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Mental health and movement behaviour during the COVID-19 pandemic in UK university students: Prospective cohort study

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ABSTRACT

Statement of problem: The COVID-19 pandemic is expected to negatively impact the mental health of university students, yet there is lack of prospective longitudinal data quantifying such changes. The purpose of this study was to examine the mental health and movement behaviours, and the associations between the changes in mental health and movement behaviours, of UK university students during the COVID-19 pandemic.
Methods: 214 students enrolled in a longitudinal cohort study (mean age = 20.0 years; males = 28.0%, females = 72.0%) at an East Midlands UK University. Participants completed a self-report, online survey twice before (14/10/2019; T1 and 28/01/2020; T2) and twice during the UK 'lockdown' (20/03/2020; T3 and 27/04/2020; T4). Mental wellbeing, perceived stress, physical activity and sedentary behaviour were assessed at each time point. Repeated measures ANCOVA was used to assess changes in variables over time, whilst Pearson's correlation analysis tested for associations.
Results: During the first 5 weeks of 'lockdown' mental wellbeing and physical activity decreased ((F (2.2, 465.0) = 6.6, P < .0010 and (F (2.7, 591.0) = 4.8, P < .010 respectively)). Meanwhile, perceived stress and time spent sedentary increased ((F (2.5, 536.2) = 94.0, P < .0050 and (F (2.7, 578.9) = 41.2, P < .0001 respectively)). A positive association was found between Δ perceived stress and Δ sedentary behaviour (r = .18, P < .010).
Conclusion: The COVID-19 pandemic is negatively impacting the mental health and movement behaviour of UK university students, though no association between these constructs was identified.

1. Introduction

The impact of the COVID-19 pandemic on students' mental health is a concern for higher education institutions across the world. In response to the pandemic, the UK government imposed a nationwide 'lockdown' meaning people were required to stay at home, except for essential activities (i.e. to shop for necessities and exercise outside once per day). Consequently, universities across the nation closed their campuses and moved to remote methods of teaching and assessment, leading many students to leave their term-time residence. These substantial changes to students' living and working arrangements, alongside the difficulties imparted by government enforced movement constraints and social distancing orders, are expected to negatively impact their mental health. Indeed, early findings show that 25% of Chinese college students experienced some level of anxiety during the pandemic, and the risk of suffering from anxiety increased in those living away from their parents (Cao et al., 2020). There is also some indication that, from a mental health perspective, young adults, students, and females may be amongst the most susceptible to the impact of the COVID-19 pandemic (Qiu et al., 2020; Rajkumar, 2020; Wang et al., 2020). In addition, those with a pre-existing mental health condition could be more susceptible to negative emotional responses in the context of COVID-19, resulting relapses or worsening of an existing mental illness (Yao et al., 2020). While these studies justify the concern about the impact of COVID-19 on student mental and physical health, prospective longitudinal studies are required to fully assess the impact.

To inform future practice and policy, an understanding of potential health-related behavioural changes and subsequent alterations in the mental wellbeing of young adults during the COVID-19 pandemic is urgently needed. The WHO suggested that those in isolation "exercise regularly" to safeguard against declines in mental health (World Health Organization, 2020). However, the 'lockdown' measures are expected to

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impair people's capacity to leave home, take part in daily activities and use community resources leading to reduced physical activity levels and increased sedentary behaviour (Hall et al., 2020). This is concerning for higher education institutions as regular exercise reduces the incidence of future depression in adults (Harvey et al., 2018) and may act to reduce depressive symptoms in adolescents and young adults (Bailey et al., 2018). Additionally, highly active people will be forced to undertake a sudden period of detraining due to the 'lockdown', leading to increased risk of injury (Bianco et al., 2016; Paoli & Musumeci, 2020). As a result, there is an emphasis on implementing home-based exercise to mitigate declines in mental and physical health in the context of COVID-19 (Ravalli & Musumeci, 2020). The impact of the COVID-19 'lockdown' measures on physical activity and sedentary behaviour, and possible links to mental health of young adults/university students is yet to be investigated. Thus, the purpose of the present prospective longitudinal study is to investigate changes in mental wellbeing (a component of mental health), stress, physical activity and sedentary behaviour in UK university students prior to Government imposed 'lockdown', in the week one of 'lockdown', and five weeks into the 'lockdown'. Additionally, the study examines the association between mental health and health-related behaviours during the COVID-19 pandemic.

2. Methods

2.1. Participants and study design

Participants were enrolled in the Student Health Study, a longitudinal cohort study that investigates the health and well-being of students at a UK, East Midlands, University. The sample consisted of students from three schools on one campus: School of Science and Technology, School of Arts and Humanities, and the Institute of Education. Initially, all students on the campus (n = 9472) were invited via email to complete the survey in term one (14th October 2019; T1) of the 2019/20 academic year. Of these, 1477 students completed this initial survey and 946 of these agreed to be invited to take part in follow-up surveys. These subsequent surveys occurred at the start of term two (28th January 2020; T2), during the first week of 'lockdown' (20th March 2020; T3) and during the fifth week of lockdown (27th April 2020; T4). Participants who completed three or more assessments including T1 and T4 were included in the study sample (n = 214). Prior to undertaking the survey, participants were informed of the purpose of the study and provided informed consent. All data was pseudo-anonymised and remained confidential throughout the study. Ethical approval was granted by the Science and Technology College Research Ethics Committee of the University.

2.2. Outcomes

The survey contained socio-demographic questions (e.g. gender, age, ethnicity, living arrangements; eight items), a health history question (one item) (Do you suffer from any diagnosed long-term health condition(s)? E.g. depression, anxiety, asthma, joint problems, cancer, diabetes, intestinal problem, cardiac illness.), questions to assess moderate to vigorous physical activity levels (MVPA) using the Exercise Vital Sign (EVS) questionnaire (Coleman et al., 2012), questions surrounding sedentary behaviour (Armstrong & Bull, 2006) (one item) (How much time have you spent sitting or reclining on a typical day in the last month?), and two scales. One, the Warwick-Edinburgh Mental Wellbeing Scale (WEMWBS), assesses mental wellbeing using a 5-point Likert scale (1 = None of the time, 2 = Rarely, 3 = Some of the time, 4 = Often, 5 = All of the time) with an outcome score ranging from 14 to 70, where higher scores indicate greater mental wellbeing. The second, Cohen's Perceived Stress Scale (PSS) (Cohen et al., 1983) examines levels of perceived stress using a 5-point Likert scale (0 = Never, 1 = Almost never, 2 = Sometimes, 3 = Fairly often, 4 = Very often) with an outcome score ranging from 0 to 40, where higher scores indicate greater levels of perceived stress. Both the WEMWBS and PSS have previously been validated in a UK student population (Denovan et al., 2019; Tennant et al., 2007).

2.3. Statistical analysis

As a preliminary analytical step, data were examined for accuracy of data entry and missing values. Little's test was used to determine whether data were missing completely at random (MCAR) throughout the dataset rather than revealing a systematic pattern. Little's test was applied to the entire set of mental wellbeing and perceived stress questionnaires and no differences were identified (respectively $\chi 2 = 7.6$, df = 10.0, P = .66 and $\chi 2 = 10.0$, df = 10.0, P = .44), indicating that these data were MCAR and supporting expectation maximization (EM) imputation. If the percentage of missing data over the four data points were less than 10%, an EM algorithm was used to handle missing values for longitudinal analysis (Nakai & Ke, 2011; Nelwamondo et al., 2007). All data were checked for normality using quantile-quantile (Q-Q) plots. Mental wellbeing and perceived stress were normally distributed, while sedentary behaviour and moderate to vigorous physical activity (MVPA) had a positively skewed distribution. As no widely-accepted non-parametric alternative was available and the sample size was much greater than 30 (Glass et al., 1972; Lumley et al., 2002), repeated measures analyses of covariance (ANCOVA) was used to determine whether mental wellbeing, perceived stress, sedentary behaviour and (MVPA) changed over time, whilst accounting for differences in other differences in other demographic variables. The categorical variables, gender, year of study at university and current mental health condition were used as covariates for each variable. Levene's Test was used to assess homogeneity of variance ($P > .050$), and sphericity was assessed using Mauchly's test ($P > .050$). If sphericity was violated the Greenhouse-Geisser correction was applied. In addition, effect size (Cohen's d) was determined for each variable to quantify the magnitude of change over time using the following parameters: small effect (≥ 0.2), medium effect (≥ 0.5), and large effect (≥ 0.8). Bonferroni post hoc tests were used to determine whether the difference between each pair of times was significant ($P < .050$). T-tests (gender and current mental health condition) and univariate ANOVA (year of study at university) were used to establish if differences were present between groups for each independent variable. Pearson's Product Moment Correlation was used to evaluate the strength of relationship between sedentary behaviour, MVPA, stress and mental wellbeing over the four time points. All data were analysed using the SPSS computer package (SPSS V. 20.0; Chicago, IL).

3. Results

3.1. Socio-demographic

The socio-demographic characteristics of the 214 participants who completed at least three surveys including T1 and T4 are summarized in Table 1. Briefly, most of our sample were 25 years old or younger (87%), with 65% aged 21 and under. The sample was comprised predominantly of females (72%), white people (82%), and those who lived off campus without their parents (69%). The prevalence of a pre-existing self-reported mental health issue was 30% (n = 64). These values are consistent with the data collected from the 1477 students sampled at T1 (supplementary data 1) and, apart from a greater proportion of female respondents, the sample is broadly similar to Higher Education Student Statistics for 2018/2019 and the University Student Mental Health Survey 2020 (24 years old or younger, 69%; female, 57%; white, 75%; pre-existing mental health condition, 26.6%) (Higher Education Statistics Agency, 2020; Pereira et al., 2020).

Table 1
Participant information.

	N (%) or M ± SD
Age (years)	
18	21 (9.8)
19	35 (16.4)
20	47 (22.0)
21	35 (16.4)
22–25	47 (22.0)
26–35	16 (7.5)
35+	13 (6.1)
Gender	
Male	60 (28.0)
Female	154 (72.0)
Ethnicity	
White	176 (82.2)
Mixed	5 (2.3)
Asian	12 (5.6)
Black	9 (4.2)
Other	8 (3.7)
Prefer not to say	4 (1.9)
Height (m)	1.7 ± 0.1
Body Mass (kg)	68.5 ± 15.8
BMI (kg/m^2)	24.1 ± 5.2
Living arrangement (at T1)	
On campus	34 (15.9)
Off campus without parents	148 (69.2)
Off campus with parents	32 (15.0)
Living arrangement (at T4)	
On campus	7 (3.3)
Off campus without parents	93 (43.5)
Off campus with parents	114 (53.3)
University year	
Year 1	58 (27.1)
Year 2	46 (21.5)
Year 3	63 (29.4)
Year 4	29 (13.6)
Other/Not specified	18 (8.4)
Smoking status	
Non-smoker	164 (76.6)
Ex-smoker	16 (7.5)
Occasional smoker	24 (11.2)
Daily smoker	10 (4.7)
Self-reported pre-existing mental health condition	
No mental health condition	150 (70.1)
Any mental health condition	64 (29.9)
Anxiety (Singular)	19 (29.7)
Depression (Singular)	11 (17.2)
Anxiety & Depression	30 (46.9)
OCD	2 (3.1)
Personality disorder	1 (1.6)
Eating disorder	1 (1.6)

Mean (M), Standard deviation (SD), Body mass index (BMI).

3.2. Mental wellbeing, stress, sedentary behaviour, and physical activity changes

Changes in mental wellbeing and stress are displayed in Fig. 1 (A & B). Repeated-measures ANCOVA (main effect) showed significant changes over time for both mental wellbeing, ($P < .0010$) with a medium effect size ($d = .41$) and perceived stress ($P < .0050$) with a medium effect size ($d = .42$). Mental wellbeing was lower at T4 compared to T1, T2 and T3 (Bonferroni post hoc test, $P < .0001$). Perceived stress was higher at T4 compared to T1 and T2 ($P < .0001$), and at T3 compared to T1 and T2 ($P < .0001$). Females had higher perceived stress and lower mental wellbeing but there was no interaction between gender and either variable over time. Similarly, those with a self-reported mental health condition had higher perceived stress and lower mental wellbeing but there was no interaction between the presence of a mental health condition and either variable over time (supplementary data 2).

Changes in sedentary behaviour and MVPA are shown in Fig. 1 (C & D). Repeated-measures ANCOVA showed that time spent sedentary increased significantly ($P < .0001$) with a large effect size ($d = .78$). Sedentary behaviour was greater at T4 compared to T1, T2 and T3 (Bonferroni post hoc test, $P < .0001$), and was greater at T3 compared to T1 ($P < .0001$). No interactions between gender and changes in sedentary behaviour were found, though males tended to spend more time sedentary (supplementary data 2). Similarly, there was no interaction between the presence of a mental health condition (vs no mental health condition) and sedentary behaviour, though those with a pre-existing mental health condition tended to spend more time sedentary (supplementary data 2).

MVPA decreased significantly over time ($P < .010$), however the effect size was trivial ($d = .12$). There was a significant gender interaction, reflecting that MVPA was higher in males at T1 but not at T4, ($P < .050$) (supplementary data 2). Similarly, there was a significant interaction between the presence of an existing mental health condition and MVPA, with MVPA higher in those without a mental health condition (vs with a mental health condition) at T1 but not T4 ($P < .010$) (supplementary data 2). There was no interaction between year of study at university and any outcome variable, and nor were there any differences between the four year groups at any time point for any variable (supplementary data 2).

3.3. Associations between changes in physical activity, sedentary behaviour, mental wellbeing, and stress

Correlations between the changes of the four independent variables are presented in Table 2. There were negative associations between the change in (Δ) perceived stress and Δ mental wellbeing, and between Δ sedentary behaviour and Δ MVPA. Δ sedentary behaviour was positively associated with Δ perceived stress but not with Δ mental wellbeing. No associations were present between Δ MVPA and Δ perceived stress or Δ mental wellbeing.

4. Discussion

4.1. Main findings

This prospective longitudinal study examined the changes in mental wellbeing and movement behaviours in UK university students prior to, and during, the government-imposed lockdown due to the COVID-19 pandemic. The key findings were that the lockdown measures impaired mental wellbeing and physical activity, and that perceived stress and sedentary behaviour both increased during the COVID-19 pandemic. The reduction in mental wellbeing and increase in perceived stress were not related to changes in physical activity, but a weak association was identified between perceived stress and sedentary behaviour. Altogether, the results indicate that mental health and movement behaviour have declined during the COVID-19 pandemic but that these changes are not strongly related to one another.

4.2. Mental health changes

Prior to the COVID-19 outbreak, the mental wellbeing and perceived stress of our sample was consistent with levels previously reported for university students (Denovan et al., 2019; Goodwin et al., 2016). After five weeks of government enforced 'lockdown,' the perceived stress of students increased, indicating a reduced ability to cope with the demands placed upon them, and mental wellbeing was decreased concomitantly. The average decline in mental wellbeing during 'lockdown' was 4 points on the WEMWBS, which exceeds the 3-point change that may indicate a meaningful decline (Maheswaran et al., 2012). These results are concerning to those working in higher education as they demonstrate empirically that student mental health has declined during the pandemic. They add to early cross-sectional data from China, taken during the COVID pandemic, which indicated that large proportions of the public were suffering with symptoms of common mental

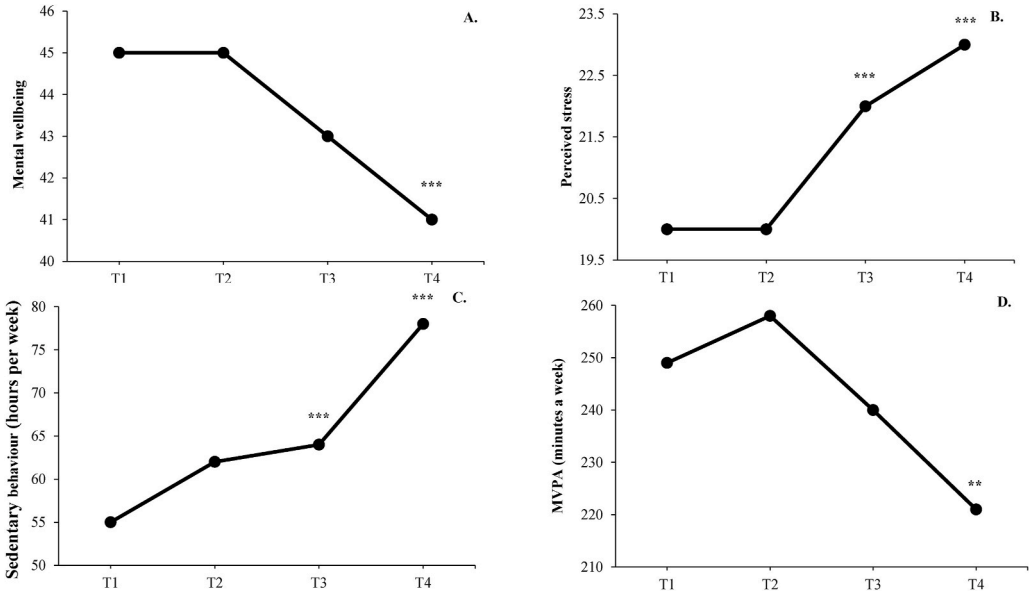

Fig. 1. Changes in variables over time. (A) Mental wellbeing was lower at T4 compared to T1, T2 and T3; (B) Perceived stress was lower at T3 compared to T1 and T2, and at T4 compared to T1 and T2; (C) Sedentary behaviour was greater at T3 compare to T1, and at T4 compared to T1, T2, and T3; (D) MVPA was lower at T4 compared to T2. *** indicates $P < .0001$, ** indicates $P < .0010$.

Table 2
Correlation between Δ mental health and movement behaviour variables.

	1. Δ Mental Wellbeing	2. Δ Perceived Stress	3. Δ Sedentary behaviour	4. Δ MVPA
1. Δ Mental wellbeing	1			
2. Δ Perceived stress	-.602***	1		
3. Δ Sedentary behaviour	-.075	.184**	1	
4. Δ MVPA	.087	-.076	-.276*	1

***P < .0010; **P < .010; *P < .050.

health conditions, such as depression, anxiety, and stress (Wang et al., 2020). However, caution is needed before assigning the changes in mental health directly to the COVID-19 pandemic and associated control measures, as other factors may have influenced mental health over this period. Most notably, previous data indicates that the prevalence of depression and anxiety increases over the academic year and peak around exam time in May (Surtees et al., 2002). Irrespective of the cause, we have shown here that, against the backdrop of already high levels of poor mental health in students (with 30% self-reporting the existence of a mental health condition), over the initial five weeks of the 'lockdown' students' reported lower mental wellbeing and higher perceived stress. The COVID-19 pandemic is set to impact the way students interact with universities for some time to come, and the true extent to which student mental health is affected will remain unknown for a considerable amount of time. Nonetheless, the results of our study highlight an acute reduction in the current mental wellbeing of the student population that requires attention.

4.3. Movement behaviour changes

In response to the COVID-19 pandemic, the government restricted movement and enforced social distancing orders that would inevitably influence movement behaviour. Between the dates of the study, people in the UK were required to stay at home as much as possible and were only allowed to leave once per day for exercise. Despite this, in the current study, average MVPA levels were greater than the recommended guidelines (150 min per week) at all time points. However, during the first five weeks of 'lockdown,' moderate to vigorous physical activity levels of the students decreased on average by 28 min per week. Interestingly, the reduction in physical activity was more pronounced in males than females. Similar findings have been reported in Italy whereby quarantine measures negatively influenced energy expenditure (MET's), particularly in males (Giustino et al., 2020). One of many possible explanations for this result is that males have a greater tendency to report exercising for social and competitive reasons (Markland & Hardy, 1993), whereas females are more likely to report exercising for weight maintenance (McDonald & Thompson, 1992). Perhaps, therefore, the impact of social distancing and cessation of all competitive sports had a greater impact on the desire to exercise in males than females. Over the duration of the study, sedentary behaviour increased by an average of 23 h per week. The impact of this acute increase in sedentary behaviour on physical and mental health should not be overlooked as prolonged periods of uninterrupted sedentary behaviour severely impairs markers of metabolic health, thereby increasing cardiometabolic risk (Saunders et al., 2012). Equally, prolonged periods of uninterrupted sedentary behaviour during leisure time are detrimentally associated with feelings of anxiety and depression (Hallgren et al., 2020; Teychenne et al., 2010, 2015). As such, the negative impacts of the COVID-19 pandemic and subsequent prolonged 'lockdown' and social distancing policies may be felt for years to come.

4.4. Associations between changes in mental health and movement behaviour

The current study identified a decline in mental wellbeing during the COVID-19 pandemic. With this, identifying factors that influence mental health within the current context may play a vital role in informing future interventions. Prior to the COVID-19 outbreak, previous research identified a link between physical activity and feelings of depression in adults (Harvey et al., 2018) and young people (Bailey et al., 2018). In contrast, the current study found no associations between the changes in physical activity and the changes in mental wellbeing and perceived stress. Additionally, no association was observed between sedentary behaviour and mental wellbeing and only a weak association was detected with perceived stress. The results of the current study therefore indicate that movement behaviours did not influence self-reported

mental wellbeing or perceived stress in students, or conversely, that the reduction in mental wellbeing did not influence movement behaviour. In contrast, studies from Italy (Maugeri et al., 2020) and Canada (Lesser & Nienhuis, 2020) conducted during their lockdowns have shown positive associations between physical activity and mental health and wellbeing. However, associations were only observed in those defined as inactive, where participants were highly active no associations were present (Lesser & Nienhuis, 2020). The current findings may therefore be explained by the relatively high physical activity levels of the studied population throughout the 'lockdown' period. Thus, perhaps the reduction in physical activity was not sufficient to impact mental health. Alternatively, the mental health phenotype is complex and influenced by a vast number of factors, any of which may override the impact of movement behaviours within the context of COVID-19. For example, students are currently experiencing a period of extreme uncertainty with altered living arrangements (Cao et al., 2020), university campus closures (Sahu, 2020), fear of infection and transmission (Bao et al., 2020), job losses and financial hardship (Zhai & Du, 2020). In addition, social distancing and self-isolation measures have led to students experiencing isolation in social networks, a lack of social interaction and reduced emotional support thereby reducing mental health (Elmer et al., 2020). All these factors, and many more, are likely to have negatively impacted student's mental health. It is therefore probable that in the context of the COVID-19 pandemic, mental health is being influenced by a complex, multidimensional system in which movement behaviours have a potentially reduced impact.

4.5. Strengths and limitations

The current study is the first to employ prospective, longitudinal design that has enabled the identification of changes in mental health and movement behaviour prior to and during the COVID-19 pandemic. This is an important addition to the body of literature that has identified a high prevalence of poor mental health during the pandemic (Lesser & Nienhuis, 2020; Maugeri et al., 2020; Qiu et al., 2020; Wang et al., 2020) but was unable to identify the extent of any such increase at this time potentially due to the high physical activity levels of the student population despite the lockdown. The present study is not without limitations. The self-reported nature of the survey may lead to inaccuracies in participant responses, with physical activity particularly subject to overestimation when compared to accelerometry (James et al., 2016). However, these inaccuracies were minimised by collecting responses prospectively and using validated survey questions (Denovan et al., 2019; Tennant et al., 2007). Additionally, light PA was not measured and may have increased to partially compensate for the reduction in MVPA. This may be important given that previous literature has indicated an inverse relationship between light PA and depression in older adults (Loprinzi, 2013). However, whether light PA positively influences mental health in young people remains unclear (Pascoe et al., 2020). Additionally, the nature of online survey's and the age of the studied population meant that the rate of dropout attrition from T1 to T4 was high (Eysenbach, 2005; Kelders et al., 2012; Rübsamen et al., 2017). These limitations may lead to concerns about the generalisability of the results however, the demographic characteristics of the final sample are representative of those in the initial sample (Supplementary data 1) and the results of the current study support findings from a student population in China (Cao et al., 2020). Taken together, these data indicate that the mental health issues reported here are likely representative of the wider student population. However, to understand the national/-global impact of the pandemic on student mental health multi-centre investigations are required. Finally, the period of COVID-19 'lockdown' coincided with the weeks leading to students' end-of-year exams, and previous literature indicates depression and anxiety are highest around this time (Surtees et al., 2002). As such, at this time it is not possible to definitively state whether the changes observed are due to the COVID-19 pandemic. However, our data clearly demonstrates impairments in perceived stress and mental wellbeing following the implementation of lockdown measures, indicating these restrictions had an important role.

5. Conclusion

The current study found mental wellbeing and physical activity were both impaired and perceived stress and sedentary behaviour both increased during the COVID-19 pandemic. The reduction in mental wellbeing and increase in perceived stress were not related to changes in physical activity, whereas a weak association was identified between perceived stress and sedentary behaviour. Together, these results indicate that the COVID-19 pandemic is negatively impacting students' mental health and movement behaviours, but that these changes are not strongly related to one another. Our results provide empirical evidence that mental well-being has reduced in students during the pandemic. These findings must be considered by universities when developing policies and interventions to support their students following this difficult time in their academic career.

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Data availability statement

Requests for all data should be submitted to the corresponding author for review. Following consideration, access to anonymised data may be approved.

Authors' contributions

Matthew Savage, Philip Hennis and Ruth James were responsible for study conceptualisation, data collection, data analysis, and drafting of the manuscript. Daniele Magistro contributed to study conceptualisation and led data analysis. James Donaldson contributed to data collection and interpretation. Laura Healy and Mary Nevill contributed to the conceptualisation of the study and data interpretation. All authors read and reviewed the manuscript before approving it for submission.

Compliance with ethical standards

Ethical approval was granted by the Science and Technology College Research Ethics Committee at Nottingham Trent University. The study was performed in accordance with the principles of the Declaration of Helsinki.

Informed consent

Informed consent was obtained from all participants included in the study.

Declaration of competing interest

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

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.

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