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Self-reported physical activity and sedentary behaviour amongst UK university students: a cross-sectional case study

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ABSTRACT

Background: This cross-sectional study investigated self-reported physical activity (PA) and sedentary behaviour amongst UK university students.
Methods: An online survey was completed by 590 students at a higher education institution in the UK to obtain both quantitative and qualitative data on PA levels and experiences, knowledge and adherence to PA guidelines, and sitting time.
Results: Considerable numbers (37%) were estimated to not meet the 150-min moderate-vigorous intensity weekly PA guideline and 56% did not meet strength-based activity guidelines. Just under half (48%) reported experiencing barriers to PA at university, with females, sexual minority students, white ethnicity students, those reporting lower levels of PA, and undergraduate students being more likely to report experiencing barriers. Respondents reported financial reasons, time and stress being the most influential barriers to PA, regardless of demographics. Average reported sitting time on weekdays was 8 h.
Conclusions: The results indicate that a large proportion of our sample of UK university students did not meet PA guidelines, experience barriers to engaging in PA, and demonstrate sedentary behaviour that has been associated with negative health outcomes. The article discusses these findings and practical considerations are offered for personnel working within universities as well as directions for future research.

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KEYWORDS
Physical activity; sedentary behaviours; university students; public health; higher education

Background

The transition from compulsory education to university is often characterised by greater autonomy in decision-making, new social influences and peer networks, increased levels of independence and, for many university students, the requirement to self-manage their overall lifestyle. Research suggests this transition can be accompanied by decreased physical activity levels (Vella-Zarb & Elgar, 2009), increased sedentary behaviours (Castro et al., 2020), disrupted sleep patterns (Russell et al., 2019), sub-optimal dietary behaviours (Tanton et al., 2015), increased body weight (Deforche et al., 2015), elevated alcohol consumption (Wicki et al., 2010), and exposure to multiple stressors unique to this developmental period (Drake et al., 2016). As such, the university setting presents unique risk factors to health and well-being amongst students.

The international recognition of higher educations' responsibility to promote health has been established for well over two-decades, with the notable publishing of the World Health

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Organization's Health Promoting Universities (Tsouros et al., 1998) and the 2015 Okanagan Charter, which both provided case studies, conceptual frameworks, and guidance for the implementation of health promoting initiatives in a higher education setting. More recently, the World Health Organization Global Action Plan of Physical Activity 2018–2030 (World Health Organisation [WHO], 2018) included a specific call to action for higher education institutions to strengthen their implementation of initiatives to 'demonstrate a whole-of-campus approaches to the promotion of physical activity and reduction of sedentary behaviour to all students, staff, and visitors'.

The advocated settings-based approach enables policies and interventions to reach a large proportion of the population. In the academic year 2021/22, a total of 2.86 million individuals were registered at a university in the United Kingdom (UK, hereafter), with 17- to 30-year-old Higher Education Initial Participation Rates surpassing 50% for the first time since 2017/18 (House of Commons Library, 2023). This is significant as it has been suggested that many health-related behaviours and lifestyle factors are established during late adolescence and early adulthood, particularly physical activity behaviours (van Sluijs et al., 2021). The proportion of the UK population attending university, coupled with the unique risk factors research has highlighted, outlines the university setting as important to consider from a public health perspective.

Research outside of the UK setting has highlighted university student populations as potentially at-risk groups for low engagement in physical activity (Clemente et al., 2016; Deforche et al., 2015; Edelmann et al., 2022; Irwin, 2007; Whatnall et al., 2020). Within the UK, the British Active Student Survey (BASS), which is jointly delivered by British Universities and Colleges Sport, Association of Colleges Sport, and UKactive, has collected data on student populations since 2017/2018 (UKActive, 2020). The most recent available report from 2019/2020 collected data on 9,013 students from across 101 higher education institutions. Findings showed that 76% of HE students were deemed as being 'active' (classified as taking part in at least 150 min of moderate intensity physical activity per week), 14% were classified as 'Inactive' (completing under 30 min per week) and 10% classified as fairly active (between 31 and 150 min per week) (UKActive, 2020). Furthermore, the results from a systematic review and meta-analysis suggested that large proportions of university students are also engaging in higher levels of sedentary time compared to the general young adult population and accumulate levels of sedentary time that have been associated with an increased risk for detrimental health outcomes (Castro et al., 2020). The review also suggested that sedentary time amongst university students is on an upward trend. Whilst limited, available data points towards university student populations being an at-risk group for elevated sedentary behaviours.

Whilst physical inactivity is a global issue, there may be barriers to achieving physical activity guidelines that are unique to student populations (Grujičić et al., 2022). Arzu et al. (2006) reported that external barriers were more important than internal barriers amongst a sample of Turkish university students, with 'lack of time due to busy lesson schedule', 'my parents give academic success priority over exercise' and 'lack of time due to responsibilities related to the family and social environment' being the most cited barriers. More recently, Deliens et al. (2015) qualitative study of Belgian university students found that, alongside other factors, specific university characteristics that presented barriers were residency, accommodation environment, university lifestyle, exams, and academic pressure. The 2019/20 BASS data suggested that students reported that they were 'too busy with studies', the 'activity options are too expensive' and they were 'too busy socialising' as the main barriers to physical activity (UKActive, 2020). Available literature suggests it is important to consider the unique barriers to engaging in physical activity that students may face, but there is a dearth of research in this area.

This is an important area as the potential health benefits of engaging in regular physical activity across the lifespan are well established and include social, emotional, mental, and physical elements (Janssen & LeBlanc, 2010). Research is increasingly highlighting the potential effectiveness of physical activity and its effect on mental well-being, with a recent systematic review and meta-analysis concluding that available evidence suggests physical activity interventions may reduce depressive symptoms in children and adolescents (Recchia et al., 2023). Furthermore, another recent

review across adult populations suggested physical activity was beneficial for improving symptoms of depression, anxiety and distress and should be a mainstay approach in the management of depression, anxiety, and psychological distress (Singh et al., 2023). Moreover, the health consequences of physical *inactivity* are also well documented, and it is considered a leading cause of mortality globally through the increased risk of a range of cardiovascular diseases and cancers (Arem et al., 2015; Ekelund et al., 2020).

Taken together, current guidance suggests that higher education setting is a unique space for health promotion and university students may be susceptible to engaging in sub-optimal health behaviours including low physical activity engagement and increased sedentary behaviours due to predominately external barriers. Therefore, it is vital to consider the contextual differences that exist between higher education institutions, as well as the wants and needs of their staff, students, and visitors, in order to scale-up the successful implementation of health promoting initiatives across the higher education sector. With this context in mind, the aims of the current study were to 1) investigate self-reported physical behaviour habits 2) assess the awareness of physical activity guidelines, 3) to compare physical activity and sedentary behaviour levels across demographic groups and 4) obtain self-reported sitting time within in a UK university student population.

Methods

Study setting

The study was conducted at the University of Northampton, UK. This institution is a post-92 university that offers a range of undergraduate and postgraduate degrees. The total on-campus student population at the institution at time of data collection was 12,554. Of these students, the distribution of study is as follows: Stand Alone Module ($n = 225$), Foundation Degrees ($n = 504$), Bachelors ($n = 8{,}442$), Taught Postgraduate ($n = 3{,}136$) and Research Postgraduate ($n = 247$). The current full-time undergraduate student population demographics are predominately female, 66.6% (male, 33.3%), white, 50.9% (Black or Black British, 24.8%; overseas, 11.5%; Asian or Asian British, 5.9%; other/mixed, 5.9%; not known, 1.0%) and report no known disability, 86.3% (other disability, 9.4%; specific learning disability, 4.3%). Full demographic breakdowns of the student population are publicly available at: https://www.northampton.ac.uk/about-us/governance-and-management/key-data-and-reports/staff-and-student-equality-data-reports/student-data/. We report this context as it is important in the interpretation of the results, as well as informing future research at other institutions.

Study design

Cross-sectional exploratory mixed-method study of the student population using a self-report anonymous online survey which obtained quantitative and qualitative data.

Sampling and recruitment strategy

The inclusion criteria for this study were to be an active enrolled student at the university, irrespective of year of study, level, or programme. We utilised a convenience sampling strategy, with the primary recruitment strategy involving email invitations to participate in the study being sent by administrative staff at the university on behalf of the researchers. All programme leaders across the institution were contacted and permission granted to post on their course page within the virtual learning environment which would have students from all levels of study enrolled on. Supplementary File 1 details all programmes where a member of the module team agreed to share the research advert on their course, alongside the total number of students enrolled on each course page. Briefly, 42 programmes leaders agreed to distribute the survey to their course

cohorts, with 5279 students enrolled on these courses collectively. This strategy was supplemented with an advertisement placed in student newsletters by the Student Union. The survey was distributed in Semester 2 of the academic year, between April-June 2023, prior to final assessment periods at the university starting.

The survey was purposefully designed to be neutral in its advertising, using 'Student health and well-being' to advertise to students. This was to reduce bias in skewing responses toward those with prior sporting and/or physical activity interests. Furthermore, upon completion, participants could enter a prize draw to win one of two £100 supermarket vouchers to provide an incentive for participation aside from personal interest in the area of study. Ethical approval was granted by the Faculty of Arts, Science and Technology Research Ethics Committee (Code: 212214).

Survey design

The survey was co-designed by the research team and students at the university. The design phase of the survey involved four workshops with 24 students (six in each group) whereby students completed the survey and feedback was gained to refine each question and ensure the survey topics were important to students. This is due to the wider project seeking to understand and develop student health and well-being strategies *with* students rather than *for* them.

During the workshops, we trialled a range of measures and question wording, gaining student feedback on ease of interpretation, likelihood to respond, and validity of expressing their views on each topic. This survey formed part of a larger project examining student health and well-being (Roberts et al., 2023), with the current paper reporting on physical activity and sedentary behaviour only. The full survey can be viewed via the link provided in the data availability statement.

The survey used a range of validated single and multi-item scales, as well as non-validated specific questions based on previous literature in the areas of interest and feedback from the development phase. In the first section of the survey broader demographic questions were included to differentiate variables for the analysis of responses. These included age, sex, sexuality, ethnicity, year of study, programme of study and current living situation. The following sections provide details on each subsection used in the survey with relevance to this manuscript.

Physical activity

Current physical activity levels were assessed with the single item 'In the past week, on how many days have you done a total of 30 min or more of physical activity, which was enough to raise your breathing rate? This may include sport, exercise and brisk walking or cycling for recreation or to get to and from places but should not include housework or physical activity that is part of your job' (Milton et al., 2013). The scale has demonstrated good validity in comparison to accelerometers (Wanner et al., 2014). For the single-item measure, those reporting 0 days of activity were classified as 'inactive', those reporting between 1 and 4 days were considered 'fairly active', and those reporting ≥5 days were considered 'active' (Milton et al., 2017). These categorisations were used to align with national reporting used in the Active Lives Survey (Sport England, 2022)

The UK guidelines on physical activity for adults recommend ≥150 min of moderate physical activity per week, or 75 min of vigorous physical activity per week, or an equivalent combination of both (GOV.UK, 2019). Typically, researchers and policymakers using the single-item measure estimate that ≥5 days per week (≥30 min per session), will approximate the achievement of physical activity guidelines (American College of Sports Medicine [ACSM], 2022; Centre for Disease Control, 2022; Kahlmeier et al., 2015; Matsudo et al., 2002; National Institute of Health, 2022). However, Bauman and Richards (2022) recently highlighted how the 5 days threshold may underestimate proportions of a population achieving 150 min of moderate-to-vigorous physical activity, mostly because it is possible people are doing more than 30 min of activity on any single day. They suggest

that ≥3 days of 30 min per week should be used to estimate prevalence of meeting the current physical activity guidelines of 150 min per week, which we use for the current study.

The UK guidelines on physical activity for adults also recommend people engage in exercises to increase muscle strength and endurance on ≥2 days per week (GOV.UK, 2019). We therefore asked participants, 'How many days per week, on average, do you engage in exercises to increase muscle strength and endurance (e.g. lifting weights, doing push-ups, using exercise machines)?'.

Respondents were also asked a range of closed and open text questions. Awareness of UK government guidelines for physical activity was assessed with a binary 'Yes' or 'No' question. Confidence in their achievement of the guidelines was assessed on a 5-point-likert scale (Extremely confident, Somewhat confident, Neutral, Somewhat not confident, Extremely not confident). Participants were asked if they felt they experienced any barriers to physical activity, with a binary option of 'Yes' or 'No'. Those that reported 'Yes', were then assessed for greater context on the barriers and thus provided a pre-selected list of 18 physical activity barriers commonly reported in the literature (Koh et al., 2022) to rate which they felt related to their experiences, with opportunity to provide open-text response to elaborate. Changes in physical activity behaviours since attending university was first assessed with the question 'Do you feel your physical activity habits have changed since coming to university (e.g. have you been more or less physically active, have you started or stopped any activities)' with a binary 'Yes' or 'No' option provided. Those that reported a change were then asked to select whether the change had been 'Overall positive', 'Neither negative or positive' or 'Overall negative'. An open-text question then asked participants to provide a description of changes to their physical activity habits. Engagement with physical activity provision at the university was assessed by asking participants if they were involved in any sport or recreational activities involving physical activity at the university with a binary 'Yes' or 'No' option provided.

Sedentary behaviour

Sitting time is a common measure of sedentary behaviour (Healy et al., 2011) and was the measure for this study. The 7th item on the International Physical Activity Questionnaire-Short Form (IPAQ-SF) was used, which measures the duration (minutes per day) of time spent sitting on a usual weekday as it has been frequently used in high- and medium-income countries for sedentary behaviour surveillance, including Great Britain (the location of the current study) (Mclaughlin et al., 2020). This single-item includes time spent sitting at a desk, visiting friends, or reading, or sitting or lying down while watching television across various contexts including work, home, or leisure. This measure has demonstrated low-moderate correlations with accelerometer-derived sedentary time (Healy et al., 2011).

Data analysis

Quantitative data were analysed using IBM SPSS Statistics for Windows (Version 28, IBM Corp., Armonk, NY, USA). Categorical responses were summarised using counts and percentages. The analysed responses were summarised for all respondents and then compared across six identified demographical variables: age group, gender, sexual orientation, ethnicity, level of study, and living situation.

Parametric data were compared across demographic groups using independent group t-tests for comparison of two variables or one-way analysis of variance for more than two variables. Non-parametric data were analysed using median tests, with Bonferroni corrections for multiple comparisons. Chi-squared tests were used to compare the distribution of categorical responses to the questions across the demographic variables. When any individual cell values in a dichotomous cross-tabulation (both variables having binary outcomes) were below 5 then a Fisher's exact test was used. For cells with counts less than 5 in a non-dichotomous cross-tabulation, chi-squared exact

significance (Fisher-Freeman-Halton exact test) was calculated where possible (if the maximum time limits for iterations of 5 min was not exceeded). If this was not possible, the categories were combined and recoded to produce greater cell values in fewer cells. All statistical tests were conducted using a two-sided significance level of 5% ($p < 0.05$).

Qualitative data from responses to open field questions were collated together and coded into key categories using qualitative content analysis. A directed, deductive, approach to content analysis (Hsieh & Shannon, 2005) was used whereby analysis was guided by previous literature and the quantitative findings. The key categories from this analysis are presented alongside the quantitative data in the form of direct quotation.

Results

The survey was initially accessed by 591 individuals. There was a total of 590 respondents who provided informed consent and valid responses to the survey, with 1 response removed for not providing informed consent. This sample represents 5% of the total student population at the university ($n = 12,554$). The estimated response rate is 11% based on advertisement to 5,279 students as detailed in our methods and Supplementary File 1. This is estimated as recruitment was also supplemented with an advert in student newsletters for which we cannot confirm numbers recruited

Table 1. Demographic details of respondents.

	Responses	
Self-reported characteristics	*n*	%
Age		
18–24	292	49%
25–34	199	34%
35–44	65	11%
45–54	29	5%
55–64	4	1%
65+	1	0%
Sex		
Female	400	68%
Male	173	29%
Other	14	2%
Prefer not to say	3	1%
Sexual orientation		
Heterosexual	477	81%
Gay, Lesbian, Bi and Other	89	15%
Prefer not to say	24	4%
Ethnicity		
Asian, Asian British, Asian Welsh	182	31%
Black, Black British, Black Welsh, Caribbean or African	158	27%
Mixed or multiple	8	1%
White	230	39%
Other	12	2%
Study commitment		
Full time	576	98%
Part time	14	2%
Level of study		
Undergraduate	339	57%
Postgraduate	242	41%
Other	9	2%
Living situation during term time		
University managed accommodation	110	19%
Private accommodation in Northampton	221	37%
Private accommodation outside of Northampton	122	21%
At home with parents or caregivers	94	16%
Other	43	7%

through this method. The demographic details of responses can be seen in Table 1. The survey took an average of 24 min 17 seconds to complete.

Reported physical activity levels

Self-reported physical activity levels of the total sample were as follows, when the ≥5 days cut-point is used to categorise 'Active' respondents: Fairly Active 61% ($n = 360$), Active 28% ($n = 168$), and Inactive 11% ($n = 62$). There was no difference in the distribution of responses by age, sex, sexual orientation or living situation. Statistically significant differences were observed in the distributions of responses across ethnicity ($\chi^2 = 15.2$, df = 2, $\phi = 0.160$; $p < 0.001$) and level of study ($\chi^2 = 8.6$, df = 2, $\phi = 0.122$, $p = 0.013$), with white students and undergraduates having higher self-reported level of physical activity.

When the cut-point was adjusted to ≥3 days of 30 min of moderate-to-vigorous physical activity (MVPA) to estimate achievement of UK government guidelines for physical activity, 37% ($n = 219$) of the respondents did not meet guidelines, compared to 72% ($n = 422$) for the ≥5 days cut-point. In the sample, 56% ($n = 328$) did not meet the physical activity guideline for engaging in exercises to increase muscle strength and endurance on at least 2 days per week.

Awareness of UK physical activity guidelines

A lack of awareness of UK physical activity guidelines was reported by 55% of respondents. There were no significant differences in the distribution of reported awareness of physical activity guidelines between age groups, sex, or sexual orientation. However, ethnicity ($p < 0.001$), level of study ($\chi^2 = 46.1$, df = 1, $\phi = 0.282$, $p < 0.001$) and living situation ($\chi^2 = 16.1$, df = 4, $\phi c = 0.165$, $p = 0.003$) all showed statistically significant differences in distributions. Respondents were more likely to report that they were not aware of the guidelines if they were ethnicities other than white, studying postgraduate courses, or living in private accommodation.

Confidence in adherence to guidelines

Only those that answered that they were aware of the guidelines were included in this analysis ($n = 264$). Most reported being 'Somewhat confident' ($n = 99$, 38%) or 'Neutral' ($n = 68$, 26%) in meeting physical activity guidelines. Full responses included 'Extremely confident' ($n = 50$, 19%), 'Somewhat not confident' ($n = 32$, 12%) and 'Extremely not confident' ($n = 15$, 6%). There were no significant differences in the distribution of responses by age or living situation. Comparisons of distributions of responses across sex ($p = 0.045$), sexual orientation ($p = 0.001$), ethnicity ($p < 0.001$) and level of study ($p = 0.013$) categories all revealed statistically significant differences. For comparisons showing statistically significant differences in distributions of responses, females were less confident about meeting the guidelines than males, sexual majorities (heterosexuals) were more confident about meeting them than sexual minority (Gay, Lesbian, Bisexual and Other) respondents, ethnicities other than white were more confident than their white counterparts, and postgraduates were more confident than undergraduates.

Perceptions of barriers to physical activity

A total of 306 (52%) students reported feeling there were not any barriers to participation in physical activity. The distributions of responses were not statistically different across age groups or living situations but there were statistically significant differences across sex ($\chi^2 = 4.6$, df = 1, $\phi = 0.090$, $p = 0.031$), sexual orientation groups ($\chi^2 = 8.9$, df = 1, $\phi = 0.125$, $p = 0.003$), ethnicities ($p = 0.001$) and levels of study ($\chi^2 = 9.5$, df = 1, $\phi = 0.127$, $p = 0.002$). Where the difference in distributions were statistically significant, a greater percentage of females, sexual minority students, white

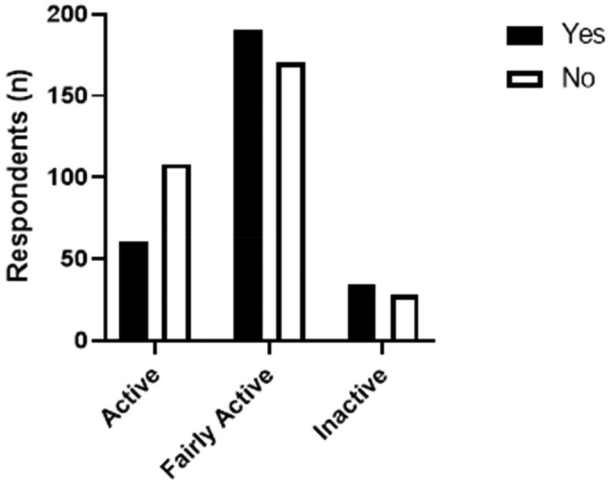

Figure 1. Differences between activity level groups and responses to perception of experiencing barriers to physical activity.

students and undergraduate students perceived barriers to physical activity than their counterparts. Analysis was also run on physical activity level groups (Active, Fairly Active and Inactive), with a significant difference in the distribution of activity levels between those that do and do not report barriers ($\chi^2 = 14.6$, df = 2, $\phi c = 0.157$; $p < 0.001$). The highest percentage of respondents reporting barriers to physical activity were either 'Fairly Active' or 'Inactive' (Figure 1).

Those that reported perceived barriers to physical activity ($n = 284$) selected 'Lack of money' ($n = 154$), 'Feel too tired' ($n = 139$), 'Lack of Time' ($n = 132$) and 'Lack of Motivation' ($n = 123$) as the main barriers to their participation in physical activity. Analysis of open-text responses did not find any specific responses to perceived barriers that related to sex, sexual orientation, ethnicity, or level of study. Time pressures were the most reported factor in preventing engagement with physical activity across all groups. Example responses include:

> With more social commitments I have found less time to exercise, I also thought I'd meet more active people at university which I could exercise with or try new sports, but there are few/lack of platform to network for this reason.

> Course work takes priority studying

> I don't have time to do any

> Due to stress, I hardly have time for physical activities

Some responses also highlighted specific contextual factors within the university which presented a barrier to their participation in physical activity. Examples include:

> I haven't participated in physical activity since coming to university. Mainly because I don't know anyone to go with, scared of feeling left out or not good enough, the societies at university only do competitive sport not recreational and because a student gym membership is very expensive

> For physical activities most students aren't aware about physical activities that you can do in the university and most of all they don't know how to join and will they be accepted by other participants.

It was also highlighted across responses that much physical activity provision was sport focused, which presented a barrier to some:

> Social physical activity that isn't directly linked to a sports team but can be carried out individually as well as socially

> More wellbeing clubs and social sport clubs rather than competitive sport
>
> Non-society based sports as I don't want to hang out with drunk morons

Changes in physical activity habits since starting university

A total of 371 (63%) reported that their physical activity habits had changed since starting university. Of these, the change was described as overall positive (46%), overall negative (36%) and neither positive nor negative (11.5%). Meanwhile, only 9% ($n = 55$) reported being involved in any sport teams or recreational activities involving physical activity at the university. Analysis of open-text responses found that one of the most reported factors in positive changes to physical activity was an increase in walking. Examples include:

> More general walking to and from places rather than being driven
>
> Walking more. Eating healthier and being outdoors more often.
>
> Before coming to UK., I use transportation to 80% of the places I go but since I came to the University I can walk for 40 min at least 3 times in a week

For those reporting a negative change to their physical activity habits, stress was regularly reported as an influential factor on changes deemed negative. Examples include

> Before university I used to exercise frequently but once starting the stress of university work became too much and didn't really leave me time to do anything.
>
> Stress of financial management.
>
> I've become more depressed and lazy due to the stress

Changes in perceptions of available time since starting university was also highlighted, with physical activity being rated lower on priorities for the students. Examples include:

> I stopped working out because of having no time and losing too much sleep over assignments
>
> I'm constantly trying to study more, and I feel like using an hour out of my study time to exercise is a waste as I could've used the time to cover an important topic. When lecturers make you feel you're stupid, you're trying to prove them wrong constantly, so your energy is put into just trying to study and cover as much as possibly can.
>
> I don't go to the gym anymore, I rarely leave the university, I don't go on walks or runs I spend most of my time inside doing work.

Reported sitting time

There were 377 valid responses to the question on estimated sitting time on a typical weekday. The median reported sitting time on weekdays was 8 h (5–10 h). There were no significant differences in the amount of time spent sitting on weekdays across any of the demographic groups. Analysis of open-text responses found that sitting down for lectures and for studying were highlighted as contributing factors for elevated sitting time. Examples include

> They [physical activity habits] have reduced due to sitting down in lectures for long periods of time
>
> Because I am not working I am sitting more and because my course isn't work related there isn't much physical pressure
>
> I have started to go to the gym because university requires a lot of sitting down

Discussion

The aim of this study was to investigate the self-reported physical activity habits, awareness of physical activity guidelines and sedentary behaviour amongst a sample of UK university students within a post-92 university. There is limited research that explores physical activity and sedentary behaviour in university students, particularly in the UK setting. This population is of interest because of the contextual factors and transition students go through which have the potential to impact health-related behaviours and lifestyles, and because it represents a significant proportion of the general population. It is also an important area to study as health-related behaviours can be strongly influenced and established during late adolescence, and often track into adulthood (van Sluijs et al., 2021). There are numerous points of discussion from this data.

Firstly, general reported physical activity levels in this population suggest room for improvement. Only 28% of the sample were classified as 'Active' (≥5 days of 30-min MVPA per week). This shows a considerable difference when compared to UK data using the same classification collected in 2019/2020 for the BASS, which showed 76% were classified as 'Active' (UKActive, 2020). We suggest that this difference may be due to differences in recruitment strategies and the types of students responding between the two studies. In our sample, only 9% reported being involved in any sport teams or recreational activities involving physical activity at university, so it is suggested it may represent a cohort of students that are not actively involved in sport and physical activity at university. This is compared to 17% of the students participating in sport in the BASS sample, and a further 42% using a gym in addition to participating in sport (UKActive, 2020). BASS also reported that 90% of the students surveyed 'agreed or strongly agreed' that they enjoy participating in sport (UKActive, 2020). The recruitment strategy for the BASS is not clear, with it reported that, 'The survey was disseminated through various routes across the project partners. These included press releases, social media channels, FEI and HEI newsletters, strategy groups, staff and volunteers' (UKActive, 2020). It is also not clear on the messaging used to recruit for the survey, which may have biased responses toward students with an investment and/or prior interest in sport and physical activity which would explain the higher overall levels of physical activity reported.

Using the typical cut-point of ≥5 days on the single-item measure used, these data suggested 72% of the sample did not achieve government guidelines of 150 min of MVPA per week. However, due to the measure used in this study having potential to overestimate levels of inactivity (Milton et al., 2017), we also applied Bauman and Richards (2022) suggestion of using ≥3 days per week as the cut-point, allowing room for those that may exercise more than 30 min on a single day. The ≥3 days per week cut-point suggested that 37% of the sample did not achieve the MVAP guideline. We suggest that the true number is likely between these two percentages, which represents a considerable number of the sample. Given previous research on Portuguese university students using accelerometers to obtain device-measured data found that the student population was not sufficiently active (Clemente et al., 2016), we suggest it is likely a high proportion of UK university students do not meet physical activity guidelines, reflecting trends in the general population (Garcia-Hermoso et al., 2023).

The UK guidelines for engaging in strength-based activities on ≥2 days per week were not met by 56% of respondents. The past 50 years have seen a trend of declining muscular fitness levels across western countries, including the UK, in general populations (Dooley et al., 2020). Low muscular fitness levels are associated with the development of non-communicable disease risk in adolescents, which can lead to negative health outcomes in adulthood such as osteoporosis, type 2 diabetes mellitus and cardiovascular disease (Bermejo-Cantarero et al., 2021; J. J. Smith et al., 2014). Furthermore, regular strength-based training in line with government guidelines are associated with a range of positive health outcomes, such as cardiorespiratory fitness (Yu et al., 2016), metabolic function (Bea et al., 2017) and bone health (Torres-Costoso et al., 2020). In recent years, there has also been increasing evidence of strength training having potential benefits on mental health. For

example, a recent randomized controlled trial on young adults suggested an 8-week strength-based programme had a significant effect on reducing mild depressive and anxiety symptoms (O'Sullivan et al., 2023). Notwithstanding the need for more research to understand the mechanisms at play regarding strength training and mental health, overall adherence to strength-based training has the potential to offer a range of health benefits and it is likely considerable proportions of university students are not achieving recommended levels.

Most (55%) of the respondents in the current study reported being unaware of the UK physical activity guidelines. This differs from findings from the BASS 2019/20 data where 43% reported unawareness of the guidelines. More targeted health promotion to university student populations may increase awareness of the physical activity guidelines. Logically, this may affect an increase in physical activity if students' knowledge on the guidelines for achieving optimal health are more widely known. However, this requires further research, and it is important to stress the complexity in health knowledge translating into behaviour changes based on that knowledge. For example, providing education and information about the health risks associated with smoking had limited impact on changing tobacco smokers' behaviour (Heikkinen et al., 2010). Thus, providing information on the health benefits of physical activity and government guidelines would not necessarily translate into changes in behaviour in student populations. Such attempts would need to be underpinned by behaviour change models used within health promotion fields, such as The Physical Activity Messaging Framework (PAMF) and Checklist (PAMC) (Williamson et al., 2021).

Regarding sedentary behaviour, a recent review suggested that large proportions of university students engaged in higher levels of sedentary time compared to the general young adult population and accumulate levels of sedentary time that have been associated with an increased risk for detrimental health outcomes (Castro et al., 2020). The findings from this study agrees with this assertion, with a median reported sitting time of 8 h on weekdays. This is similar to a recent study on a German student cohort, which had an average sitting time of 7 h 25 minutes ($n = 4{,}351$) (Edelmann et al., 2022). Furthermore, the true number is likely higher, as it has been suggested that self-reported sitting time underestimates sedentary time by a relatively large margin when compared with device-measured methods (Zhao et al., 2020). Currently, quantitative sitting time levels have not been quantified and added into public health guidelines (Stamatakis et al., 2019). However, sedentary behaviours including sitting time have been proposed as an 'independent' risk factor for chronic disease (Stamatakis et al., 2019).

The current study suggests the student population had levels of reported sitting times in ranges associated with negative health outcomes. This warrants attention from relevant stakeholders and university management to intervene and promote greater movement within student population. This should be done cautiously, avoiding messaging such as 'Stand up, sit less' and 'Sit less, move more' due to the ableist sentiments, and more inclusive messaging such as 'Move more' should be adopted (B. Smith & Wightman, 2021).

The next point is to highlight the heterogeneity across the data. It was found that white students and undergraduates had a higher self-reported level of physical activity than other groups, and white students were more likely to be aware of the guidelines than those of other ethnicities. Furthermore, females were less confident about meeting the guidelines than males and sexual majorities were more confident about meeting them than sexual minority respondents. In terms of reported barriers to physical activity, there was a greater percentage of females, sexual minority students, white students and undergraduate students reporting perceived barriers to physical activity than their counterparts. Those that reported lower levels of physical activity were also more likely to report barriers to physical activity.

Physical activity occurs in social contexts in which certain groups may experience specific barriers, such as discrimination and exclusion based on social stratifications of race and ethnicity (Bantham et al., 2021), gender (Corr et al., 2019), sexuality (Herrick & Duncan, 2018), socio-economic status and class (Ball, 2015), and disability (Ginis et al., 2021). Based on these data, sexual minorities and females consistently reported less confidence around meeting physical activity guidelines and more

perceived barriers to participation. This reflects findings from a large body of research on experiences of physical activity for these groups (Greenspan et al., 2019; Moreno & Johnston, 2014).

However, there were some inconsistencies that prevent us inferring anything from this data based on ethnicity, for example white students reported being less confident than other ethnicities in meeting guidelines and white students were more likely to report barriers. The main point is that the student population is not homogeneous and individual experiences and relationships to physical activity must be considered. Our data cannot offer explanation for any of these individual differences, and qualitative research is required to investigate these findings further. This understanding of barriers is vital as improving physical activity engagement in inactive populations will incur the greatest relative health benefits. For example, meta-analysis of 47,471 adults demonstrated that there is a negative curvilinear association between step count per day and all-cause mortality, which suggested increasing steps might be beneficial in terms of reducing risk of mortality, particularly among individuals who have lower step volumes (Paluch et al., 2022).

There were, however, more global issues reported across the sample, regardless of demographics. Specific to the university setting, concerns around money, time and stress were highlighted as presenting barriers to engaging in physical activity. This finding supports previous qualitative research on Turkish (Arzu et al., 2006) and Belgian (Deliens et al., 2015) students, as well as 2019/20 BASS data from UK students, which suggested being too busy with studies, activities being too expensive and too busy socialising being the main barriers to physical activity (UK Active, 2020). It is suggested that these external factors are significant determinants of physical inactivity in UK student populations, which can help shape any potential physical activity interventions in the population.

The final point is to highlight that the university setting offers a significant area for public health interventions to focus efforts. Findings from the current study showed that coming to university resulted in changes to physical activity habits in most of the participants (63%). These changes were described as both positive (46%) and negative (36%). This tentatively suggests that the university setting has potential to both promote increased physical activity levels, but also presents unique barriers that influence potentially health-negating behaviours and increased sedentariness. Furthermore, in our sample, only 9% reported being involved in any sport teams or recreational activities involving physical activity at the university. Our qualitative data gave some insight on reasonings for this, with the exclusive nature of sport-based provisions at universities potentially preventing engagement.

Collectively, many health-related behaviours and lifestyle factors are established during late adolescence and early adulthood, particularly physical activity behaviours (van Sluijs et al., 2021), which positions the university setting as a key location for targeted health-promoting interventions which may have wide reaching influence on public health. This data suggests there is room for improvement in the physical activity and sedentary behaviours of UK university students as well as a need for increased attention to understanding the barriers and facilitators for health-promoting behaviours in this cohort.

Strengths and limitations

This study offers an important contribution to the literature on physical activity and sedentary behaviour amongst university students. A notable strength of the study is the large sample size, which represents 4.7% of the university population at the time of data collection. Another strength is the range of programmes represented in the cohort, which ensures a more representative dataset without being restricted to students on programmes with a bias towards the areas investigated.

However, there are limitations associated with the study. Firstly, the cross-sectional design of the study means we only present a snapshot of the areas investigated. Health-related behaviours and self-rated health are complex processes that cannot be fully understood through single time point methods. This is particularly the case in university student populations where there are significant variations throughout the year with assessment periods. This

research is positioned as a starting point, and it is hoped further research using a range of methodologies is conducted to build a better picture of UK university students' physical activity and sedentary behaviours, as well as broader health and well-being. Second, we acknowledge the limitations in using self-reported measures, with social desirability bias and other inaccuracies potentially occurring with this approach. However, our entire surveillance and guideline development is based on such self-report measures. Third, our sample was heavily weighted towards females which reflects the demographics of the university and provides reservations in making any gender-based inferences on the data. Finally, we caution against generalising these results in the total UK university student population. This is because each university has unique contextual factors and differences in student populations (such as sex-distributions), which is why we provided this context in our methods. More research is required across a range of UK universities before any generalised inferences can be made.

Practical considerations

Based on this study, there are practical considerations for stakeholders working within higher education, as well as public health, with an interest in student health and well-being. These are:

- The university setting is influential on physical activity and sedentary behaviours in young adults and warrants investment to promote general public health.
- More students reported being unaware of physical activity guidelines than aware in the current study. Targeted education strategies to student populations *may* improve awareness and adherence to guidelines.
- The student population is not homogenous in experiences with physical activity, thus stakeholders should work with student populations to understand unique challenges and needs that are contextually relevant to the university.
- Provision of physical activity in universities should be diverse, and not reliant on sport-centred opportunities. Further research and university management attention is required to understand provision of physical activity opportunities that may have a wider appeal.
- Money, time, and stress are external factors that have an influence on university students' physical activity and sedentary behaviours. Potential interventions to alleviate these barriers would likely promote increased physical activity and reduced sedentary time amongst student populations.
- Sitting time is likely elevated in university student populations. University management and staff should seek to address this with potential interventions being greater provision of standing desks within student study areas as well as academic staff integrating movement and regular breaks into lecture schedules.

Conclusions

The findings from this study suggest there is much room for improvement in physical activity and sedentary behaviour amongst UK university students. This population faces unique challenges in achieving physical activity guidelines as well as having specific health-related challenges compared to the general population. Future research is required to better understand this area and support the implementation of policies to improve the engagement in physical activity and reductions in sedentary behaviours. In particular, qualitative research using interviews and focus group would be well positioned to provide greater insights to the experiences of university students with regard to physical activity behaviours and aid the development of effective interventions.

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Author contributions

CR, DR and JH were responsible for the conception and design of the project. CR, JC and JH were responsible for the analysis and interpretation of the data. All authors were involved in the drafting of the paper, and revising it critically for intellectual content. All authors provided final approval for the version to be published and agree to be accountable for all aspects of the work.

Consent to participate

All participants provided informed consent prior to any data collection occurring.

Data availability statement

The data that support the findings of this study are openly available in University of Northampton PURE at 10.24339/ed0d11de-790a-4b58k-b523-8421c3eb8eeb

Ethical statement

Ethical approval was granted by the University of Northampton Faculty of Arts, Science and Technology Research Ethics Committee (Code: 212214).

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