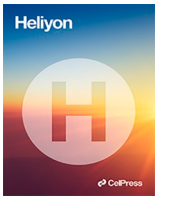
Heliyon 9 (2023) e19338

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon



Physical activity, sleep, and mental health during the COVID-19 pandemic: A one-year longitudinal study of Spanish university students

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ARTICLE INFO

Keywords:
Physical activity
Mental health
Sedentary behavior
Confinement
University students

ABSTRACT

The objective of this longitudinal study was to analyze changes in physical activity, sedentary time, sleep, anxiety, mood, and perceived health as a result of COVID-19 pandemic in a cohort of Spanish university students, both during the home confinement and one year after. Additionally, we analyzed the associations between physical activity, sedentary time, and other measured parameters. Data were collected through two online questionnaires that included the International Physical Activity Questionnaire-Short Form, the Pittsburgh Sleep Quality Index, and self-reported anxiety, mood, and perceived health levels before, during and one year after home confinement. Participants reported decreased physical activity, increased sedentary time, and deterioration in sleep quality and perceived health during confinement. Most parameters had improved one year later; however, the participants still reported less physical activity, more sedentary time, and deterioration in sleep quality and perceived health compared to before confinement. Men reported greater reduction of physical activity during home confinement than women. In contrast, women reported reduced physical activity one year after confinement,

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https://doi.org/10.1016/j.heliyon.2023.e19338
Received 2 May 2023; Received in revised form 16 August 2023; Accepted 18 August 2023
Available online 23 August 2023

whereas men reported increased activity. Participants reported higher anxiety and worse mood both during and one year post-confinement compared to pre-confinement, with women reporting higher levels of anxiety than men. Sports science students were closer to regaining pre-pandemic levels of physical activity one year post-confinement than students in other disciplines. Sleep, anxiety, and mood were worse among students with obesity compared to students in other BMI categories. Overall, increased physical activity and decreased sedentary time were associated with less anxiety and better sleep, mood, and perceived health during and one year post-confinement. In conclusion, our results demonstrate that physical activity, sedentary behavior, sleep, anxiety, mood, and perceived health were disrupted one year after home confinement. Higher levels of physical activity and lower sedentary time were associated with preserved sleep and mental health during the pandemic.

1. Introduction

The COVID-19 pandemic prompted many countries to take extraordinary measures to avoid spreading the disease. At the beginning of the pandemic (Winter-Spring 2020), entire populations were instructed to stay at home for a number of weeks to months. Spain in particular had some of the strictest conditions. On March 14th' 2020, the Spanish government declared the first State of Alarm [1] and for 7 weeks, people could only go out to purchase food or pharmacological supplies or to perform specific professional activities. Teaching in universities, high schools and primary schools changed drastically from face-to-face to online modalities. Even individual outdoor physical activity (PA), which was considered essential and therefore permitted in other countries, was banned in Spain. After this strict home confinement, the restrictions were gradually lifted, and leisure PA was permitted in certain circumstances [2]. However, considering that the spread of COVID-19 was not interrupted, specific laws to reduce mobility, social interaction, and leisure activities continued in Spain until May 2021 [3]. In particular, access to sports centers, sporting competitions, and certain physical activities was restricted, and face-to-face teaching did not completely return to pre-pandemic levels in universities in the 2020–2021 academic year [2]. As a group, university students are of great importance to the socioeconomic future of society, as they will become qualified professionals. Moreover, university life usually coincides with the transition from adolescence to adulthood, which is crucial for establishing habits that will be maintained throughout life [4]. In addition to the changes affecting the whole population during the COVID-19 pandemic, some elements, such as changes in teaching modalities [5], academic uncertainty [6], and the loss of social contact with friends and classmates, could also impact university students [7].

Due to the measures taken to control the pandemic, a considerable number of researchers have focused on measuring changes to the PA habits of the population. Most published studies reported that, with some exceptions [8], levels of PA decreased and sedentary time increased during the COVID-19 pandemic [9,10]. These changes are quite consistent across countries and age groups [11]. Since Spain had some of the harshest restrictions, it is understandable that PA was reduced more than in other populations [11]. One of the most worrying aspects of this decrease in PA is that, even two years after the beginning of the pandemic, PA measured using step-counters did not return to pre-pandemic levels globally [12]. Regarding university students, with some exceptions in specific groups of students [13], most of the published literature demonstrates that PA reduced during this period, with students focusing their leisure-time on sedentary behaviors involving screens [14].

The COVID-19 pandemic also seems to have had an impact on the sleep of the population [15]. Overall, sleep quality worsened [16], and sleep time increased during the pandemic [17]. Sleep is critical for academic, psychological, and behavioral aspects of the transition from adolescence to adulthood [17]. Unfortunately, the COVID-19 lockdown impacted the sleep quality of university students [18,19] more than other groups [20,21]. This is perhaps due to the particular characteristics of university students and the specific external stressors caused by the pandemic [22].

There is growing evidence of the negative effects of the pandemic and the measures taken to prevent its spread on the mental well-being of several populations [23,24]. Mental health disruption during COVID-19 severely affected young adults [25,26], a population that had already suffered a significant increase in the prevalence of mental disorders over the past decade [27,28]. A similar trend was seen among university students, who were at higher risk of developing depression [29], anxiety [30], and mood deterioration [31] compared to the pre-pandemic period.

Considering the benefits of PA [32,33] and deleterious effects of sedentary behavior [34], the disruptions associated with the pandemic could have negatively impacted the physical and mental health of university students. Accordingly, in most studies, reduced physical activity and increased sedentary time during the pandemic was associated with worse mental health [35,36] and perceived health [37]. The increased use of social media in conjunction with physical inactivity could also have impacted mental health during the pandemic [38].

Most studies on the impact of the COVID-19 pandemic on the habits and health of university students have been cross-sectional [35, 39,40] or compared pre-pandemic values with those measured at one time point during the pandemic [14,41]. Most of the longitudinal studies that have examined changes in the general population [42] or university students [43] had short follow-up periods, except for one study that involved five cohorts of University of Pittsburgh students [44].

Longitudinal studies are critical for understanding the negative impact of the pandemic on the future habits and health of university students. Furthermore, it is important to determine the longitudinal impact of different pandemic phases on PA, sedentary time, sleep, and mental health. Such research could help better prepare policymakers for future pandemics or provide evidence on the health impact of a lifestyle resembling behaviors seen during the pandemic. As Spain was one of the Western countries with the strictest

measures regarding outdoor PA, it is particularly relevant to analyze this population.

In addition, although university students share many characteristics in common, there could be differences among them in the response to the COVID-19 pandemic. Thus, depending on gender, the academic degree or branch of knowledge they are enrolled in, and the physical characteristics of the individuals, the concern about being infected, lifestyle, academic and work uncertainty, and the effects of estrangement from their peers due to the pandemic could vary. Although a few studies have compared the differential impact of the COVID-19 pandemic on life habits and mental health between different groups of university students, they compared very few groups without performing an exhaustive analysis [45,46].

Therefore, this study aimed to analyze changes in physical activity, sedentary time, sleep-related parameters, anxiety, mood, and perceived health in different groups of Spanish university students from the pre-pandemic period to one-year post-home confinement. Additionally, cross-sectional relationships between physical activity and sedentary time parameters, and sleep-related parameters, anxiety, mood, and perceived health were analyzed in each period. Our hypotheses are: a) disruptions in PA, sedentary behavior, sleep, anxiety, mood, and perceived health occurred during home-confinement, b) these changes did not recover one year later, c) changes were not equal between genders, BMI categories, academic degree, and branch of knowledge groups, and d) higher levels of PA and lower sedentary behavior were associated with better sleep and mental health throughout the pandemic.

2. Materials and methods

2.1. Design

This was a longitudinal study (Clinicaltrials.gov, NCT04361019) analyzing changes in PA, sedentary behavior, sleep, anxiety, mood, and perceived health in Spanish university students during the COVID-19 pandemic. Data were collected via two online surveys sent at two time points: 1) during home confinement (April 16–May 2, 2020) [47] and 2) one year after the home-confinement period (April 19–May 2, 2021) [48]. The first survey asked about these parameters before and during home confinement, and the second survey collected the same information one year after home confinement. Full versions of both questionnaires are included as supplementary files. Data from the first survey on PA and sedentary behavior have already been published [14].

2.2. Participants

The only inclusion criterion was to be enrolled in a Spanish university in the 2019–2020 academic year. Students over the age of 55 were excluded because they take courses without exams. In addition, they are not as concerned about their future careers as younger students, since many of them are already retired. Consequently, the suspension of face-to-face classes and uncertainty regarding exams and professional futures could affect mental health and sleep differently for students over 55.

Before completing the survey, all participants provided informed consent. The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the Ethics Committee for Human Beings of the University of the Basque Country (M10_2020_078).

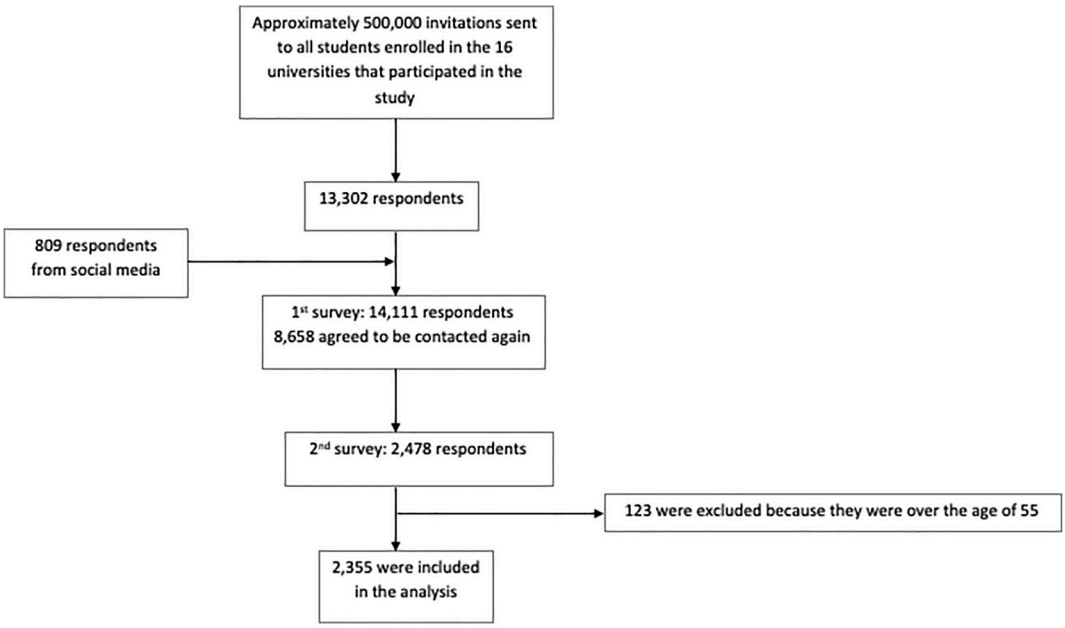

Fig. 1. Flow chart illustrating the number of university students who were contacted and responded to each survey.

2.3. Procedure

In April 2020, participants were recruited via an invitation distributed by email through administrative channels to all students enrolled at the 16 universities participating in the study. In this email, the students were provided a link to the first survey. Additionally, the survey was disseminated via social media (Twitter, Facebook, and Instagram). The link to the second survey was emailed to participants who had agreed to be contacted again in the first one, regardless of whether they were still enrolled at the university. To protect against bots, students had to solve some calculations before entering the survey. The results collected from the survey website were transferred to a Microsoft Excel file. Fig. 1 shows the number of students who were contacted and responded to each survey.

2.4. Survey

2.4.1. Sociodemographic, academic, and anthropometric data

Data were collected on gender, age, academic degree, place of residence, and self-reported height and weight.

2.4.2. Physical activity and sedentary time

Time spent per week on moderate physical activity (MPA), vigorous physical activity (VPA), and walking and sedentary time were assessed using the International Physical Activity Questionnaire-Short Form (IPAQ-SF), which has been previously validated among Spanish university students [49].

2.4.3. Sleep

The fourth item of the Spanish validated Pittsburgh Sleep Quality Index was used to measure sleep time (hours/night), while the sixth item measured sleep quality [50]. To define sleep quality, participants chose from four responses: "very good," "good," "bad," and "very bad." These responses were subsequently categorized into two groups: good (including good and very good) and bad (including bad and very bad).

2.4.4. Anxiety and mood

Levels of self-reported anxiety were measured with a single question [51]. The response options were "higher," "same," or "lower" than before home confinement. Levels of self-reported mood were measured in the same way. The response options were "worse," "same," or "better" than before home confinement [51]. For both parameters, responses were converted to 0, 1, and 2, respectively, to enable statistical analysis of changes over time.

2.4.5. Perceived health

Perceived health was assessed using an 11-point Likert scale (0 = "worst imaginable," 10 = "best imaginable") from the Visual Analogical Scale of the Spanish-validated EuroQoL-5D (EQ-5D) questionnaire [52], adapted for online assessment.

2.5. Statistical analysis

Quantitative variables were expressed as means and standard deviations. Distributions were tested for normality using the Kolmogorov–Smirnov test. Non-normally distributed data were square root-transformed for statistical analysis. Categorical variables were expressed as numbers and percentages. Categorical parameters with three response options (i.e., anxiety and mood) were converted into numbers for longitudinal comparison. The following statistical tests were performed, segmenting participants by gender, body mass index (BMI), academic degree, and branch of knowledge. A repeated measures ANOVA test was used to compare quantitative data before, during, and one year after confinement for each gender. Bonferroni's post-hoc test was used to analyze differences between specific time periods. The Wilcoxon test was used to compare numbered categories during and one year after home confinement. Changes in the proportions of categorical binary variables between different time points were analyzed using the Cochrane Q test, followed by the McNemar test for pairwise comparisons.

A mixed model (ANCOVA), adjusted for age, region, branch of knowledge, academic degree, and baseline parameter values, was used to compare the evolution of quantitative parameters between women and men over the analyzed period. Differences in quantitative variables between women and men at each time point were analyzed using a Student's t-test for non-related measures. Chi-square tests were used to compare the percentage of women and men in each category. The cross-sectional associations of physical activity parameters and sedentary time with sleep hours, and perceived health pre-, during, and one year post-home confinement were analyzed using linear regressions adjusted for age, gender, region, academic degree, and field of study. The cross-sectional associations between physical activity parameters and sedentary time, and categorized sleep quality, anxiety, and mood was analyzed at each time point using logistic regression, with age, gender, autonomous community, academic degree, and branch of knowledge included as covariates.

For all analyses, the significance level was set at $p < 0.05$. Statistical analysis was performed using IBM SPSS Statistics for Windows, version 24.0 (IBM Corp., Armonk, NY, USA).

3. Results

3.1. Descriptive analysis of participants

Table 1 reports descriptive data of the sample.

3.2. Physical activity and sedentary time

Fig. 2 shows the mean time spent on each intensity of physical activity and sedentary time in women and men. There were significant time-related changes in VPA for both genders ($p < 0.005$) (Fig. 2A). In addition, there were differences between genders in the time spent on VPA during the analyzed periods (period × gender interaction $p < 0.005$), with the time spent on VPA before home confinement higher among men ($p < 0.005$). However, during home confinement, time spent on VPA decreased more in men than women (−14.7%, $p < 0.005$ in women; −31.7%, $p < 0.005$ in men), with no differences between genders in this period ($p > 0.05$). The time spent on VPA continued to decrease to one year after confinement for women (−21.2%, $p < 0.005$), whereas it increased for men (+16.5%, $p < 0.05$). One year after home confinement, this value was again higher for men ($p < 0.005$). Analysis of the entire period revealed decreased time spent on VPA for both genders from pre-confinement to one year after confinement, with a greater decrease in women (−32.8%, $p < 0.005$ for women; −20.4%, $p < 0.005$ for men).

When the data were categorized by BMI, academic degree, or branch of knowledge (Tables 2–4a and b), overall VPA decreased during home confinement compared to pre-confinement levels, and either continued to decrease or remained stable one year post-confinement. The only exception was among sports science students, whose VPA increased at one year post-confinement compared to the home confinement period. However, it did not recover to pre-confinement levels.

Table 1
Descriptive data of university students who completed both surveys (n = 2,355) with a comparison between women and men.

Variable	Women	Men
Age, mean (SD)*	$n = 1651$	$n = 704$
Years	23.3 (5.6)	24.1 (6.6)
BMI, mean (SD)*	$n = 1625$	$n = 697$
kg/m^2	22 (3.1)	23.5 (3.4)
Academic degree, n (%)	$n = 1631$	$n = 700$
Bachelor's degree	1251 (76.7)	499 (71.3)
Master's degree	175 (10.7)	88 (12.6)
PhD	192 (11.8)	109 (15.6)
Other	13 (0.8)	4 (0.6)
Branch of knowledge, n (%)*	$n = 1621$	$n = 696$
Arts and Humanities	159 (9.8)	31 (4.5)
Engineering and Architecture	215 (13.3)	234 (33.6)
Experimental Sciences	157 (9.7)	96 (13.8)
Health Sciences	642 (39.6)	155 (22.3)
Social and Legal Sciences	366 (22.6)	99 (14.2)
Physical Activity and Sports Sciences	82 (5.1)	81 (11.6)
Housing type, n (%)	$n = 1621$	$n = 695$
Apartment in a multi-story building	1117 (68.9)	476 (68.5)
Semi-detached house	253 (15.6)	101 (14.5)
Detached family house	251 (15.5)	118 (17)
Cohabitation at home, n (%)	$n = 1630$	$n = 700$
Parents	401 (24.6)	177 (25.3)
Parents and siblings	724 (44.4)	308 (44)
Partner	153 (9.4)	46 (6.6)
Roommates	191 (11.7)	85 (12.1)
Alone	56 (3.4)	26 (3.7)
Other	105 (6.4)	58 (8.3)
People per dwelling, n (%)	$n = 1628$	$n = 696$
1 person	46 (2.8)	40 (5.7)
2 people	277 (17)	99 (14.2)
3 people	445 (27.3)	193 (27.7)
4 people	631 (38.8)	257 (36.9)
≥ 5 people	229 (14.1)	107 (15.4)
COVID-19-related information		
Diagnosed by a health professional, n (%)	$n = 1653$	$n = 709$
Yes	188 (11.4)	79 (11.1)
Vaccinated, n (%)*	$n = 1654$	$n = 709$
Yes	500 (30.2)	113 (15.9)

*$p < 0.05$, a statistically significant difference (Student's t and χ^2 tests) between women and men. SD, standard deviation.

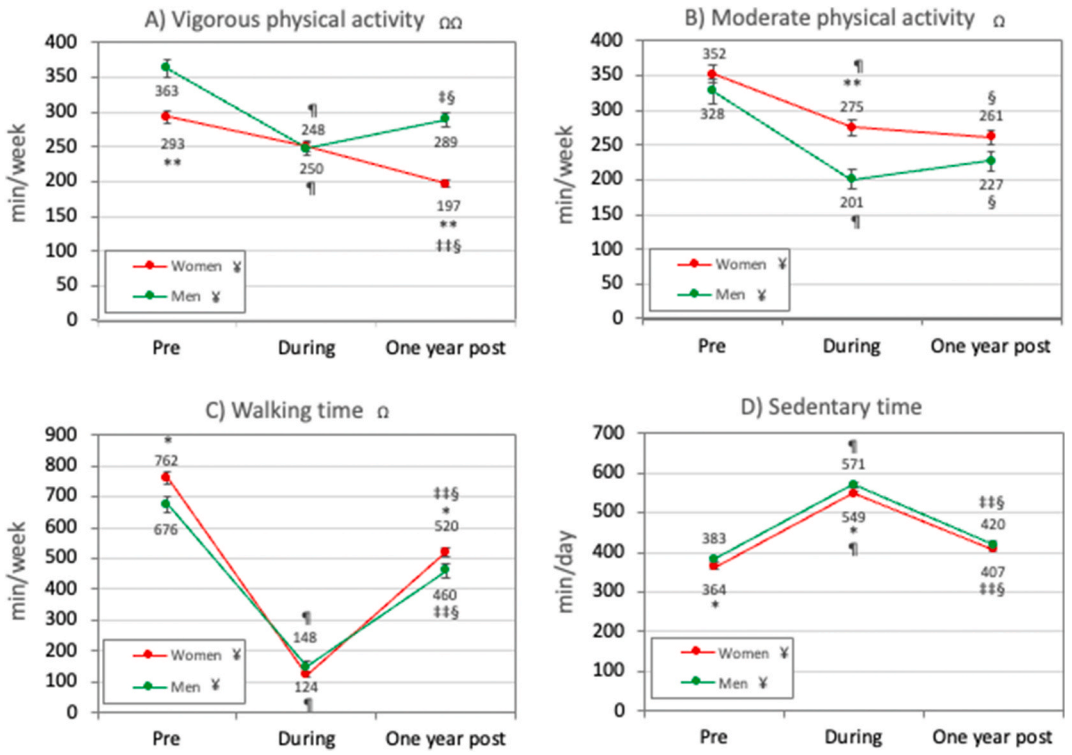

Fig. 2. Participants' self-reported physical activity (A–C) and sedentary time (D) pre-, during, and one year post-confinement in women and men. Vigorous physical activity: women, n = 1623; men, n = 698; Moderate physical activity: women, n = 1603; men, n = 688; Walking time: women, n = 1600; men, n = 694; Sedentary time: women, n = 1639; men, n = 697. Data are shown as mean ± standard deviation. Notes: min, minutes. Ω $p < 0.05$, ΩΩ $p < 0.005$ (period × gender interaction). *$p < 0.05$, **$p < 0.005$ (Student's independent *t*-test) between women and men in each period. ¥ $p < 0.005$ comparisons throughout the analyzed period for each gender (repeated measures ANOVA). ¶$p < 0.005$ (Bonferroni post-hoc test) between, pre- and during confinement. ‡$p < 0.05$, ‡‡$p < 0.005$ (Bonferroni post-hoc test) between during and one year post-confinement. §$p < 0.05$ (Bonferroni post-hoc test) between pre- and one year post-confinement.

Significant changes in MPA occurred in both genders ($p < 0.05$), although there were differences regarding the development of these changes during the analyzed period (period × gender interaction $p < 0.05$) (Fig. 2B). Time spent on MPA did not differ significantly between genders before home confinement ($p > 0.05$). However, during home confinement, it decreased more in men (−38.7%, $p < 0.005$) than in women (−21.9%, $p < 0.005$), with significantly higher values for women ($p < 0.005$). One year post-confinement, the time spent on MPA was not significantly different for either gender compared to the time spent during confinement, with no differences between genders ($p > 0.05$). However, compared with the pre-confinement period, the time spent on MPA was lower one-year post-confinement for both genders (−25.8%, $p < 0.005$ in women; −30.8%, $p < 0.005$ in men).

Categorization based on BMI, academic degree, and branch of knowledge (Tables 2–4a and b) showed similar results. The only exception was among the sports science students, whose MPA increased from the home-confinement period to one year post-confinement (Table 4a and b).

Significant time-related changes occurred in both genders ($p < 0.05$), along with differences between women and men, in walking time over the analyzed periods (period × gender interaction $p < 0.05$) (Fig. 2C). Prior to home confinement, women spent more time walking than men ($p < 0.05$). However, during home confinement, walking time decreased more in women (−83.7%, $p < 0.005$) than in men (−64.6%, $p < 0.005$), with no difference in walking time between genders ($p > 0.05$). One year post-confinement, walking time was higher than during home confinement for both women (+319%, $p < 0.005$) and men (+211%, $p < 0.005$) participants. However, it did not reach pre-confinement levels for either gender (−31.8%, $p < 0.005$ for women, −31.9%, $p < 0.005$ for men). One year post-confinement, walking time was again higher for women than men ($p < 0.05$).

A similar trend was observed among students with different BMI categories, academic degrees, and branches of knowledge. In this analysis, walking time also decreased from before home confinement to during, and increased one-year post confinement without reaching pre-confinement levels (Tables 2–4a and b).

Sedentary time changed significantly during the analyzed period ($p < 0.005$) (Fig. 2D). However, there were no differences between genders (period × gender interaction, $p > 0.05$). Sedentary time was higher in men than in women before and during home confinement ($p < 0.05$). Compared with the pre-confinement period, sedentary time increased for both genders during home confinement (+50.8%, $p < 0.005$ for women; +50%, $p < 0.005$ for men). In contrast, one year post-confinement this parameter was lower in both genders than during confinement (−25.9%, $p < 0.005$ for women; −26.4%, $p < 0.005$ for men). However, sedentary time

Table 2
Participants' reported physical activity, sedentary time, sleep time, and perceived health pre-, during, and one year post-COVID-19 confinement, analyzed by BMI categories.

	Underweight <18.5				Normal weight 18.5–24.9				Overweight 25–29.9				Obesity >30			
Variable	n	Pre	During	Post	n	Pre	During	Post	n	Pre	During	Post	n	Pre	During	Post
IPAQ-SF																
VPA (min/ week)	130*	252 (315)	230 (220)	172 (236)§	1803**	320 (342)	256 (260)¶	230 (259)‡ §	318**	322 (342)	218 (215)¶	221 (248)§	69	246 (325)	249 (374)	175 (201)
MPA (min/ week)	133*	367 (544)	294 (412)	224 (289)§	1778**	335 (497)	251 (410)¶	247 (380)§	311**	381 (486)	229 (344)¶	273 (421)§	68	365 (584)	334 (693)	272 (518)
WT (min/ week)	131**	768 (864)	140 (359)¶	567 (477)‡ §	1779**	727 (732)	131 (363)¶	495 (584)‡ §	314**	794 (906)	136 (379)¶	518 (651)‡ §	69**	666 (718)	99 (201)¶	450 (421)‡
ST (min/day)	134**	381 (171)	555 (205)¶	432 (188)‡ §	1814**	369 (177)	558 (192)¶	409 (189)‡ §	318**	361 (172)	542 (187)¶	403 (195)‡ §	69**	402 (213)	553 (204)¶	448 (200)‡
Sleep (h/day)	132**	7.1 (1)	7.5 (1.6)¶	6.8 (1.1)‡ §	1806**	7.2 (1.1)	7.5 (1.4)¶	6.8 (1.1)‡ §	316**	7.2 (1)	7.3 (1.5)	6.6 (1.2)‡ §	68**	6.9 (1)	6.8 (1.6)	6.2 (1.4)‡ §
Health (0–10)	134**	7.6 (1.4)	6.9 (1.9)¶	6.9 (1.6)§	1816**	7.9 (1.3)	6.9 (1.8)¶	7.2 (1.5)‡ §	324**	7.6 (1.4)	6.7 (1.8)¶	6.7 (1.6)§	71**	6.8 (1.6)	6 (1.7)¶	5.9 (2)§

Notes: Data are presented as mean (SD). IPAQ-SF, International Physical Activity Questionnaire—Short Form; VPA, vigorous physical activity; MPA, moderate physical activity; WT, walking time; ST, sedentary time.
*<0.05 (ANOVA test) changes during the whole study period.
**<0.005 (ANOVA test) changes during the whole study period.
¶<0.05 (post hoc Bonferroni) between pre- and during confinement.
‡<0.05 (post hoc Bonferroni) between during and one year post-confinement.
§<0.05 (post hoc Bonferroni) between pre- and one year post-confinement.

Table 3
Participants' reported physical activity, sedentary time, sleep time, and perceived health pre-, during, and one year post-COVID-19 confinement, analyzed by academic degree.

	Bachelorś degree				Masterś degree				PhD				Other			
Variable	n	Pre	During	Post	n	Pre	During	Post	n	Pre	During	Post	n	Pre	During	Post
IPAQ-SF																
VPA (min/ week)	1752**	318 (344)	257 (260)¶	228 (258)‡ §	263**	307 (348)	229 (220)¶	226 (260)§	299**	301 (319)	219 (269)¶	198 (231)§	14	223 (252)	192 (144)	175 (166)
MPA (min/ week)	1729**	333 (470)	253 (403)¶	261 (410)§	256*	329 (504)	242 (391)¶	221 (339)§	298**	410 (640)	252 (483)¶	205 (258)§	15	369 (376)	283 (257)	220 (117)
WT (min/ week)	1734**	735 (752)	124 (336)¶	502 (579)‡ §	260**	737 (722)	104 (227)¶	545 (722)‡ §	292**	738 (881)	193 (542)¶	461 (480)‡ §	15*	765 (653)	229 (394)¶	384 (291)
ST (min/day)	1766**	362 (175)	554 (192)¶	405 (190)‡ §	260**	383 (178)	559 (200)¶	403 (200)‡	302**	405 (183)	566 (183)¶	450 (181)‡ §	15*	330 (236)	492 (240)¶	398 (161)
Sleep (h/day)	1755**	7.2 (1)	7.5 (1.5)¶	6.7 (1.1)‡ §	261**	7.3 (1.1)	7.5 (1.5)	6.8 (1.1)‡ §	299**	7 (1)	7.3 (1.3)¶	6.7 (1)‡ §	15	7 (0.9)	7.6 (1)	6.9 (0.9)
Health (0–10)	1772**	7.8 (1.4)	6.7 (1.8)¶	7 (1.5)‡ §	264**	7.7 (1.4)	6.9 (1.8)¶	7.1 (1.5)§	302**	7.9 (1.2)	7.1 (1.7)¶	7.2 (1.5)§	15	7.5 (1.5)	7.3 (1.5)	7.1 (1.5)

Notes: Data are presented as mean (SD). IPAQ-SF, International Physical Activity Questionnaire—Short Form; VPA, vigorous physical activity; MPA, moderate physical activity; WT, walking time; ST, sedentary time.
*<0.05 (ANOVA test) during the whole period.
**<0.005 (ANOVA test) during the whole period.
¶<0.05 (post hoc Bonferroni) between pre- and during confinement.
‡<0.05 (post hoc Bonferroni) between during and one year post-confinement.
§<0.05 (post hoc Bonferroni) between pre- and one year post-confinement.

Table 4a
Participants' reported physical activity, sedentary time, sleep time, and perceived health pre-, during, and one year post-COVID-19 confinement, analyzed by branch of knowledge.

	Arts and humanities				Engineering and architecture				Experimental sciences				Health sciences			
Variable	n	Pre	During	Post	n	Pre	During	Post	n	Pre	During	Post	n	Pre	During	Post
IPAQ-SF																
VPA (min/ week)	189**	320 (497)	235 (298)	148 (208)‡ §	448**	294 (292)	225 (226)¶	223 (237)§	252**	317 (336)	247 (214)¶	223 (255)§	797**	297 (312)	253 (263)¶	212 (239)‡ §
MPA (min/ week)	186	392 (643)	313 (610)	303 (568)	444**	273 (383)	181 (240)¶	208 (394)§	249**	275 (406)	194 (304)¶	201 (287)§	786**	318 (449)	259 (413)¶	229 (312)§
WT (min/ week)	189**	788 (894)	152 (364)¶	504 (547)‡ §	446**	624 (598)	95 (246)¶	391 (459)‡ §	248**	769 (680)	123 (253)¶	508 (562)‡§	783**	701 (684)	123 (283)¶	521 (580)‡ §
ST (min/day)	195**	375 (185)	557 (192)¶	432 (194)‡ §	448**	419 (183)	592 (192)¶	486 (183)‡ §	252**	390 (178)	578 (182)¶	439 (177)‡§	799**	357 (171)	541 (189)¶	379 (186)‡ §
Sleep (h/day)	194**	7.5 (1.3)	7.5 (1.6)	6.8 (1.1)‡ §	449**	7.1 (1)	7.4 (1.3)¶	6.7 (1.1)‡ §	252**	7.1 (1.1)	7.4 (1.4)¶	6.7 (1.2)‡§	797**	7.2 (0.9)	7.5 (1.4)¶	6.8 (1)‡ §
Health (0–10)	195**	7.5 (1.6)	6.8 (1.9)¶	6.9 (1.5)§	456**	7.6 (1.4)	6.6 (1.7)¶	7 (1.6)‡ §	254**	7.8 (1.2)	6.9 (1.8)¶	6.9 (1.7)§	801**	8 (1.3)	7.1 (1.7)¶	7.3 (1.4)‡§

Notes: Data are presented as mean (SD). IPAQ-SF, International Physical Activity Questionnaire—Short Form; VPA, vigorous physical activity; MPA, moderate physical activity; WT, walking time; ST, sedentary time.
*<0.05 (ANOVA test) during the whole period.
**<0.005 (ANOVA test) during the whole period.
¶<0.05 (post hoc Bonferroni) between pre- and during confinement.
‡<0.05 (post hoc Bonferroni) between during and one year post-confinement.
§<0.05 (post hoc Bonferroni) between pre- and one year post-confinement.

Table 4b
Participants' reported physical activity, sleep time, and perceived health pre-, during, and one year post-COVID-19 confinement, analyzed by branch of knowledge.

Variable	Social and legal sciences				Physical activity and sports sciences			
	n	Pre	During	One Year Post	n	Pre	During	One Year Post
IPAQ-SF VPA (min/week)	465**	286 (322)	238 (258)¶	207 (258)§	162**	515 (376)	330 (288)¶	421 (323)‡§
MPA (min/week)	460**	369 (506)	294 (432)¶	253 (324)§	160**	589 (651)	277 (304)¶	434 (513)‡§
Walking time (min/week)	464**	780 (885)	147 (427)¶	521 (627)‡§	158**	940 (966)	182 (559)¶	612 (687)‡§
Sedentary time (min/day)	472**	354 (174)	544 (203)¶	403 (189)‡§	162**	313 (154)	530 (175)¶	318 (166)‡
Sleep (h/day)	461**	7.3 (1.2)	7.4 (1.6)	6.8 (1.2)‡§	163**	7.1 (1)	7.3 (1.5)	6.7 (1.1)‡§
Health (0–10)	471**	7.6 (1.4)	6.5 (1.9)¶	6.8 (1.5)‡§	162**	8.1 (1.1)	6.8 (1.8)¶	7.4 (1.5)‡§

Notes: Data are presented as mean (SD). IPAQ-SF, International Physical Activity Questionnaire—Short Form; PA, physical activity. *<0.05 (ANOVA test) during the whole period. **<0.005 (ANOVA test) during the whole period.¶<0.05 (post hoc Bonferroni) between pre- and during confinement. ‡<0.05 (post hoc Bonferroni) between during and one year post-confinement. §<0.05 (post hoc Bonferroni) between pre- and one year post-confinement.

remained elevated one year post-confinement compared with pre-confinement levels (+11.8%, $p < 0.005$ for women; +9.7%, $p < 0.005$ for men).

When the results were categorized by BMI, academic degree, and branch of knowledge, all groups demonstrated similar trends regarding changes in sedentary time, except for the sports sciences students, who had returned to pre-confinement levels by one year post-confinement (Table 4a and b).

3.3. Changes in sleep time and perceived health

Fig. 3 depicts participants' sleep time (3A) and perceived health (3B). There were no significant differences between genders in the trends of the two variables (period × gender interaction, $p > 0.05$). Furthermore, there were no gender differences in sleep time in any of the analyzed periods ($p > 0.05$). Repeated measures ANOVA demonstrated that sleep time changed significantly during the analyzed time periods ($p < 0.005$) in both genders. Participants reported more hours of sleep during the confinement period compared with pre-confinement (+2.8%, $p < 0.005$ for women; +4.2% for men, $p < 0.005$). One year post-confinement, sleep hours had decreased compared to during the confinement period (−8.2%, $p < 0.005$ for women; −10.7%, $p < 0.005$ for men). Compared with pre-confinement values, sleep time was lower one year post-confinement (−5.6%, $p < 0.005$ for women; −6.9%, $p < 0.005$ for men).

Changes in sleep time varied by BMI category and branch of knowledge. For example, students with obesity did not increase their sleep time during the home confinement period and slept fewer hours than students in other BMI categories during and one year post-confinement (Table 2). In addition, sleep time remained stable for arts and humanities students from before to during home confinement (Table 4a and b). Other groups followed the same trend described for women and men.

Men reported better health perception than women ($p < 0.05$) before and one year post-confinement (Fig. 3B). Time-related changes occurred in both genders during the analyzed periods ($p < 0.005$), and health was perceived to be worse during home confinement than pre-confinement (−11.7%, $p < 0.005$ for women; −13.9%, $p < 0.005$ for men). In contrast, these levels had improved one year post-confinement (+2.9%, $p < 0.005$ for women; +5.9%, $p < 0.005$ for men). However, they remained lower than pre-confinement levels (−9.1%, $p < 0.005$ for women; −8.9%, $p < 0.005$ for men).

The same trend was found in students with normal weight (Table 2), undergraduate students (Table 3), and engineering,

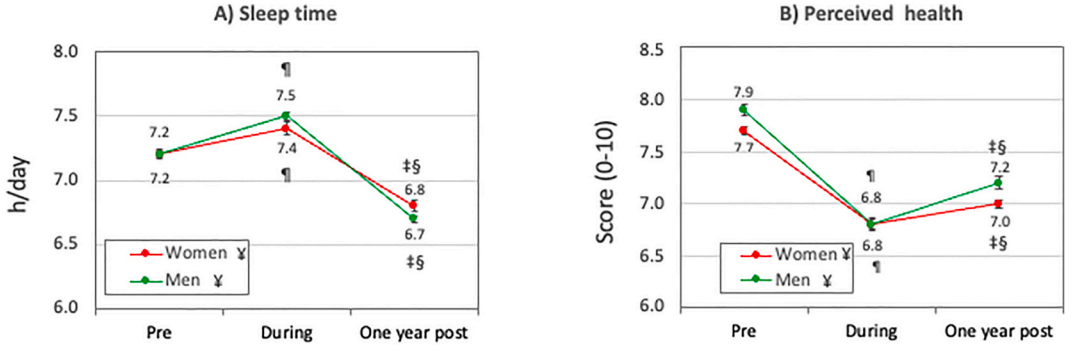

Fig. 3. Participants' reported sleep time (A) and perceived health (B) pre-, during, and one year post-confinement in women and men. Sleep time: women, n = 1630; men, n = 693; Perceived health: women, n = 1642; men, n = 704. Data are shown as mean ± standard deviation. Notes: h, hours. *$p < 0.05$ (Student's independent *t*-test) between women and men in each period. ¥$p < 0.005$ comparisons throughout the analyzed period for each gender (repeated measures ANOVA). ¶$p < 0.005$ (Bonferroni post-hoc test) between pre- and during confinement. ‡$p < 0.005$ (Bonferroni post-hoc test) between, during and one-year post-confinement. §$p < 0.005$ (Bonferroni post-hoc test) between pre- and one year post-confinement.

architecture, and health, social, and sports science students (Table 4a and b). For the other groups, perceived health did not improve significantly from home confinement to one year post-confinement.

3.4. Changes in sleep quality, anxiety, and mood

Changes in the proportions of students of each gender with good and poor sleep quality are shown in Fig. 4. There were no differences between genders in any of the analyzed periods ($p > 0.05$). The profile of changes was similar in women and men ($p < 0.005$). Reported good sleep quality scores decreased during home confinement (−27.3%, $p < 0.005$ for women; −22.1%, $p < 0.005$ for men). In contrast, the proportion of participants reporting good sleep quality increased from during confinement to one year post-confinement (+18.5%, $p < 0.005$ for women; +15.2%, $p < 0.005$ for men). However, the number of participants reporting good sleep quality one year post-confinement remained lower than pre-confinement (−8.8%, $p < 0.005$ for women; −6.9%, $p < 0.005$ for men).

Results categorized by BMI, academic degree, and branch of knowledge (Tables 5–7a and b) showed the same trend. However, in contrast to other categories, the majority of students with obesity (53.5%) reported poor sleep quality during home confinement.

The changes in the percentage of students in each category of anxiety (higher, lower, or the same as pre-confinement) are shown in Fig. 5A. In both genders, those who reported higher anxiety during and one year after confinement than before it outnumbered those who reported the opposite ($p < 0.05$), with more women than men reporting an increase in anxiety ($p < 0.05$). Both genders' anxiety levels improved from during to one year post-confinement. However, only the women' anxiety levels had significantly improved ($p < 0.005$). Similar trends were found when categorized by BMI, academic degree, and branch of knowledge (Tables 5–7a and b).

There were no significant differences in mood (better, worse, or the same as before the home confinement) between genders in either of the time periods examined (Fig. 5B; $p > 0.05$). During and one year after the confinement, both women and men who reported a worse mood than pre-confinement outnumbered those who reported the opposite. Values one year post-confinement were significantly better than during confinement for both genders ($p < 0.005$). The same trend was found when categorized by academic degree or branch of knowledge (Tables 6 and 7a, b). However, in contrast to the other BMI categories, the proportion of students with obesity who reported a worse mood one year post-confinement was greater than the proportion who reported a worse mood during confinement (Table 5).

3.5. Associations between physical activity parameters and sedentary time, and sleep time and perceived health

Table 8 shows cross-sectional linear regressions at given time points between the time spent on various physical activities and being sedentary, and sleep time and perceived health scores. VPA, MPA, and walking time were negatively associated with sleep time one year post-confinement ($p < 0.05$, $p < 0.005$, and $p < 0.005$, respectively). In contrast, higher levels of VPA ($p < 0.005$) and MPA ($p <$

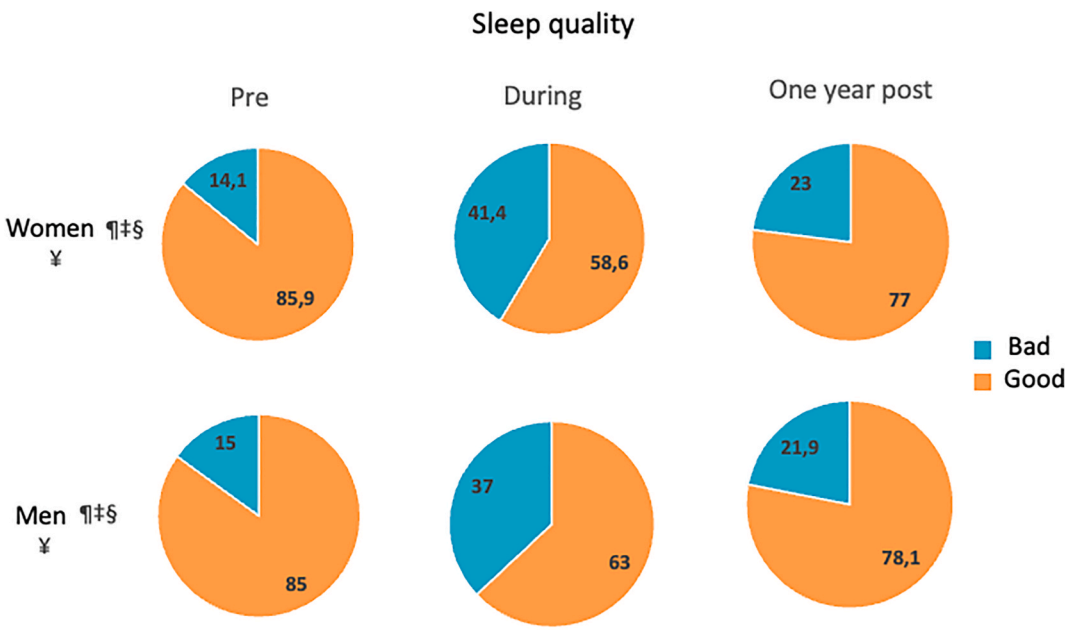

Fig. 4. The proportion of participants with good and poor sleep pre-, during, and one year post-confinement in women (n = 1642) and men (n = 703). ¶$p < 0.05$ (McNemar test) between pre- and during confinement. ‡$p < 0.05$ (McNemar test) between, during and one year post-confinement. §$p < 0.05$ (McNemar test) between pre- and one year post-confinement. ¥ $p < 0.005$ comparisons across the analyzed period for each gender (Cochran's test).

Table 5
Categorized sleep quality, anxiety, and mood, analyzed by BMI categories.

	Underweight <18.5				Normal weight 18.5-24.9				Overweight 25-29.9				Obesity >30			
Variable	n	Pre n (%)	During n (%)	Post n (%)	n	Pre n (%)	During n (%)	Post n (%)	n	Pre n (%)	During n (%)	Post n (%)	n	Pre n (%)	During n (%)	Post n (%)
Sleep quality	133**				1805**				321**				72**			
Good		102 (77.3)	80 (60.6)¶	94 (71.2)		1551 (86)	1104 (61.2)¶	1411 (78.2)‡ §		275 (85.9)	178 (55.6)¶	246 (76.9)‡ §		61 (85.9)	31 (43.7)¶	47 (66.2)‡ §
Bad		30 (22.7)	52 (39.4)	38 (28.8)		253 (14)	700 (38.8)	393 (21.8)		45 (14.1)	142 (44.4)	74 (23.1)		10 (14.1)	40 (56.3)	24 (33.8)
Anxiety	133				1805**				319				72			
Same as pre-confinement			48 (36.4)	49 (37.1)			658 (36.5)	686 (38)			123 (38.7)	111 (34.9)			34 (47.9)	27 (38)
Higher than pre-confinement			66 (50)	62 (47)			962 (53.3)	875 (48.5)			167 (52.5)	165 (51.9)			29 (40.8)	35 (49.3)
Lower than pre-confinement			18 (13.6)	21 (15.9)			184 (10.2)	243 (13.5)			28 (8.8)	42 (13.2)			8 (11.3)	9 (12.7)
Mood	134				1812**				322**				72			
Same as pre-confinement			40 (30.1)	45 (33.8)			682 (37.7)	649 (35.8)			119 (37.1)	116 (36.1)			38 (53.5)	25 (35.2)
Better than pre-confinement			13 (9.8)	20 (15)			111 (6.1)	292 (16.1)			16 (5)	48 (15)			1 (1.4)	11 (15.5)
Worse than pre-confinement			80 (60.1)	68 (51.1)			1018 (56.2)	870 (48.1)			186 (57.9)	157 (48.9)			32 (45.1)	35 (49.3)

**<0.005 (Cochrańs Q for sleep quality and Wilcoxon test for anxiety and mood) during the whole period.
¶<0.05 (McNemar test) between pre- and during confinement.
‡<0.05 (McNemar test) between during and one year post-confinement.
§<0.05 (McNemar test) between pre- and one year post-confinement for sleep quality.

Table 6
Categorized sleep quality, anxiety, and mood, analyzed by academic degree.

	Bachelor's degree				Master's degree				PhD				Others			
Variable	n	Pre n (%)	During n (%)	Post n (%)	n	Pre n (%)	During n (%)	Post n (%)	n	Pre n (%)	During n (%)	Post n (%)	n	Pre n (%)	During n (%)	Post n (%)
Sleep quality	1761**				262**				299**				17			
Good		1501 (85.3)	1038 (59)¶	1352 (76.8)‡§		222 (85.1)	151 (57.9)¶	214 (82)‡		262 (87.9)	197 (66.1)¶	225 (75.5)‡ §		13 (81.3)	13 (81.3)	13 (81.3)
Bad		259 (14.7)	722 (41)	408 (23.2)		39 (14.9)	110 (42.1)	47 (18)		36 (12.1)	101 (33.9)	73 (24.5)		3 (18.8)	3 (18.8)	3 (18.8)
Anxiety	1756**				263				301				17			
Same as pre-confinement			637 (36.3)	634 (36.1)			106 (40.5)	112 (42.7)			116 (38.7)	124 (41.3)			7 (43.8)	6 (37.5)
Higher than pre-confinement			945 (53.8)	883 (50.3)			125 (47.7)	112 (42.7)			151 (50.3)	138 (46)			7 (43.8)	7 (43.8)
Lower than pre-confinement			173 (9.9)	238 (13.6)			31 (11.8)	38 (14.5)			33 (11)	38 (12.7)			2 (12.5)	3 (18.8)
Mood	1767**				263				301**				17			
Same as pre-confinement			654 (37)	624 (35.3)			107 (40.8)	93 (35.5)			115 (38.3)	112 (37.3)			6 (37.5)	6 (37.5)
Better than pre-confinement			111 (6.3)	290 (16.4)			16 (6.1)	40 (15.3)			13 (4.3)	41 (13.7)			1 (6.3)	3 (18.8)
Worse than pre-confinement			1001 (56.7)	852 (48.2)			139 (53.1)	129 (49.2)			172 (57.3)	147 (49)			9 (56.3)	7 (43.8)

**<0.005 (Cochrańs Q for sleep quality and Wilcoxon test for anxiety and mood) during the whole period.
¶<0.05 (McNemar test) between pre- and during confinement.
‡<0.05 (McNemar test) between during and one year post-confinement.
§<0.05 (McNemar test) between pre- and one year post-confinement for sleep quality.

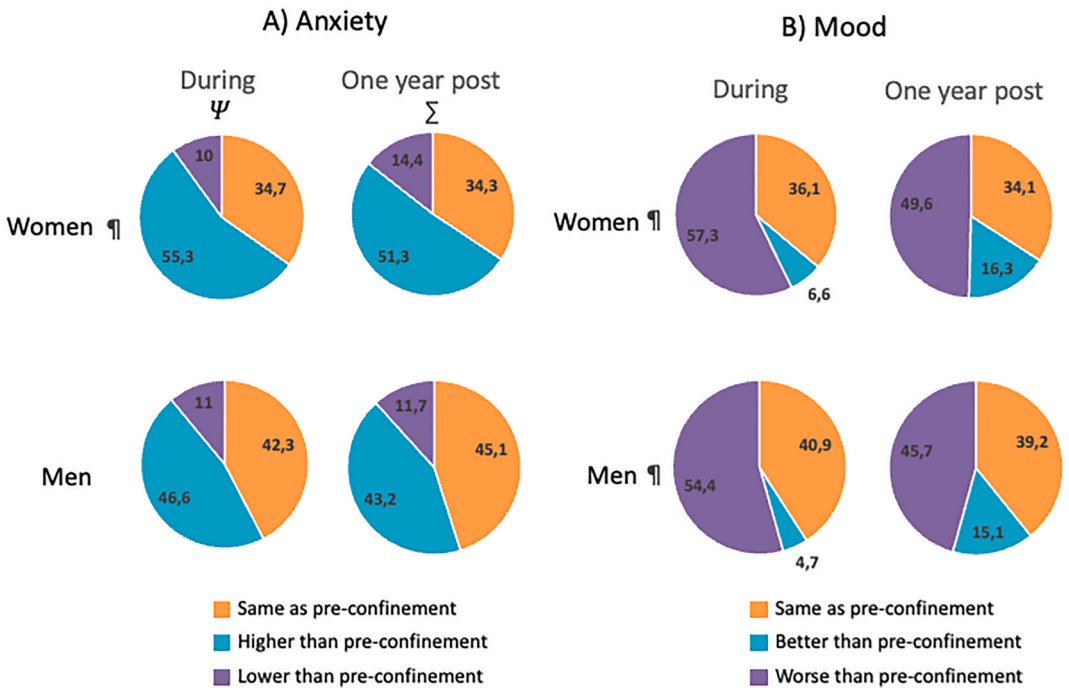

Fig. 5. Participants' anxiety (A) and mood (B) during and one year post-confinement compared to pre-confinement levels women and men. Ψ $p < 0.05$ (χ^2 test) between women and men during confinement. Anxiety: women, n = 1626; men, n = 700; Mood: women, n = 1635; men, n = 702. $\sum p < 0.005$ (χ^2 test) between women and men one year post-confinement. ¶$p < 0.005$ (Wilcoxon test) between during and one year post-confinement in both genders.

0.05) were associated with better perceived health pre- and during home confinement. The same association was found for VPA ($p <$ 0.005) one year post-confinement. Furthermore, sedentary time was negatively associated with perceived health scores at all time points analyzed ($p < 0.005$ and $p < 0.005$, respectively).

3.6. Associations between physical activity parameters and sedentary time and sleep quality, anxiety, and mood

Table 9 shows the β coefficients and odds ratios for the cross-sectional associations of each hour/week increase in physical activity and each hour/day increase in sedentary time with sleep quality, anxiety levels, and mood status pre-, during, and post-confinement. Increased time spent on VPA was positively associated with good sleep quality pre- and post-confinement ($p < 0.05$ and $p < 0.005$, respectively). In contrast, a higher number of sedentary hours was associated with lower sleep quality before, during, and one year after confinement ($p < 0.005$, $p < 0.05$, and $p < 0.005$, respectively). Students who spent more time on VPA had a lower risk of poor mood ($p < 0.005$) during home confinement than pre-confinement, a higher likelihood ($p < 0.05$) of better mood, and a lower risk ($p < 0.05$) of anxiety one year post-confinement compared to pre-confinement. Students with higher levels of MPA during home confinement were less anxious ($p < 0.05$) and had better mood ($p < 0.05$) compared to pre-confinement. One year post-confinement, students who spent more time walking had better mood ($p < 0.05$) compared to pre-confinement. Finally, higher sedentary time during home confinement was positively associated ($p < 0.05$) with worse mood than pre-confinement. A higher sedentary time one year post-confinement was negatively associated with less anxiety ($p < 0.05$) and better mood than pre-confinement ($p < 0.05$).

4. Discussion

The results reported herein supported our hypotheses: a) during home confinement due to the COVID-19 pandemic, university students were less physically active, more sedentary, more anxious, and had poorer perceived health, sleep quality, and mood than before the confinement. b) Overall, these parameters tended to improve one year post-confinement. However, they did not recover to pre-confinement levels. c) The profile of changes differed among different groups of students. Men reduced their physical activity more than women during confinement. In contrast, while men became more active during the year after home confinement, women decreased their VPA during this period. In addition, perceived health and anxiety were worse in women than in men. When the sample was categorized by BMI, academic degree, or branch of knowledge, some exceptions to these trends were found, particularly among students with obesity and those studying sports science. d) Overall, higher VPA and MPA and lower sedentary time were associated with better perceived health, sleep quality, anxiety, and mood scores.

With a few exceptions in specific populations [45], most published studies report that the measures taken to prevent the spread of

Table 7a
Categorized sleep quality, anxiety, and mood, analyzed by branch of knowledge.

	Arts and humanities				Engineering and architecture				Experimental sciences				Health sciences			
Variable	n	Pre n (%)	During n (%)	Post n (%)	n	Pre n (%)	During n (%)	Post n (%)	n	Pre n (%)	During n (%)	Post n (%)	n	Pre n (%)	During n (%)	Post n (%)
Sleep quality	194**				456**				252**				794**			
Good		167 (86.5)	113 (58.5)¶	148 (76.7)‡ §		369 (81.1)	278 (61.1)¶	339 (74.5)‡ §		207 (82.5)	152 (60.6)¶	182 (72.5)‡ §		711 (89.7)	503 (63.4)¶	635 (80.1)‡ §
Bad		26 (13.5)	80 (41.5)	45 (23.3)		86 (18.9)	177 (38.9)	116 (25.5)		44 (17.5)	99 (39.4)	69 (27.5)		82 (10.3)	290 (36.6)	158 (19.9)
Anxiety	192				456				253				795			
Same as pre-confinement			65 (34)	67 (35.1)			188 (41.3)	205 (45.1)			97 (38.5)	84 (33.3)			312 (39.3)	297 (37.4)
Higher than pre-confinement			102 (53.4)	100 (52.4)			217 (47.7)	202 (44.4)			135 (53.6)	131 (52)			401 (50.5)	377 (47.5)
Lower than pre-confinement			24 (12.6)	24 (12.6)			50 (11)	48 (10.5)			20 (7.9)	37 (14.7)			81 (10.2)	120 (15.1)
Mood	194				457**				254**				799**			
Same as pre-confinement			71 (36.8)	62 (32.1)			184 (40.4)	166 (36.4)			93 (36.8)	80 (31.6)			318 (39.8)	302 (37.8)
Better than pre-confinement			18 (9.3)	37 (19.2)			25 (5.5)	67 (14.7)			14 (5.5)	44 (17.4)			47 (5.9)	123 (15.4)
Worse than pre-confinement			104 (53.9)	94 (48.7)			247 (54.2)	223 (48.9)			146 (57.7)	129 (51)			433 (54.3)	373 (46.7)

**<0.005 (Cochrańs Q for sleep quality and Wilcoxon test for anxiety and mood) during the whole period.
¶<0.05 (McNemar test) between pre- and during confinement.
‡<0.05 (McNemar test) between during and one year post-confinement.
§<0.05 (McNemar test) between pre- and one year post-confinement for sleep quality.

Table 7b
Categorized sleep quality, anxiety, and mood, analyzed by branch of knowledge.

Variable	Social and legal sciences				Physical activity and sports sciences			
	n	Pre n (%)	During n (%)	One Year Post n (%)	n	Pre n (%)	During n (%)	One Year Post n (%)
Sleep quality	470**				162**			
Good		391 (83.4)	250 (53.3)¶	353 (75.3)‡§		142 (87.7)	94 (58)¶	137 (84.6)‡
Bad		78 (16.6)	219 (46.7)	116 (24.7)		20 (12.3)	68 (42)	25 (15.4)
Anxiety	471				160			
Same as pre-confinement			149 (31.7)	162 (34.5)			50 (31.4)	57 (35.8)
Higher than pre-confinement			275 (58.5)	247 (52.6)			91 (57.2)	76 (47.8)
Lower than pre-confinement			46 (9.8)	61 (13)			18 (11.3)	26 (16.4)
Mood	471**				163**			
Same as pre-confinement			158 (33.6)	161 (34.3)			53 (32.7)	61 (37.7)
Better than pre-confinement			27 (5.7)	70 (14.9)			9 (5.6)	32 (19.8)
Worse than pre-confinement			285 (60.6)	239 (50.9)			100 (61.7)	69 (42.6)

**<0.005 (Cochran's Q for sleep quality and Wilcoxon test for anxiety and mood) during the whole period. ¶<0.05 (McNemar test) between pre- and during confinement. ‡<0.05 (McNemar test) between during and one year post-confinement. §<0.05 (McNemar test) between pre- and one year post-confinement for sleep quality.

Table 8
Linear regressions between physical activity parameters (predictor variables), sleep time, and perceived health (outcome variables) pre-, during and one year post-confinement.

	Pre		During		Post	
	Sleep	Health	Sleep	Health	Sleep	Health
VPA	n = 2314	n = 2317	n = 2316	n = 2315	n = 2298	n = 2319
Beta	0.013	0.164	−0.032	0.168	−0.041	0.213
p-value	0.535	< 0.005	0.125	< 0.005	< 0.05	< 0.005
MPA	n = 2284	n = 2287	n = 2293	n = 2292	n = 2270	n = 2291
Beta	−0.001	0.054	−0.036	0.055	−0.065	0.036
p-value	0.968	< 0.05	0.088	< 0.05	< 0.005	0.086
WT	n = 2293	n = 2296	n = 2296	n = 2295	n = 2272	n = 2293
Beta	0.006	0.019	−0.038	0.021	−0.064	0.018
p-value	0.762	0.362	0.065	0.304	< 0.05	0.399
ST	n = 2309	n = 2312	n = 2307	n = 2306	n = 2287	n = 2307
Beta	−0.063	−0.109	−0.007	−0.120	−0.019	−0.153
p-value	< 0.05	< 0.005	0.754	< 0.005	0.374	< 0.005

VPA, vigorous physical activity; MPA, moderate physical activity; WT, walking time; ST, sedentary time. All analyses were adjusted for age, gender, region, academic degree, and branch of knowledge.

COVID-19 reduced time spent on physical activity and increased sedentary time [10,11]. At the beginning of the pandemic, Spain had one of the greatest reductions in VPA and MPA [11], possibly due to the especially strict home confinement. Mixed results were found in Spanish university students. While there are studies that reported a decrease in physical activity, including one with objective measures [53], others reported the opposite [45]. However, the small sample size is a major limitation of those studies. Our research, with a larger sample size, suggests that physical activity was reduced during home confinement due to COVID-19 in Spanish university students.

Few longitudinal studies have been published on changes in physical activity during the pandemic [42,54]. Most of them have short follow-up times. For this reason, an important new finding of our study is that Spanish university students' physical activity and sedentary time had not returned to pre-pandemic levels after a one-year follow-up period. The same trend was reported in five cohorts of university students in the United States [44] and in the general population of New Zealand [54]. A cross-sectional study conducted one year after the onset of the pandemic showed that 70% of Polish university students reported that the pandemic had a negative impact on their physical activity [55]. However, in a six-month follow-up of a small sample of French university students, the profile of changes was different, and physical activity levels were higher at the beginning of the pandemic than before, and were reduced thereafter [56]. Notably, unlike in Spain, recreational outdoor PA was not completely banned in France during the first lockdown.

The profile of changes in PA differed between genders. During home confinement, the time spent engaging in VPA and MPA decreased less in women than in men. The same trend was observed in the general population of Spain [57] and in university students from Qatar [58] and Italy [59]. In addition, men spent more time sitting [58] and engaging in leisure-time screen activities than women [60]. Overall, men engage in more outdoor physical activities than women [61,62]. Therefore, men's' PA could be more affected by the prohibition of recreational outdoor activity during home confinement. However, in the current study, VPA had decreased in women but increased slightly in men one year post-confinement. Women were reportedly more fearful of contracting COVID-19 than men, with the fear of infection associated with lower PA [63]. One year after the beginning of the pandemic, most fitness centers had re-opened with restrictions. However, reports of outbreaks at these facilities could result in decreased attendance rates among more cautious individuals. This could explain the decrease in PA reported by women one year after home confinement.

Table 9
Logistic regression (back model) between physical activity parameters and sedentary time (predictor variables), and sleep quality and psychological factors (anxiety and mood; outcome variables) pre-, during and one year post-confinement.

	Pre		During								One Year Post							
	Sleep Quality		Sleep Quality		Anxiety			Mood			Sleep Quality		Anxiety			Mood		
	Bad	Good	Bad	Good	Same as Before	Higher Than Before	Lower Than Before	Same as Before	Worse Than Before	Better Than Before	Bad	Good	Same as Before	Higher Than Before	Lower Than Before	Same as Before	Worse Than Before	Better Than Before
VPA	n = 2334		n = 2315		n = 2307			n = 2304			n = 2319		n = 2316			n = 2318		
Beta	-	0.035	-	0.013	-	-0.010	0.004	-	-0.036	-0.001	-	0.032	-	-0.030	0.027	-	-0.021	0.036
p-value	-	< 0.05	-	0.191	-	0.340	0.793	-	< 0.005	0.961	-	< 0.05	-	< 0.05	0.052	-	0.071	< 0.05
Exp (B)	1 (REF)	1.035	1 (REF)	1.014	1(REF)	0.990	1.004	1(REF)	0.965	0.999	1 (REF)	1.033	1(REF)	0.971	1.027	1(REF)	0.979	1.037
MPA	n = 2305		n = 2292		n = 2284			n = 2281			n = 2291		n = 2288			n = 2290		
Beta	-	0.001	-	-0.004	-	0.015	0.023	-	-0.006	0.020	-	-0.006	-	0.012	0.015	-	0.007	0.015
p-value	-	0.916	-	0.531	-	< 0.05	< 0.05	-	0.371	< 0.05	-	0.419	-	0.115	0.159	-	0.344	0.118
Exp (B)	1 (REF)	1.001	1 (REF)	0.996	1(REF)	1.016	1.023	1(REF)	0.994	1.020	1 (REF)	0.994	1(REF)	1.012	1.015	1(REF)	1.007	1.015
WT	n = 2313		n = 2295		n = 2287			n = 2284			n = 2293		n = 2290			n = 2292		
Beta	-	0.001	-	-0.004	-	0.013	-0.001	-	0.012	0.019	-	< 0.001	-	0.004	0.008	-	-0.003	0.013
p-value	-	0.806	-	0.610	-	0.134	0.959	-	0.171	0.184	-	0.985	-	0.393	0.207	-	0.529	< 0.05
Exp (B)	1 (REF)	1.001	1 (REF)	0.996	1(REF)	1.013	0.999	1(REF)	1.012	1.019	1 (REF)	1	1(REF)	1.004	1.008	1(REF)	0.997	1.013
ST	n = 2329		n = 2306		n = 2299			n = 2296			n = 2307		n = 2304			n = 2306		
Beta	-	-0.091	-	-0.031	-	0.011	0.016	-	0.044	-0.011	-	-0.049	-	0.002	-0.046	-	0.007	-0.044
p-value	-	< 0.005	-	< 0.05	-	0.419	0.480	-	< 0.005	0.692	-	< 0.005	-	0.917	< 0.05	-	0.660	< 0.05
Exp (B)	1 (REF)	0.913	1 (REF)	0.970	1(REF)	1.011	1.016	1(REF)	1.045	0.989	1 (REF)	0.952	1(REF)	1.002	0.955	1(REF)	1.007	0.957

VPA, vigorous physical activity; MPA, moderate physical activity; WT, walking time; ST, sedentary time. All analyses were adjusted for age, gender, region, academic degree, and branch of knowledge.

When the data were analyzed by BMI category, academic degree, or branch of knowledge, the profile of changes in PA was similar to those described for women. Sports science students were the only exception, with increased PA levels one year after home confinement and sedentary time returned to the pre-pandemic level. The specific characteristics of these students regarding their motivation for PA may have encouraged them to be more active than other students after the restrictions were lifted [64].

In our sample, sleep time increased during home confinement, which was in line with the results of previous studies [65], including those performed in Spanish populations [66]. This increase has been associated with later wake-up times [21,67], perhaps because students did not have to get up early to go to campus for classes during home confinement. In contrast, one year post-confinement, sleep time decreased to a level lower than pre-pandemic levels, alongside the partial resumption of face-to-face classes. Students reported poorer sleep quality during confinement compared to pre-pandemic. The same tendency was found in a sample of Spanish adults [66]. However, the sleep of young adults, including university students, seems to have been impacted more than in other populations [20,21] due to their specific characteristics and the external stressors related to the pandemic such as campus closures, lack of contact with friends, or fear of being infected [22]. The poor sleep quality of university students is worrisome, considering the importance of sleep in the transition from adolescence to adulthood [68]. In our study, one year post-confinement, sleep quality had improved but had not reached pre-pandemic levels, which is a novel finding. Students with obesity were particularly affected, showing the greatest decreases in sleep time and quality during the pandemic. These results are not surprising, as the relationship between obesity and poor sleep is well established [69]. However, the further deterioration in sleep quantity during the pandemic in this particular group, even one year post-confinement, is of concern.

The prevalence of anxiety and depression among university students has increased in recent years [27]. Recent studies have reported a dramatic increase in depression and anxiety scores and prevalence among university students at the onset of the pandemic [25,29]. Our results demonstrated a similar trend. A notable new finding of the current study is that although the number of students who reported higher anxiety and lower mood compared to pre-confinement had decreased slightly one year post-confinement, this number still clearly exceeded the number of students who reported the opposite. As reported in other studies of the Spanish population [70,71], women were more affected by anxiety than men during COVID-19 pandemic. Students with obesity were the only group with a higher proportion of participants with more anxiety and lower mood status one year post-confinement than during the confinement period. This trend is concerning due to the bidirectional association between obesity and psychiatric disorders [72], which, in turn, may exacerbate obesity.

The cumulative health effects of simultaneous alterations in several lifestyle behaviors are believed to be greater than the sum of the individual parts [73]. This makes the present study's findings relevant, particularly the changes in lifestyle behaviors and the marked decrease in perceived health during the pandemic. Strikingly, almost all of the analyzed parameters had the same trend, with figures significantly worse one year after the onset of the pandemic compared to pre-pandemic figures. These results are largely consistent with a recent study comparing different cohorts of American university students before and during the pandemic, which concluded that some initial disruptions to lifestyle and mental health documented at the onset of COVID-19 persisted a year later [44].

The results of the current study demonstrated a positive association between VPA and sleep quality and a negative association between sedentary time and sleep quality. A recent systematic review found that physical activity was positively associated with sleep quality from mid-adolescence to early adulthood [74]. Furthermore, regular PA is known to improve sleep quality in different populations of adults [75]. Regarding sleep time, the current study found weak negative associations with VPA, MPA, and time spent walking one year post-confinement. Overall, our results are consistent with those of a recent systematic review that reported a positive association between MVPA and sleep quality and a weak and negative association with sleep time [76].

In the present study, PA was negatively associated with anxiety and positively associated with mood. The opposite was found for sedentary time. PA is known to have a negative association with anxiety symptoms [77] and a positive association with mood. However, studies conducted during the COVID-19 pandemic have reported mixed results. Most studies have reported associations between physical activity [36] or sedentary time [39] and anxiety and mood. However, other studies have that these parameters were not significantly associated [35]. This contradiction could be due to differences in samples size, country, pandemic period, gender ratio, and age. In addition, a cross-sectional study demonstrated that the relationship between PA and mental health during the COVID-19 pandemic was nonlinear [43].

We found positive associations between PA and perceived health before, during, and one year after confinement. However, the opposite was found for time spent on sedentary activities. These results are consistent with a large cross-sectional study that found the same trend among university students in 24 countries before the pandemic [78]. In addition, they are consistent with the known health benefits of PA and the risks of sedentary behavior.

This study has several limitations. First, because the data were collected subjectively through an online survey, students may have overestimated or underestimated some of the analyzed parameters. In addition, although information from the previous seven days was collected in the first questionnaire, information from further back was also requested. Consequently, participants had to remember their habits or feelings before the pandemic, which could have resulted in recall bias. Anxiety and mood were assessed with non-validated instruments, used in the Spanish population during the COVID-19 pandemic [51]. This could have caused information bias. Nevertheless, previous studies have used similar questions, and demonstrated moderate correlations with validated scales [79,80]. In addition, a recent study indicated that utilizing single-item questions can provide an efficient alternative to complete questionnaires, particularly during crises such as the COVID-19 pandemic [81]. The results of the current study cannot be directly generalized to other populations as several parameters, such as age and education level, are not comparable. Furthermore, the restrictions in Spain during the COVID-19 pandemic were not the same as those in other countries. Therefore, these findings cannot be directly extrapolated to other circumstances. Finally, the response rate for the first survey was low, with a high attrition rate from the baseline. Therefore, certain results may be biased because those who participated in the survey may have been more interested in PA

and health.

The main strength of our study is its longitudinal nature, including a one-year follow-up of the same cohort, which is the longest time frame reported for such studies. Following up at exactly one year minimized the possibility of seasonal changes and differences. Furthermore, the population studied is a group of paramount importance for the socioeconomic future of society. In addition, to assess possible differences between men and women, genders were analyzed separately. Moreover, the comparison between BMI categories, academic degrees, and branches of knowledge provides one of the most comprehensive analyses of the long-term effects of the pandemic on PA, sedentary behavior, sleep, and mental health among university students. Finally, despite the high attrition rate, the sample is larger than in the majority of published studies.

5. Conclusions

Spanish university students reported decreased PA, increased sedentary time, and worsened sleep, anxiety, mood, and perceived health during home confinement caused by the COVID-19 pandemic. Overall, these parameters had improved slightly one year post-confinement, but did not return to pre-pandemic levels. The changes were different between genders, with women being more affected in terms of their VPA, anxiety, and perceived health scores one year post-confinement. Overall, higher levels of PA and less sedentary time were associated with better sleep quality, health, and mood, and less anxiety during and one year post-confinement. PA and sleep are key preventatives for common chronic diseases, and could reduce the high prevalence of mental health disorders in university students. Therefore, specific health strategies are needed to help students cope with the negative impact of the pandemic on their lifestyle habits, with particular attention paid to increasing PA, reducing sedentary time, and improving sleep, mood, and anxiety. Further longitudinal studies should be conducted to determine whether COVID-19-related changes persist long-term. In addition, randomized clinical trials should examine the potential benefits of PA on the pandemic-induced worsening of sleep, anxiety, and mood.

Author contribution statement

Julia Garcia-Garcia: Performed the experiments; Analyzed and interpreted the data; Wrote the paper.

Asier Mañas: Marcela Gonzalez-gross: Jonatan R Ruiz: Francisco B Ortega: Jose Antonio Casajus: Performed the experiments; Wrote the paper.

Ander Espin: Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Ignacio Ara: Ana Rodriguez-Larrad: Conceived and designed the experiments; Performed the experiments; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Jon Irazusta: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper. </p>

Data availability statement

Data will be made available on request.

Funding

This research was funded by the High Sports Council (Consejo Superior de Deportes, CSD) of the Ministry of Culture and Sports of the Government of Spain (45/UPB/20 and EXP_75045). EXP_75045 grant was also funded by European Union Next Generation EU/PRTR). A.E. is a recipient of a grant from the Basque Government (Eusko Jaurlaritza), grant number PRE_2019_1_0373.

Additional information

Supplementary content related to this article has been publish online at [URL].

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.

Acknowledgments

We would like to thank the vice-rectorships of our universities for their help in the distribution of the surveys, as well as all students who participated in the surveys.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2023.e19338.

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