Introduction
The confinement caused by the coronavirus disease 2019 (COVID-19) pandemic significantly reduced the physical activity levels of university students. This effect was primarily due to the reduction in active transportation for commuting and the subsequent increase in sitting time and screen time. However, the decrease in physical activity levels was more pronounced for individuals who were more active before COVID-19, men, and younger adults (ages 18-34). In contrast, older adults (>34 years old) experienced no significant changes in their physical activity levels.

Adopting active transportation, which includes any human-powered forms of travel, such as walking or cycling, makes people achieve the recommended physical activity levels for health (i.e., 150 minutes/week moderate physical activity). Students who adopt active transportation display higher physical activity levels than those who do not adopt it. Similarly, people who adopt longer time of active transport increase their total physical activity levels more than those who engage in shorter time of this activity. Furthermore, active transport, such as walking, is a powerful preventive measure against physical conditions such as excessive weight, type 2 diabetes, and cardiovascular diseases. It also reduces the likelihood of suffering mental issues such as stress, anxiety, depression, and cognitive impairments.

Although the threshold for physical activity to achieve health benefits is well defined, this is not the case for sitting time. Despite this lack of evidence, recent studies suggest that uninterrupted sitting for periods longer than 30 minutes has a detrimental impact on health. A threshold of six to eight hours per day of sitting and three to four hours of television is a health risk. Students spend more than six hours per day studying while sitting down, thus increasing health risks when sitting time accumulates uninterrupted. Besides this sitting time, students increasingly use screens to study sitting, mainly computers. Another study suggested that computer use was a prevalent sedentary behaviour in university students, resulting in prolonged periods of sitting and, consequently, greater sedentary time.

While there has been a tendency to associate screens with sitting time, screen use does not always reflect that behaviour. Regardless of sitting time, screen time could be an independent health risk factor. Furthermore, the relationship between physical activity, sitting time and screen time is mixed. A systematic review showed no association between physical activity and sitting time. Even high physical activity levels do not mitigate the adverse effects of high screen time on health. Some studies have shown that students’ physical activity levels are negatively associated with sitting time, where high sitting time displaces total physical activity time, mainly light physical activity. Similarly, when people spend more than six hours sitting, they replace that time with walking and moderate to vigorous physical activity.

According to Heller and colleagues, sitting time during the COVID-19 pandemic was significantly lower among students who were highly physically active before the pandemic than among physically inactive students. The same authors showed no differences in sitting time between students who were moderately physically active and those who were physically inactive. In the same study, there were no differences between students who were highly physically active and those who were only moderately physically active.

In the literature related to the COVID-19 pandemic, university students would not show significant changes in their screen time related to sedentary time or physical activity, as students with higher levels of sedentary time also had higher levels of screen time.

Most studies about confinement in the COVID-19 pandemic have focused on total times of changes in physical activity levels and sitting time or screen time. However, it is suggested that not only the total duration of these behaviours, but also the way it is accumulated throughout the day (e.g., in a few long periods of time or in several shorter periods of time) might have a different effect on health. Furthermore, more research needs to study the accumulation of these times before and during COVID-19 pandemic in university students. To our knowledge, no studies have explored active transportation duration, uninterrupted sedentary time, and the time using screens for studying before and during the COVID-19 pandemic.
For this reason, the main objective of this study was to assess whether the duration of active transportation time, uninterrupted sitting time, and screen time spent studying before confinement determinate physical activity, sitting and screen times during confinement (Figure 1).

**Hypotheses**

**H1**: The first hypothesis was that the longer the duration in minutes of students’ active transportation trips prior to confinement, the greater the reduction in their physical activity levels, excluding active transportation time during confinement.

**H2**: The second hypothesis was that the greater the uninterrupted sitting time prior to confinement in students, the greater the increase in the amount of time they would spend sitting during confinement.

**H3**: The third hypothesis was for screen time; due to the increase in online courses during confinement, the longer the screen time studying prior to confinement in students, the greater the increase in their screen time during confinement.

**H4**: Finally, we hypothesised that there would be no relationship between active transportation, sitting time and screen time during confinement.

**Methods**

This was a cross-sectional study. Students from 16 faculties enrolled (N=6705) in the university sports service (SUAPS) received an invitation via the institutional e-mails to a health webinar for French students (Webex®) (November 10, 2020) on physical (in) activity and sedentary behaviours during the confinement. A link to an online questionnaire was then sent to each student via the institutional e-mail addresses 15 minutes after the end of the Webinar, except for sports sciences students. Due to the type of training, these students were the only ones who partially maintained physical activities during the confinement, which would bias the data. The questionnaire was a voluntary survey, and it was available on the Drag n Survey® platform between November 10th and 18th, 2020. The survey used in this study is available as Extended data. There was a separate informed consent page where students agreed to participate by checking a checkbox. The survey invitation was sent twice to increase response rates, and participants were offered access to the final research results as a non-monetary incentive. A total of 2986 students visited the website and agreed to participate in the study and only 2873 completed the screening questionnaire. Each questionnaire included a completeness check with forced response items (i.e., highlight mandatory items). In order to prevent a single user from filling in the same questionnaire multiple times, one response per IP address was possible (the flowchart is shown in Figure 2).

**Ethics**

The National Commission for Data Protection and Liberties (CNIL—France) approved the study (2221060v0-CNIL). The final decision was determined on 8th February 2021. The posteriori approval of our study is because it was not possible to know that the second wave of COVID-19 would occur in France. The protocol was submitted one week before the second COVID wave in France and initially this study was only supposed to investigate the effects of the first wave of COVID-19. We then adapted the protocol to examine the condition of confinement in the second wave of the pandemic.

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**Figure 1. Schematic overview of the study objectives.** IPAQ=International Physical Activity Questionnaire.
The statement followed the Declaration of Helsinki and the French methodological reference MR-01. Students who visited the informed consent page and agreed to participate were considered to have provided informed consent. If participants did not want to participate in the survey, they could turn off the electronic questionnaire and drop out.

**Measures**

**Demographics.** Information was collected, including sex and age in years (open-ended question).

**Physical activity.** Participants answered questions about how much time and how many days they spent doing moderate and vigorous physical activities during one week (excluding the weekend): First, “prior to the confinement” and then “during the confinement”. The survey was based on the International Physical Activity Questionnaire (IPAQ) short form.

**Transportation type for commuting.** Participants were asked what type of transport they habitually used to commute to university (open-ended question). Following which, the participants answered the following question: “On a typical day (prior to confinement), how many minutes do you spend carrying out active transportation?” A definition of active transportation was then proposed to the participants in the following statement: “Active transportation is defined as any form of human-powered transportation (e.g., walking and cycling)”.

**Sitting time.** The IPAQ short form included the following question: “How much time did you spend sitting during a weekday? (i.e., hours and minutes per day, excluding the weekend)”. For this study, this question was asked prior to confinement and during confinement.
Uninterrupted sitting time. Students reported the average time of uninterrupted sitting. The question was, “On average (prior to confinement), how long do you sit without getting up? (hours and minutes)”. 

Screen time. Students indicated average minutes per day of screen-time usage prior to and during confinement. The question posed with regards to their time prior to the confinement was: “Normally (prior to confinement), how many hours on average per day do you spend in front of a screen (computer, tablet, smartphone, TV…)?”. The question posed with regards to their time during the confinement was: “How many hours on average per day (during confinement) do you spend in front of a screen (computer, tablet, smartphone, TV)?”. 

Screen time studying. Students reported their average daily hours using a computer (i.e., desktop, laptop, tablet) or smartphone to study. The question posed was, “Normally (prior to confinement), how many hours on average per day do you spend in front of a screen studying (computer, tablet, smartphone)?”. The question posed with regards to their time during the confinement was: “Normally (during confinement), how many hours on average per day do you spend in front of a screen studying (computer, tablet, smartphone)?”.

Statistical analysis
We calculated the differences (i.e., delta $\Delta$) in physical activity, sitting and screen time between the period prior to confinement and the period during confinement, using Microsoft Excel version 16.48 (RRID:SCR_016137). These differences were the dependent variables for four multiple regression models. Sex and age were included in the regression models as control variables to assess the impact of confounding variables. A graphic method of generalized additive models (GAM) examined subgroups and interactions. The graphs are available as Extended data. Missing data were handled by excluding incomplete cases from the dataset, avoiding the use of multiple imputations.

The models were used to prove our fourth hypothesis. The first regression model was for moderate physical activity and the second regression model was for vigorous physical activity. Both models were used to test the first hypothesis, which stated that the longer time a student adopted active transportation, the greater the reduction in physical activity minutes during confinement. The third model tested the second hypothesis that those who spent longer sitting for an uninterrupted time prior to confinement, the greater the increase in sitting time during confinement. The fourth model tested the third hypothesis, which suggested that the higher time students spent in front of a screen for study, the greater the increase in screen time during confinement. The four models tested our fourth hypothesis about the relationship between active transportation, sitting time and screen time during confinement. All regression analyses were performed with RStudio (2021.09.0) (RRID:SCR_000432) and the package lme4 (RRID:SCR_015654).

Results
Table 1 presents the characteristics of 2873 students. Overall, the sample was balanced between men (46%) and women (54%). They were aged between 18 and 29 years old ($M=19.93$, $SD=1.76$) and they were, according to IPAQ classification, inactive prior to confinement (60%). Students adopted walking (70%) as a mode of active commuting, 17% participated in cycling, 8% were passive commuters (e.g., car, bus, underground), 3% combined walking and cycling, and 2% adopted any combination of active and passive transport (e.g., bus, tramway and walking or tramway and cycling). The average duration of active transportation, prior to confinement, was approximately 30 minutes per trip. Moreover, the

| Variable             | n   |
|----------------------|-----|
| Sex                  |     |
| Women                | 1540|
| Men                  | 1333|
| Age, years, mean (SD)|     |
| 18                   | 488 |
| 19                   | 916 |
| 20                   | 693 |
| 21                   | 387 |
| 22                   | 199 |
| ≥23                  | 202 |

Table 1. Descriptive statistics.
students spent approximately eight hours sitting down per day prior to confinement and with an average uninterrupted sitting time of almost 100 minutes prior to confinement. Students spent more than 10 hours per day using screens during confinement, of which approximately five hours were for studying and five hours outside of study hours. Analyses of the GAM models did not show the presence of subgroups within the data or interactions between variables.40

**Hypothesis**

Four multiple regression models assessed the extent to which active transportation, uninterrupted sitting time, and screen time studying before confinement exacerbated or attenuated the effects of confinement on total physical activity time and sitting time. Multiple regression models indicate that when the variables had a negative effect, there was significantly less time reduction during the confinement. Conversely, when the effect was positive, it predicted a more considerable time change during confinement.

**H1**: The first hypothesis was that the longer the duration in minutes of students’ active transportation trips prior to confinement, the greater the reduction in their physical activity time during confinement.

To evaluate our first hypothesis, we conducted two multiple regression analyses (Table 2), one for moderate physical activity (Model 1) and one for vigorous physical activity (Model 2). The results of the first model indicated that five predictors explained 47% of the variance in moderate physical activity time ($R^2_{adjusted}=0.46$, $F(9,2863)=283.1$, $p<0.001$). Older students ($\beta_{age}=-0.73$, $p<0.001$), as well as those who accumulated more moderate physical activity ($\beta=-0.71$, $p<0.001$) and sitting time prior to confinement ($\beta=-0.01$, $p<0.001$), had significantly less reduction in their moderate physical activity levels during confinement. It was found that active transportation time predicted a larger reduction in moderate physical activity ($\beta=0.16$, $p<0.001$), as did vigorous physical activity prior to confinement ($\beta=0.07$, $p<0.001$). These results mean that the more time spent in active transport and vigorous physical activity before confinement, the greater the reduction in moderate physical activity levels during confinement.

| Variable                                           | n    |
|----------------------------------------------------|------|
| IPAQ categories, before confinement                |      |
| Low                                                | 1738 |
| Moderate                                           | 523  |
| High                                               | 612  |
| IPAQ categories, during confinement                |      |
| Low                                                | 1932 |
| Moderate                                           | 448  |
| High                                               | 493  |
| Time of commuting to university in minutes per trip, mean (SD) | 28.61 (18.44) |
| Passive commuting (bus, car and underground)       | 229  |
| Active transportation time categories              |      |
| Between 10-15 min                                  | 447  |
| >15-30 min                                         | 723  |
| >30-45 min                                         | 1025 |
| >45-60 min                                         | 337  |
| >60 min                                            | 112  |
| Uninterrupted categories of sitting time in minutes, mean (SD) | 97.53 (63.00) |
| Sitting time categories                            |      |
| 15-30 min                                          | 259  |
| >30-45 min                                         | 327  |
| >45-60 min                                         | 695  |
| >60 min                                            | 1592 |

*IPAQ=International Physical Activity Questionnaire.*
Table 2. Multiple regression analysis of changes in physical activity levels during confinement.

| Variables                              | Change of MPA (Model 1) | Change of VPA (Model 2) |
|----------------------------------------|--------------------------|-------------------------|
|                                        | β (SE) | LL | UL | p-value | β (SE) | LL | UL | p-value |
| Intercept                              | 35.26(6.13) | 23.23 | 47.29 | 1.01e-08*** | 34.07(7.00) | 20.24 | 47.91 | 1.44e-06*** |
| Sex/Women                              | -1.63(1.00) | -0.32 | 3.60 | 0.102 | -1.64(1.15) | -3.90 | 0.61 | 0.153 |
| Age                                    | -0.73(0.27) | -1.28 | -0.18 | 0.008** | -0.58(0.32) | -1.21 | 0.04 | 0.069 |
| MPA min/day (prior confinement)       | -0.71(0.01) | -0.74 | -0.69 | <2e-16*** | 0.05(0.01) | 0.01 | 0.08 | 0.002** |
| VPA min/day (prior confinement)       | 0.07(0.01) | 0.05 | 0.09 | 3.63e-10*** | -0.95(0.01) | -0.98 | -0.93 | <2e-16*** |
| Active transportation min/trip (without confinement) | 0.16(0.02) | 0.10 | 0.21 | 5.55e-09*** | 0.03(0.03) | -0.02 | 0.09 | 0.234 |
| Sitting min/day (prior confinement)   | -0.01(0.003) | -0.02 | -0.008 | 1.61e-06*** | -0.001(0.003) | -0.008 | 0.005 | 0.614 |
| Uninterrupted sitting min/day (without confinement) | -0.005(0.007) | -0.02 | -0.009 | 0.471 | -0.002(0.009) | -0.01 | 0.01 | 0.820 |
| Screen min/day (prior confinement)    | 0.002(0.003) | 0.003 | 0.008 | 0.374 | -0.008(0.003) | -0.01 | -0.001 | 0.018* |
| Screen studying min/day (without confinement) | 0.001(0.003) | -0.005 | 0.008 | 0.708 | 0.002(0.004) | -0.005 | 0.01 | 0.563 |

**Observations**

| 2873 |

**R²**/adj R²

| .470/.469 | .645/.644 |

**F-statistics**

| 283.1 | <2.2e-16 |

**AIC**

| 26960.02 | 27762.23 |

MPA=Moderate physical activity; VPA=Vigorous physical activity; LL=Lower Limit; UL=Upper Limit; AIC=Akaike information criterion. Significance codes: *p<0.05; **p<0.01; ***p<0.001.
### Table 3. Multiple regression models for changes in sitting and screen time during confinement.

| Variables                                      | Change of sitting time (Model 3) | p-value | 95% CI          | Change of screen time (Model 4) | 95% CI          | p-value |
|------------------------------------------------|----------------------------------|---------|-----------------|---------------------------------|-----------------|---------|
|                                                | β (SE)                           |         | LL          | UL          | β (SE)                           |         | LL          | UL          |         |
| Intercept                                      | 501.11(40.45)                   | <2e-16  | 421.78      | 580.43     | 405.80(37.34)                   | 332.57     | 479.03     | <2e-16  |
| Sex/Men                                        | 1.14(6.60)                      | 0.862   | -11.81      | 14.09      | 2.36(6.09)                      | -9.59      | 14.32      | 0.698    |
| Age                                            | -0.18(1.84)                     | 0.921   | -3.79       | 3.43       | -0.68(1.70)                     | -4.02      | 2.64       | 0.685    |
| MPA min/day (prior to confinement)             | 0.02(0.09)                      | 0.791   | -0.16       | 0.21       | 0.06(0.08)                      | -0.11      | 0.23       | 0.490    |
| VPA min/day (prior to confinement)             | -0.006(0.07)                    | 0.931   | -0.15       | 0.14       | -0.07(0.07)                     | -0.21      | 0.06       | 0.266    |
| Active transportation min/trip (without confinement) | -0.31(0.18)                   | 0.083   | -0.66       | 0.04       | -0.52(0.16)                     | -0.85      | -0.19      | 0.001**  |
| Sitting min/day (prior to confinement)         | -0.97(0.01)                     | <2e-16  | -1.01       | -0.93      | 0.01(0.01)                      | -0.02      | 0.04       | 0.585    |
| Uninterrupted sitting min/day (without confinement) | 0.62(0.05)                   | <2e-16  | 0.52        | 0.72       | 0.43(0.04)                      | 0.33       | 0.52       | <2e-16  |
| Screen min/day (prior to confinement)          | 0.29(0.02)                      | <2e-16  | 0.25        | 0.33       | -0.45(0.01)                     | -0.48      | -0.41      | <2e-16  |
| Screen studying min/day (prior to confinement) | -0.07(0.02)                     | 0.001** | -0.122      | -0.02      | -0.09(0.02)                     | -0.14      | -0.05      | 7.65e-06** |
| Observations                                   | 2873                            |         |             |             |                                |             |             |            |
| R²/adj R²                                       | .500/.499                      |         |              |              |                                |             |              |            |
| F-statistics                                    | 318.8                           | <2.2e-16|             |              |                                |             |              | <2.2e-16 |
| AIC                                             | 37796.33                       |         |              |              |                                |             |              |            |

MPA=Moderate physical activity; VPA=Vigorous physical activity; LL=Lower Limit; UL=Upper Limit; AIC=Akaike information criterion. Significance codes: *p<0.05; **p<0.01; ***p<0.001.
The second model showed that three predictors explained 64% of the variance in vigorous physical activity ($R^2_{\text{adjusted}}=0.64$, $F(9,2863)=580$, $p<0.001$). Students who engaged in vigorous physical activity ($\beta=-0.95$, $p<0.001$) for more minutes prior to confinement showed significantly less reduction in vigorous physical activity during confinement. Conversely, students who presented higher amounts of moderate physical activity prior to confinement ($\beta=0.05$, $p<0.01$) showed a significantly greater reduction in their levels of vigorous physical activity.

**H2:** The second hypothesis was that the greater the uninterrupted sitting time prior to confinement in students, the greater the increase in the amount of time they would spend sitting during confinement.

In the case of our second hypothesis, a multiple linear regression (Table 3) showed four predictors (Model 3) explaining 49% of the variance in students’ sitting time ($R^2_{\text{adjusted}}=0.49$, $F(9,2863)=318.8$, $p<0.001$). Students’ sitting time ($\beta=-0.97$, $p<0.001$) and screen time studying ($\beta=-0.07$, $p=0.001$) prior to confinement significantly predicted a smaller increase in sitting time during confinement. Conversely, the greater the uninterrupted sitting ($\beta=0.62$, $p<0.001$) and screen time ($\beta=0.29$, $p<0.001$) prior to confinement, the greater the increases in sitting time during confinement.

**H3:** The third hypothesis was for screen time; due to the increase in online courses during confinement, the longer the screen time studying prior to confinement in students, the greater the increase in their screen time during confinement.

Regressions (Table 3) showed that four predictors explained 20% of the variance in screen time during confinement ($R^2_{\text{adjusted}}=0.19$, $F(9,2863)=79.54$, $p<0.001$). Active transportation ($\beta=-0.52$, $p<0.01$), screen time prior to confinement ($\beta=-0.45$, $p<0.001$), and screen time studying ($\beta=-0.09$, $p<0.001$) predicted a lower increase in screen time during confinement. Only uninterrupted sitting ($\beta=0.43$, $p<0.001$) significantly predicted a higher increase of screen time during confinement (Model 4).

**H4:** Finally, we hypothesised that there would be no relationship between active commuting, sitting time and screen time during confinement.

Multiple regression results on changes in moderate physical activity showed that the reduction in moderate physical activity levels was less significant for students who spent more time sitting prior to confinement ($\beta=-0.01$, $p<0.001$). Model 2 showed no relationship between vigorous physical activity and either sitting or screen time. Model 3 showed no relationship between physical activity behaviour and sitting time or screen time. Finally, there was a negative relationship between the increase of screen time during confinement and active transportation minutes prior to confinement (Model 4). Students who adopted active transportation showed a less significant increase in screen time during confinement ($\beta=-0.52$, $p=0.001$).

**Discussion**

The main objective of this study was to determine whether the adoption of active transportation, uninterrupted sitting time, and screen study time predicted changes in physical activity, sitting time and screen time in students during confinement.

Studies on confinement and its effects on university students showed that it reduced physical activity levels in this population with at least two elements: the levels of physical activity before confinement and the age of the students. In fact, the reductions in physical activity levels were more significant for the more active students prior to confinement. Moreover, these students are also the ones who used active transport to get to university before confinement. Thus, our results confirm that adopting active transport contributes to university students’ physical activity levels. Students who adopted active transportation were more active before confinement than those who did not, which is consistent with the literature. In addition, among those students who adopt active transport, those who have longer commuting times are also those who further decrease their physical activity levels. It is therefore necessary not only to look at total physical activity and active transport times, but also to look in detail at journey times. Another detail of active transport could be whether students walk, cycle or combine these modes of transport. The study by Yang and colleagues showed that men tend to cycle and women tend to walk.

In this study, age was a determining factor in reducing physical activity levels during confinement. The youngest students reduced their physical activity levels the most, which is consistent with the literature. Thus, the year of training could have an influence; as the years of training progress, students decrease their physical activity levels. Therefore, future studies on physical activity levels in university students should consider the year of training.
Moreover, active transportation could be part of students’ daily routines, given that the city the study took place in has high active transportation rates (Walk Score® city of Villerbanne: 89 errands can be accomplished on foot and very bikeable: 70-89). However, the suspension of campus lectures reduced active commuting, decreasing overall moderate physical activity levels. This factor explains why active transportation time did not predict a greater reduction in vigorous physical activity levels. In addition, students were inactive and spent no more than 30 minutes per day in physical activity, coupled with reduced movement perimeter during confinement (i.e., 5 km around the house).

It might have been expected that levels of moderate and vigorous physical activity before confinement would explain the changes in the respective levels during confinement. However, the results only showed that vigorous physical activity levels before confinement had a smaller reduction in time spent in vigorous activities during confinement. With regard to moderate physical activity levels, the reduction of that time during confinement also reduced vigorous activity levels. This result could be due to the fact that in order to reach vigorous intensity, it is necessary to go through moderate activity levels. This is of concern because, for students who were more inclined to engage in vigorous physical activity prior to confinement, their practice during confinement was significantly reduced. This reduction could lead to negative health outcomes, a serious concern that warrants further attention.

Our second hypothesis was confirmed; the longer the uninterrupted time spent in a seated position before confinement, the more the students increased their time in that position during confinement. Furthermore, this increased time was exacerbated by the screen’s use during confinement. This factor, combined with sitting time, indicated that the students who spent the most time sitting without interruption were those who spent the most time in front of screens. Uninterrupted sitting time has been identified as a health risk factor in adults. This behaviour pattern is particularly marked in university students who accumulate this time during their lectures. Consequently, the point is the accumulation pattern of sitting time (i.e., how this time accumulates). For example, two students might accumulate six hours in total, but one will do so in three periods of two hours each and another in six periods of one hour.

Regarding the positive association between sitting time and screen use, it is likely that the online courses during the pandemic period have increased the association between screen use and sitting in university students, increasing the use of screens to study. Similarly, screen use in students could be interpreted as a proxy for time spent sitting.

The third hypothesis postulated that the more time students used screens prior to confinement, the more they would increase this time during confinement. The results did not confirm this hypothesis; on the contrary, the more time spent using screens prior to confinement, the smaller the increase in this behaviour. One possible explanation could be that high time spent using screens did not undergo significant modifications since screen-based devices have become pervasive in students’ lives. Likewise, the time students spent using screens could be independent of the confinement factor. However, screen time would not be independent of the uninterrupted time spent sitting since the longer the prolonged periods of this behaviour, the greater the increase in screen time. Thus, it could be postulated that students defined as prolongers of sitting time would be more prone to prolonged use of screens and vice-versa.

The last hypothesis postulated that there would be no relationship between active transportation times, sitting, and screen time was partially confirmed. The relationship between moderate physical activity and students’ sitting time showed that low levels of physical activity could coexist with high levels of sitting time in students. This inactive-sedentary profile should be the most alarming health risk factor. Inactivity itself results in low levels of physical and mental health such as stress, anxiety, depression, but if it is associated with high levels of sitting time, there is a potentially higher risk of suffering from metabolic diseases or exacerbating risk for mortality. Another element highlighted is the “protective” effect of time spent in active transportation. This study highlights that the more time students adopted active transportation,
the less they increased screen use in confinement. This phenomenon could reflect a negative association between the two behaviours and that somehow, screen time would be displaced by active transportation time.30 Similarly, students who adopt active transportation are generally more active people7 and spend less time using screens.

Limitations
The present study is not free of limitations. Behaviours were measured via questionnaires, leading to the overestimation of physical activity and underestimation of sitting time. This phenomenon is associated with social desirability. There could be a bias of recall about before the confinement. The students who could answer this questionnaire had access to the internet and were enrolled in the health seminars offered during the pandemic. A potential selection bias may be present, as students who participated in the health webinar may represent a portion of the university population already more sensitive to the topic of physical activity. There were several measures to continue working at universities in France. Few universities organize face-to-face teaching. Thus, this study only represents part of the student population of French universities. Regional differences in lockdown policies may have influenced the results, necessitating caution when interpreting the data at a national level.

Future studies on physical activity levels, the adoption of active transport and screen use in university students could include socio-economic and cultural factors.

Conclusions
Our study confirms that active transportation is the primary source of physical activity in the daily lives of university students. Thus, active transport at university should be a health priority, including its promotion on university campuses. Moreover, access to cycle paths and footpaths near universities would facilitate the adoption of this behaviour by students. Similarly, the time young people spend studying contributes to the accumulation of high levels of sitting time, which screens could exacerbate. In addition, screens’ ubiquity and association with sedentary behaviours could induce prolonged sitting positions, generating patterns of behaviour that are riskier for students’ health.

For the reasons outlined above, implementing short breaks from sitting time during university courses should be a policy to apply at universities. Similarly, online courses in which screens are the main element should include recommendations for teachers and students to interrupt the time students spend in front of these devices in sedentary positions. Therefore, the study of online courses and e-learning on physical activity levels and sitting time must be determined.

Data availability
Underlying data
Figshear: UnidataCovid19 (spreadsheet data of questionnaire results). https://doi.org/10.6084/m9.figshare.19583821.

Extended data
Figshear: Questionnaire Uni (study questionnaire), https://doi.org/10.6084/m9.figshare.19778761.v1.

Figshear: GAM_RDGraphs_uni (GAM graphs to examine subgroups and interactions). https://doi.org/10.6084/m9.figshare.19630434.

Data are available under the terms of the Creative Commons Attribution 4.0 International license (CC-BY 4.0).

References
1. Lopez-Valenciano A, Suarez-Iglesias D, Sanchez-Lastra MA, et al.: Impact of COVID-19 Pandemic on University Students’ Physical Activity Levels: An Early Systematic Review. Front. Psychol. 2020; 11: 624567.
2. Gemin PM, Lambert C, Larras B, et al.: How Did the COVID-19 Confinement Period Affect Our Physical Activity Level and Sedentary Behaviors? Methodology and First Results From the French National ONAPS Survey. J. Phys. Act. Health. 2021; 18(3): 296–303. PubMed Abstract | Publisher Full Text
3. Romero-Blanco C, Rodriguez-Almagro J, Onieva-Zafría MD, et al.: Physical Activity and Sedentary Lifestyle in University Students: Changes during Confinement Due to the COVID-19 Pandemic. Int. J. Environ. Res. Public Health. 2020; 17(18).
4. Motevalli M, Drenowatz C, Warnitzer KC, et al.: Changes in physical activity during the COVID-19 lockdown based on the sociodemographic profile of 5569 students and academic staff of Austrian universities. Public Health. 2021; 219: 1102–1109. Publisher Full Text
5. Meyer J, Herring M, McDowell C, et al.: Joint prevalence of physical activity and sitting time during COVID-19 among US adults in April 2020. Prev. Med. Rep. 2020; 25: 101256. Epub 2020 Nov 27. Erratum in: Prev Med Rep. 202106; 22: 101354, 20. PubMed Abstract | Publisher Full Text | Free Full Text
46. Eijsvogels TM, George KP, Thompson PD: Cardiovascular benefits and risks across the physical activity continuum. *Curr. Opin. Cardiol.* 2016; 31(5): 566–571. PubMed Abstract | Publisher Full Text

47. Deliens T, Deforche B, De Bourdeaudhuij I, et al.: Determinants of physical activity and sedentary behaviour in university students: a qualitative study using focus group discussions. *BMC Public Health.* 2015; 15: 201. PubMed Abstract | Publisher Full Text
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Version 2

Reviewer Report 03 December 2024

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Pierluigi Diotaiuti
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2 Department of Human Sciences, Society and Health, University of Cassino and Southern Lazio, Cassino, Italy

I sincerely thank you for giving me the opportunity to review your study titled "Behavioural patterns of university students during the COVID-19 pandemic: A cross-sectional study of the effects of active transportation, uninterrupted sitting time, and screen use on physical activity and sitting time." This manuscript addresses a highly relevant topic, rigorously exploring the behavioral changes of university students during the pandemic lockdown. The methodological approach, combined with the large sample size and detailed statistical analysis, makes this work a valuable contribution to understanding the pandemic's impact on students' physical and sedentary behaviors.

Strengths of the Study
1. **Originality of the Topic**: The study focuses on a current and under-explored subject in scientific literature: the pandemic's effect on behaviors related to active transportation, uninterrupted sitting time, and screen use among university students.
2. **Strong Methodological Structure**: The use of the IPAQ questionnaire and multiple regression models ensures robust data collection. The decision to examine various variables, such as active transportation and screen time for studying, provides a comprehensive and well-rounded analysis.
3. **Clarity of Presentation**: The text is generally clear and well-structured, with appropriate scientific terminology and a thorough description of methods and results.

However, during the review process, I identified several areas where improvements could further enhance the value of the manuscript. Below, I provide detailed suggestions, specifying the exact lines and the modifications to be made.

Suggested Modifications
1. **Abstract**
   - **Lines 19-22**: The sentence “The closure of universities due to the COVID-19 pandemic may alter the behaviour of students“ can be made more precise. I suggest replacing it
with: "The closure of universities due to the COVID-19 pandemic significantly affected students' behaviors, particularly regarding physical activity, sitting time, and screen use." This wording clarifies the direct impact described in the study.

- **Lines 23-24**: As previously mentioned, replace "lockdown" with "confinement" to maintain terminological consistency.
- **Lines 26-27**: It is mentioned that the sample completed the International Physical Activity Questionnaire (IPAQ), but some key details are missing. Please add the average completion time and specify how informed consent was obtained. I suggest: "Participants completed the IPAQ in an average time of around 15 minutes, after providing digital informed consent."

2. **Introduction**

- **Lines 62-65**: The sentence "The decrease in physical activity levels was more significant for people who were more active before COVID-19, men and younger adults (ages 18-34) compared to older adults." needs more clarity and support. You might expand by explaining why these categories were more affected, such as referencing specific behavioral or socio-economic factors.
- **Lines 71-73**: It would be helpful to expand the section on active transportation, including studies that support the importance of this form of movement for mental and physical health during confinement.

3. **Methods**

- **Lines 105-106**: The description of the email invitation to students could be improved by adding more detail. I suggest clarifying if the invitation was sent multiple times, whether incentives were used to encourage participation, and the final response rate. Add: "The survey invitation was sent twice to increase response rates, and participants were offered access to the final research results as a non-monetary incentive."
- **Lines 116-117**: It would be useful to specify how missing data were handled. I suggest: "Missing data were handled by excluding incomplete cases from the dataset, avoiding the use of multiple imputations."

4. **Results**

- **Lines 146-150**: In this section, where the regression model results are reported, it would be helpful to provide a more detailed interpretation of the $\beta$ coefficients. For example, regarding active transportation, explain more clearly how transport time predicted a greater reduction in moderate physical activity, specifying the practical implications of these findings.
- **Lines 160-162**: The description of the sample in terms of IPAQ could be improved by adding a reflection on the importance of including socio-economic or cultural categories in the analysis models.

5. **Discussion**

- **Lines 192-195**: The paragraph discussing the importance of active transportation could benefit from more emphasis on the mental health benefits in addition to physical ones. I suggest including a reference to the literature that highlights how physical activity positively affects psychological well-being, especially in a confinement context.
- **Lines 203-207**: It would be helpful to clarify the interpretation of the results related to vigorous versus moderate physical activity. The explanation provided seems too concise and may confuse the reader. I suggest expanding, specifying how the intensity of physical activity influenced behaviors during confinement.
In the **limitations** section, although some crucial points have been identified, there are other aspects that deserve further discussion:

1. **Lines 263-265**: While social desirability bias is mentioned, a more in-depth reflection on selection bias is needed. Those who participated in the health webinar might have already been more sensitive to the topic of physical activity compared to the general student population. I suggest adding: "A potential selection bias may be present, as students who participated in the health webinar may represent a portion of the university population already more sensitive to the topic of physical activity."

2. **Lines 267-269**: You might consider the potential influence of regional differences within France, where some areas may have experienced stricter restrictions than others. Add a comment: "Regional differences in lockdown policies may have influenced the results, necessitating caution when interpreting the data at a national level."

3. **Section "Screen time and sedentary behaviour" (Lines 143-146)**: This section is somewhat repetitive. Some concepts, such as the correlation between screen time and sedentariness, have already been mentioned in other parts. I suggest condensing and merging these sections to avoid redundancy.

In reviewing your manuscript, I suggest including the following reference: Diotaiuti P, et al., 2021 (Ref 1)

This article could be particularly relevant to enrich the discussion on the validation of psychometric tools used to measure behaviors and psychological variables related to physical activity and sedentary behavior. I recommend inserting this citation in the following sections of your manuscript:

1. **Methods Section**, specifically where you describe the validation and reliability of the tools used to measure sedentary behaviors and screen time. You could add a sentence such as: "To ensure the accuracy and validity of behavioral measurements, we considered the validation of similar tools in other contexts, as demonstrated in the study by Diotaiuti et al. (2021), which confirmed the psychometric robustness of temporal focus measurement scales."

2. **Discussion Section**, when addressing the importance of using validated and reliable tools in research on behaviors during confinement. You might add: "The importance of using validated tools to measure psychological factors is well documented in the literature, as illustrated by the study of Diotaiuti et al. (2021) [Ref 1], which demonstrated the psychometric validity of the Temporal Focus Scale in a university setting."

**References**

1. Diotaiuti P, Valente G, Mancone S: Validation study of the Italian version of Temporal Focus Scale: psychometric properties and convergent validity. *BMC Psychology*. 2021; 9 (1). Publisher Full Text

**Is the work clearly and accurately presented and does it cite the current literature?**

Yes

**Is the study design appropriate and is the work technically sound?**

Yes

**Are sufficient details of methods and analysis provided to allow replication by others?**

Yes
If applicable, is the statistical analysis and its interpretation appropriate?
Yes

Are all the source data underlying the results available to ensure full reproducibility?
Yes

Are the conclusions drawn adequately supported by the results?
Partly

Competing Interests: No competing interests were disclosed.

Reviewers Expertise: In the context of reviewing and providing feedback on research articles, my areas of research focus on physical activity, sedentary behavior, public health interventions, and behavioral patterns during pandemics. This includes understanding how environmental factors such as confinement and lifestyle changes (e.g., screen use, sitting time, active transportation) affect physical and mental health outcomes, particularly among vulnerable populations like students. Additionally, I am engaged in methodological assessments related to cross-sectional and longitudinal studies, emphasizing data collection tools, psychometric validations, and regression models.

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 22 Jan 2025
Gonzalo Marchant

Suggested Modifications
1. Abstract
   ○ Lines 19-22: The sentence "The closure of universities due to the COVID-19 pandemic may alter the behaviour of students" can be made more precise. I suggest replacing it with: "The closure of universities due to the COVID-19 pandemic significantly affected students' behaviors, particularly regarding physical activity, sitting time, and screen use." This wording clarifies the direct impact described in the study.
   Answer: We replaced this phrase.
   ○ ○ Lines 23-24: As previously mentioned, replace "lockdown" with "confinement" to maintain terminological consistency.
   Answer: We replaced lockdown with confinement.
   ○ ○ Lines 26-27: It is mentioned that the sample completed the International Physical Activity Questionnaire (IPAQ), but some key details are missing. Please add the average completion time and specify how informed consent was obtained. I suggest: "Participants completed the IPAQ in an average time of around 15 minutes, after providing digital informed consent."
   Answer: We have included your suggestion.
1. Introduction

- Lines 62-65: The sentence "The decrease in physical activity levels was more significant for people who were more active before COVID-19, men and younger adults (ages 18-34) compared to older adults." needs more clarity and support. You might expand by explaining why these categories were more affected, such as referencing specific behavioral or socio-economic factors.

**Answer:** The cited study (5) shows that the determining factor in this decline was age. To make it clear that the age category was the key factor in this decline, we have added age >34 years. The scientific literature shows that physical activity levels tend to decrease with advancing age.

- Lines 71-73: It would be helpful to expand the section on active transportation, including studies that support the importance of this form of movement for mental and physical health during confinement.

**Answer:** We have included active transport adoption’s mental and physical effects. See page 4, lines 14-18, and references 11 to 14.

1. Methods

- Lines 105-106: The description of the email invitation to students could be improved by adding more detail. I suggest clarifying if the invitation was sent multiple times, whether incentives were used to encourage participation, and the final response rate. Add: "The survey invitation was sent twice to increase response rates, and participants were offered access to the final research results as a non-monetary incentive."

**Answer:** We added your suggestion in the method section.

- Lines 116-117: It would be useful to specify how missing data were handled. I suggest: "Missing data were handled by excluding incomplete cases from the dataset, avoiding the use of multiple imputations."

**Answer:** We added your suggestion in the method section.

1. Results

- Lines 146-150: In this section, where the regression model results are reported, it would be helpful to provide a more detailed interpretation of the β coefficients. For example, regarding active transportation, explain more clearly how transport time predicted a greater reduction in moderate physical activity, specifying the practical implications of these findings.

**Answer:** We explain the results of active transport and vigorous activity. Please see the results section Hypothesis 1. Page 9, lines 197-199.

- Lines 160-162: The description of the sample in terms of IPAQ could be improved by adding a reflection on the importance of including socio-economic or cultural categories in the analysis models.

**Answer:** We did not include these factors in our questionnaire. We include this suggestion in our study’s limitations, page 15, lines 349-351.

1. Discussion

- Lines 192-195: The paragraph discussing the importance of active transportation could benefit from more emphasis on the mental health benefits in addition to physical ones. I suggest including a reference to the literature that highlights how physical activity positively affects psychological well-being, especially in a confinement context.

**Answer:** We included this reference, and we wrote a new phrase. See age 15, line 331.
It would be helpful to clarify the interpretation of the results related to vigorous versus moderate physical activity. The explanation provided seems too concise and may confuse the reader. I suggest expanding, specifying how the intensity of physical activity influenced behaviors during confinement.

**Answer:** We rephrase this explanation. Please see page 14, Lines 290-299.

In the **limitations** section, although some crucial points have been identified, there are other aspects that deserve further discussion:

1. **Lines 263-265:** While social desirability bias is mentioned, a more in-depth reflection on selection bias is needed. Those who participated in the health webinar might have already been more sensitive to the topic of physical activity compared to the general student population. I suggest adding: "A potential selection bias may be present, as students who participated in the health webinar may represent a portion of the university population already more sensitive to the topic of physical activity."

**Answer:** We have now included your suggestion.

1. **Lines 267-269:** You might consider the potential influence of regional differences within France, where some areas may have experienced stricter restrictions than others. Add a comment: "Regional differences in lockdown policies may have influenced the results, necessitating caution when interpreting the data at a national level."

**Answer:** We have now included your suggestion.

**Section "Screen time and sedentary behaviour" (Lines 143-146):** This section is somewhat repetitive. Some concepts, such as the correlation between screen time and sedentariness, have already been mentioned in other parts. I suggest condensing and merging these sections to avoid redundancy.

**Answer:** We prefer to repeat this information as it is key to the importance of this relationship for university students, mainly because screens are increasingly being used in universities. Thanks for your suggestion.

In reviewing your manuscript, I suggest including the following reference:

Diotaïuti P, et al., 2021 (Ref 1)

This article could be particularly relevant to enrich the discussion on the validation of psychometric tools used to measure behaviors and psychological variables related to physical activity and sedentary behavior. I recommend inserting this citation in the following sections of your manuscript:

1. **Methods Section**, specifically where you describe the validation and reliability of the tools used to measure sedentary behaviors and screen time. You could add a sentence such as: "To ensure the accuracy and validity of behavioral measurements, we considered the validation of similar tools in other contexts, as demonstrated in the study by Diotaïuti et al. (2021), which confirmed the psychometric robustness of temporal focus measurement scales."

2. **Discussion Section**, when addressing the importance of using validated and reliable tools in research on behaviors during confinement. You might add: "The importance of using validated tools to measure psychological factors is well documented in the literature, as illustrated by the study of Diotaïuti et al. (2021) [Ref 1], which demonstrated the
psychometric validity of the Temporal Focus Scale in a university setting.”

**Answer:** Thank you for your suggestion. However, I would like to point out that we used an already validated questionnaire (IPAQ) and secondly, we did not use psychological assessments. Moreover, I could not find the reference to which you refer.

**Competing Interests:** No competing interests were disclosed.
Reviewer Expertise: Statistics, educational technology

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Version 1

Reviewer Report 20 July 2023

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Noémie Lienhart
1 Sport Psychology, University of Nantes, Nantes, France
2 Sport Psychology, University of Nantes, Nantes, France
3 Sport Psychology, University of Nantes, Nantes, France

Overall, this study sought to determine whether the adoption of active transportation, uninterrupted sitting time, and screen study time predicted changes in physical activity, sitting time, and screen time in students during confinement. I think this has the potential to contribute to physical activity and sitting time fields. However, there are several concerns that I have with the manuscript. I have outlined them below, including general and specific comments.

General comments:
○ The whole study is based on the closure of the universities and therefore the e-teaching during this second lockdown (October to December 2020). At that time, however, universities had the right to organize face-to-face teaching under some conditions. The situation was dependent on the faculty and even the year of study. If the authors do not have this information, they must consider this situation in their interpretation.

○ Recall bias does not appear to be considered by the authors. However, prior to confinement data are collected during confinement and this bias can be very significant.

○ Introduction: the interest and direction of hypothesis 4 were not discussed in the light of the literature in the introduction part.

○ Methods: Were participants required to attend the webinar to receive the link? What was the content of the webinar? Depending on this, participants may have adapted their responses.

○ Discussion: authors must make a real effort to present the practical applications of their work. Outside of the pandemic, what can we learn from this work?
Specific comments:
- Abstract: The wording of the objective is confusing. It is not the effect of the pandemic on pre-lockdown and lockdown that is being explored but the effect of active transportation, uninterrupted sitting time, and screen study time on physical activity and sitting time during the lockdown.

- Introduction: I don’t understand what hypothesis 3 is based on. The increase in online courses during confinement is a phenomenon independent of the screen time prior to confinement.

- Measures – Physical activity and Sitting time: Be careful of inconsistency. A sentence mentions that the data of the last seven days are requested while in the example it is mentioned “prior to confinement” and “during the confinement”.

- Measures: Some data were measured only on weekdays while others are measured in general. Why sitting time, uninterrupted sitting time, screen time, and screen time studying data were not measured separately for weekdays and weekends? We might hypothesize there are differences.

- Statistical analysis: Why sex and age were included in the regression model as control variables? You need to justify this in the introduction part.

- Statistical analyses: the 4th hypothesis is not mentioned.

- Results: “Students spent more than 10 hours per day using screens, of which approximately five hours were for ...”. Please specify “during confinement“ if this data refers to this period.

- Table 1: The data in the right-hand column is based on headcount, not frequency.

- Hypothesis: Please reformulate “Multiple regression models showed that when there was a negative effect in changes, it opposes the effect of confinement, if there is a positive change effect, it increases the impact of confinement.” for the lecturer.

- Tables 2 and 3: Does “habitual” corresponds to data during confinement? This term is not used in the manuscript.

- Results – H3: Is this the screen time to study before confinement that predicts a lower increase in screen time during confinement?

Is the work clearly and accurately presented and does it cite the current literature?
Partly

Is the study design appropriate and is the work technically sound?
Partly

Are sufficient details of methods and analysis provided to allow replication by others?
Partly
If applicable, is the statistical analysis and its interpretation appropriate?
Yes

Are all the source data underlying the results available to ensure full reproducibility?
Yes

Are the conclusions drawn adequately supported by the results?
Yes

**Competing Interests:** No competing interests were disclosed.

**Reviewer Expertise:** Sport psychology, elite athletes, parents, coaches, self determination theory, coping

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

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**Author Response 28 Nov 2023**

**Gonzalo Marchant**

Dear Colleague,

First of all, we appreciate your time and constructive comments so that we can improve our work.

In the following lines, we detail each of the responses to your comments.

Our response is presented after each of your comments.

**General comments:**

- The whole study is based on the closure of the universities and therefore the e-teaching during this second lockdown (October to December 2020). At that time, however, universities had the right to organize face-to-face teaching under some conditions. The situation was dependent on the faculty and even the year of study. If the authors do not have this information, they must consider this situation in their interpretation.

  Answer 1: We are aware of this limit. However, we did not control it because the whole university was closed when the questionnaire was online. We include this factor as a limitation of our study.

  - Recall bias does not appear to be considered by the authors. However, prior to confinement data are collected during confinement and this bias can be very significant.

  Answer 2: We include this recall bias in the limits section.
Introduction: the interest and direction of hypothesis 4 were not discussed in the light of the literature in the introduction part.

Answer 3: We complete this literature and include new arguments to make them more coherent with our fourth hypothesis. Please see the references Heller et al., 2023; Trott et al., 2022 (Fifth paragraph of introduction section).

Methods: Were participants required to attend the webinar to receive the link? What was the content of the webinar? Depending on this, participants may have adapted their responses.

Answer 4: The Webinar was about physical (in) activity and sedentary behaviours. The duration was 15 minutes. It was before questionnaires. Students received via email the link to the questionnaire after the Webinar. However, the response turnaround time varied between a few minutes (e.g., 15 minutes after the Webinar) and several days (e.g., five days). We included this information in the method section and its limitations.

Discussion: authors must make a real effort to present the practical applications of their work. Outside of the pandemic, what can we learn from this work?

Answer 5: In the discussion, we have argued the implications that could help to study the levels of physical activity of students and advance in the promotion of physical activity and the fight against a sedentary lifestyle in the university.

Specific comments:

- Abstract: The wording of the objective is confusing. It is not the effect of the pandemic on pre-lockdown and lockdown that is being explored but the effect of active transportation, uninterrupted sitting time, and screen study time on physical activity and sitting time during the lockdown.

Answer 1: We modified the objective in the abstract as it's suggested, thanks for pointed it out.

- Introduction: I don't understand what hypothesis 3 is based on. The increase in online courses during confinement is a phenomenon independent of the screen time prior to confinement.

Answer 2: Hypothesis 3 is linked to screen time to study. University students use screens to study (i.e., computers). The computer use is also a prevalent behavior in this population. Therefore, the explosion of this type of screen use increased during Covid. We included new references to present this idea. Please see Castro et al., 2021 reference).

- Measures – Physical activity and Sitting time: Be careful of inconsistency. A sentence mentions that the data of the last seven days are requested while in the example it is mentioned “prior to confinement” and “during the confinement”.

Answer 3: You are right; there was an inconsistency in these phrases. We did not see them when we created the online questionnaire, as we used the IPAQ statement. We should have modified this sentence. We have now modified it so that this element will be considered in other studies.

- Measures: Some data were measured only on weekdays while others are measured in general. Why sitting time, uninterrupted sitting time, screen time, and screen time
studying data were not measured separately for weekdays and weekends? We might hypothesize there are differences.

Answer 4: we considered only week days because we measured the university context or time when students were “at university”, having lectures. Another idea was to measure physical activity with a validated questionnaire (IPAQ); for that reason, the measure was a general one. We modified the sentences to improve the questionnaires’ consistency in case other projects want to assess the same behaviors.

○ Statistical analysis: Why sex and age were included in the regression model as control variables? You need to justify this in the introduction part.
Answer 5: We included the sentences to justify the inclusion and control of these variables in our models. Please see the reference Motevalli et al., 2023.

○ Statistical analyses: the 4th hypothesis is not mentioned.
Answer 6: We mentioned the four models which allowed us to test our fourth hypothesis. Please see this modification in statistical analysis.

○ Results: “Students spent more than 10 hours per day using screens, of which approximately five hours were for ...”. Please specify “during confinement” if this data refers to this period.
Answer 7: We specified that the data was during confinement.

○ Table 1: The data in the right-hand column is based on headcount, not frequency.
Answer 8: We changed frequency by “n” on Table 1.

○ Hypothesis: Please reformulate “Multiple regression models showed that when there was a negative effect in changes, it opposes the effect of confinement, if there is a positive change effect, it increases the impact of confinement.” for the lecturer.
Answer 9: We reformulated the phrase you indicated.

○ Tables 2 and 3: Does “habitual” corresponds to data during confinement? This term is not used in the manuscript.
Answer 10: “Habitual” corresponds to data in “normal periods” without confinement. We include this information in the table 2 and 3.

○ Results – H3: Is this the screen time to study before confinement that predicts a lower increase in screen time during confinement?
Answer 11: It's the screen time to study before confinement. It was modified in the H3.

Competing Interests: We have no interest to declare.
The paper has the potential to contribute to the related fields. However, some improvements should be considered:

1. Lit. review related to the four hypotheses should be supported by prior studies.
   
a. **H1**: The first hypothesis was that the longer the duration in minutes of students' active transportation trips prior to confinement, the greater the reduction in their physical activity levels, excluding active transportation time during confinement.
   
b. **H2**: The second hypothesis was that the greater the uninterrupted sitting time prior to confinement in students, the greater the increase in the amount of time they would spend sitting during confinement.
   
c. **H3**: The third hypothesis was for screen time; due to the increase in online courses during confinement, the longer the screen time studying prior to confinement in students, the greater the increase in their screen time during confinement.
   
d. **H4**: Finally, we hypothesized that there would be no relationship between active transportation, sitting time and screen time during confinement.

It is essential to integrate previous work discussed and critiqued in the literature review and discussion sections with the findings and tone of the study and bring out what was done in this study which addressed some of the shortcomings of those studies.

2. The gap between this research and prior research should also be more detailed. Besides, the significance of the current study is recommended to be more clear and more novel. In this sentence, “Most studies about confinement in the COVID-19 pandemic have focused on total times of changes in physical activity levels, sitting time, and screen time. For this reason, the main objective of this study was to assess if active transportation time, uninterrupted sitting time, and screen time spent studying prior to confinement were factors influencing these changes”. The studies are not cited and elaborated on. I suggest that the authors elaborate more on them, highlights on each finding of the works should be informed.

3. With N=2873 samples involved in the study, the authors need to conduct normality tests like Q-Q plot, skewness, and Kurtosis. The normality test is used to determine whether sample data has been drawn from a normally distributed population (within some tolerances). Without this, bias could be high for further statistical analysis.

4. The conclusion could be improved to motivate the related communities to get down to
actionable, practical, and academic implications. The authors missed the limitation, implications, and recommendations for practical and theoretical sections. Please include those parts in the conclusion of the study.

Is the work clearly and accurately presented and does it cite the current literature?
Yes

Is the study design appropriate and is the work technically sound?
Partly

Are sufficient details of methods and analysis provided to allow replication by others?
Yes

If applicable, is the statistical analysis and its interpretation appropriate?
Partly

Are all the source data underlying the results available to ensure full reproducibility?
Yes

Are the conclusions drawn adequately supported by the results?
Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Statistics, educational technology

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 28 Nov 2023

Gonzalo Marchant

Dear Colleague,

First of all, we would like to thank you for your comments and suggestions.

Secondly, you will find our detailed responses to your comments in the following lines.

Thus, you will see your comments followed by our answers, including the references that allowed us to complete our arguments.

1. Lit. review related to the four hypotheses should be supported by prior studies.

Answer 1: As requested, we have further developed our propositions, including new references in the introduction section, to complete the arguments according to our hypotheses.

a. H1: The first hypothesis was that the longer the duration in minutes of students’ active
Transportation trips prior to confinement, the greater the reduction in their physical activity levels, excluding active transportation time during confinement.

**Answer 1.a:** We justified the first hypothesis with the following arguments: Students who use active transportation are more active than those who do not. Among those who do, those who take longer trips also have a higher total physical activity time. Consequently, confinements reduce the active transportation to the university, thus reducing the total physical activity of the more active students during this period. Please see references in the first paragraph: Motevalli et al., 2023; Meyer et al., 2020. The second paragraph includes Yang et al., 2012 reference to complete our arguments according to the first hypothesis.

b. **H2:** The second hypothesis was that the greater the uninterrupted sitting time prior to confinement in students, the greater the increase in the amount of time they would spend sitting during confinement.

c. **H3:** The third hypothesis was for screen time; due to the increase in online courses during confinement, the longer the screen time studying prior to confinement in students, the greater the increase in their screen time during confinement.

**Answer 1.b and 1.c:** For the second and third hypotheses, we have given two arguments to improve the theoretical framework that allows us to justify them. Thus, we considered that having online courses during confinement increases students' time spent sitting in front of a screen (Please see Castro et al., 2021 reference). The second argument considers the literature showing that screens increase sitting time as it is uninterrupted and longer. Please see the reference Castro et al., 2021.

d. **H4:** Finally, we hypothesized that there would be no relationship between active transportation, sitting time and screen time during confinement.

**Answer 1.d:** Regarding the fourth hypothesis; the new version includes arguments explaining why we think there are no relationships between active transport, sitting time, and screen time. Please see references Heller et al., 2023; Trott et al., 2022.

It is essential to integrate previous work discussed and critiqued in the literature review and discussion sections with the findings and tone of the study and bring out what was done in this study, which addressed some of the shortcomings of those studies.

**Answer 1.d1:** We have included this information in the literature review and present the elements that allow us to advance knowledge about the levels of physical activity and sedentary behaviors in university students.

**Answer 1.d1 bis:** The literature review section includes new articles and analyses that allow us to highlight elements missing from previous studies. The main argument has to do with the type of variables included (e.g., duration of active transport journeys and uninterrupted sedentary time, duration of time spent using screens to study) in this study and the behaviours assessed (active transport, sedentary behavior, and screen use).

2. The gap between this research and prior research should also be more detailed. Besides, the significance of the current study is recommended to be more clear and more novel. In this sentence, "Most studies about confinement in the COVID-19 pandemic have focused on total times of changes in physical activity levels, sitting time, and screen time. For this reason, the main
The objective of this study was to assess if active transportation time, uninterrupted sitting time, and screen time spent studying prior to confinement were factors influencing these changes. The studies are not cited and elaborated on. I suggest that the authors elaborate more on them, highlights on each finding of the works should be informed.

**Answer 2:**
We have detailed the arguments that allow us to show the gap between this research and previous ones. In addition, we have added new literature to elaborate these arguments in a more complete, precise and coherent way. Consequently, we have modified the sentences and content you have indicated.

3. With N=2873 samples involved in the study, the authors need to conduct normality tests like Q-Q plot, skewness, and Kurtosis. The normality test is used to determine whether sample data has been drawn from a normally distributed population (within some tolerances). Without this, bias could be high for further statistical analysis.

**Answer 3:**
We are aware that our independent variables do not follow a normal distribution. Thank you for this comment. However, two arguments allowed us to carry out the multiple regression analyses.

Our sample size is 2873 students. According to the Central Limit Theorem, as sample sizes get larger, the distribution of the means approaches a bell curve even when the underlying distribution is highly skewed (Fisher, 2011; Sainani, 2012). Consequently, biases could be important in small samples (≤ N= 80). Thus, for our sample, linear regression provides a convenient and practical alternative (Lumley et al., 2002).

The second argument concerns physical activity behaviors. For example, data about physical activity is rarely bell-shaped. Instead, these follow a right-skewed distribution: they have a cluster of values at zero or zero-inflated distributions (non-practitioners for moderate-to-vigorous physical activity), another bunch in the low-to-moderate range, and a few extreme values to the right (highly active).

For more information, see:
- Fischer, Hans (2011). A History of the Central Limit Theorem: From Classical to Modern Probability Theory (PDF). Sources and Studies in the History of Mathematics and Physical Sciences. New York: Springer. doi:10.1007/978-0-387-87857-7.
- Lumley T, Diehr P, Emerson S, Chen L. The importance of the normality assumption in large public health data sets. Annu Rev Public Health. 2002;23:151-69. doi: 10.1146/annurev.publhealth.23.100901.140546.
- Sainani KL. Dealing with non-normal data. PM R. 2012 Dec;4(12):1001-5. doi: 10.1016/j.pmrj.2012.10.013.

4. The conclusion could be improved to motivate the related communities to get down to actionable, practical, and academic implications. The authors missed the limitation, implications, and recommendations for practical and theoretical sections. Please include those parts in the conclusion of the study.

**Answer 4:**
We included the limitations and proposed practical and theoretical recommendations about our results in the study's conclusion.
**Competing Interests:** We have no interest to declare.

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