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REVIEW ARTICLE

The impact of physical activity levels on mental health and sleep quality in university online students

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Abstract

Aim Online university students face unique challenges that can impact their well-being, including sedentary lifestyles, prolonged screen exposure, and reduced physical activity. These factors have been linked to mental health issues, emphasizing the need to explore the role of physical activity in this specific population. This study aims to examine physical activity levels and the prevalence of mental health disorders, such as burnout, academic stress, sleep quality, and screen time among online university students.

Subject and methods A cross-sectional study was conducted with a sample of 2204 university students (34.66 ± 9.15 years) undertaking an online university course. The students completed various self-report measures to assess life habits (sleep quality and screen time), physical activity levels, and indicators of mental health, including stress, anxiety, depression, and emotional exhaustion.

Results Students who engaged in higher levels of physical activity reported fewer sleep problems and lower screen time on both weekdays and weekends. Also, significant differences were observed in academic stress, generally revealing better mental health outcomes. Gender differences were found in sleep problems, screen time, and depression, indicating that these variables may be influenced differently depending on gender.

Conclusion The findings suggest that physical activity influences sleep quality, screen habits, and six key mental health factors. Additionally, sleep problems, screen time, and depression should be addressed with a gender-specific approach in online education settings.

Keywords Active lifestyles · Higher education · Mental disorders · Physical activity · Screen use habits

Abbreviation

PA Physical activity

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Introduction

In recent years, the online student population has experienced significant growth. According to EUROSTAT (2025), 33% of European Union citizens aged 16–74 participated in at least one online course or used digital learning materials in 2022. The highest participation rates were recorded in Ireland (61%), Finland (53%), Spain (48%), Sweden and the Netherlands (59%), while the lowest were observed in Romania (10%), Bulgaria (17%) and Cyprus (11%). In particular, this study is grounded in Spain, where the latest report from the Ministry of Science, Innovation and Universities (2024) indicates that 18.3% of university students are enrolled in online universities, with sustained growth in recent years.

While virtual environments have facilitated access to education, they have also created new challenges, especially in

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terms of health. Several studies have shown the impact of distance learning on students' mental health, highlighting inadequate time management and lack of effective coping strategies as critical factors (Aditya and Ulya 2021; Di Malta et al. 2022; Wang 2023; Zhytova and Butuzova 2023). Hence, a systematic review on university students found that the prevalence of depressive symptoms reached 33.6%, while anxiety affected 39% of students (Li et al. 2022). Furthermore, it has been shown that daily exposure to screens for more than 3 hours is associated with a higher risk of depression (Agarwal and Agarwal 2022).

In the context of online learning, where academic activities rely heavily on digital devices, sleep disruption has become a growing concern. One study found that college students who spend more time per day in front of a screen are at a higher risk of experiencing lower rates of nighttime sleep quality and quantity (Hjetland et al. 2021). These effects can negatively impact memory, concentration, and academic performance, creating a vicious cycle where sleep deprivation affects productivity and overall well-being (Mason et al. 2021; Mehta 2022). Scientific literature has shown that prolonged use of electronic devices, especially before sleep, can disrupt circadian rhythms due to exposure to blue light emitted by screens (Haghani et al. 2024). This interference in the production of melatonin, the hormone responsible for regulating sleep, can lead to difficulties in falling asleep, reduce the duration of sleep, and affect its quality (Silvani et al. 2022). In contrast, some studies suggest that online learning environments do not necessarily negatively affect sleep or cognitive functions in general. However, they may influence certain aspects of physical activity (PA) and specific cognitive tasks (Haddad et al. 2024). To mitigate these adverse effects, incorporating PA into the daily routine has been shown to be an effective strategy to improve sleep quality and reduce the negative impact of screen time on mental and physical health (Wang and Boros 2021).

Online learning, by its very nature, entails long periods of screen exposure and a sedentary lifestyle, which represents an increasing risk to students' current and future health due to their sedentary behaviors (Musa et al. 2022; Yildiz et al. 2023). Scientific evidence has shown that sedentary habits and insufficient PA are risk factors for the development of non-communicable diseases, cardiovascular conditions, and musculoskeletal disorders (Goyal and Rakhra 2024). On the other hand, sedentary habits have also been linked to an increase in psychological distress, depressive symptoms, and a lower sense of well-being and happiness (Rodríguez-Ayllon et al. 2019). Similarly, a review on the impact of these factors on student well-being indicated that the use of technology and online learning directly influence self-esteem, self-perception, and stress levels (Halupa and Risks 2019). However, the magnitude of these effects varies depending on various institutional characteristics, such as the type of residence, university lifestyle, exam load, and academic pressure (Deliens et al. 2015). In this context, regular PA has been identified as a key factor for the protection of mental health, as it contributes to the prevention of anxiety, depression, and stress (Mahindru et al. 2023). For this reason, the integration of frequent physical exercise, especially short-duration aerobic activities, can significantly benefit the well-being and mental health of university students (Herbert et al. 2020).

The importance of this study lies in its comprehensive approach to the relationship between PA, mental health, and lifestyle habits in students pursuing their studies online. As digital learning becomes established as an educational modality, it is essential to understand how PA levels influence psychological well-being and other key habits, such as sleep quality and screen time. Unlike previous research that has analyzed these factors in isolation, in face-to-face settings, or during exceptional circumstances like the COVID-19 pandemic, this study offers a broader perspective within a normalized online education context. Thus, the objective of this study is to demonstrate the relationship between PA levels and the prevalence of mental disorders, such as burnout, academic stress, sleep quality, and screen time in Spanish online university students. It is hypothesized that those students with higher PA levels experience lower levels of stress and depressive symptoms, better sleep quality, and a greater sense of well-being compared to those who lead a sedentary lifestyle.

The possible conclusions of this study could have significant practical implications for the online university educational context. First, the findings could serve as a basis for the implementation of institutional strategies that promote PA as an essential component in the training of students, promoting active breaks, extracurricular sports activities, and recommendations on healthy habits among their students. Likewise, the results could guide the design of educational policies that seek to balance academic demands with student well-being, integrating interdisciplinary approaches that address mental health and academic performance together. Finally, this study could contribute to raising students'awareness of the importance of PA as a protective factor against the adverse effects of online learning, encouraging the adoption of habits that favor their overall well-being and consequently optimizing their academic performance.

Methods

Participants

A cross-sectional study was conducted using non-probability convenience sampling, recruiting an initial sample of

2480 students. After erasing incomplete questionnaires, a final sample of 2204 Spanish students (1660 women and 544 men) was obtained, with a mean age of 34.66 years old ($SD = 9.15$) and an age range between 18 and 73 years old. The study population included all students enrolled in programs in the Faculties of Education, Law, Health Sciences, and Business and Communication, taught entirely online during the 2023–2024 academic year at the Universidad Internacional de La Rioja (UNIR). To briefly describe the characteristics of the students: 80.9% were working, 8.7% were unemployed, 9.9% were only students, and 0.4% were retired. Besides, 26.2% were living with their parents, 13.9% were living alone, 3.7% were sharing the house with friends and 55.8% were living as a couple. On the other hand, 64% did not have children, 15.3% had one child, 16.3% had two children, 3.8% had three children and 0.6 had four children or more.

Instruments

Physical activity

Assessment of physical activity engagement was conducted through the Spanish version of the International Physical Activity Questionnaire-Short Form (IPAQ-SF), which was validated for use with Spanish university students by Rodríguez-Muñoz et al. (2017). The IPAQ-SF is a self-report form that gathers data on the number of days per week and minutes per day spent engaged in PA, in accordance with four levels of intensity: sedentary, walking, moderate (e.g., recreational cycling) and vigorous (e.g., running or doing aerobics). Total weekly PA engagement is expressed in terms of weekly metabolic energy expenditure (MET), which is calculated in the following way: walking MET = 3.3 × (minutes walking) × (days walking during leisure time); moderate METs = 4.0 × (minutes of moderate intensity activity) × (days of moderate activity during leisure time); vigorous METs = 8.0 × (minutes of vigorous intensity activity) × (days of vigorous activity during leisure time). The IPAQ-SF classifies PA levels into three categories: "high" (between 1500 and 3000 MET-minutes/week), "average" (between 600 and 1500 MET-minutes/week), and "low" (less than 600 MET-minutes/week). The Cronbach alpha obtained in the study was 0.73, which reveals its adequacy in measuring PA in this context.

Sleep quality

In order to evaluate sleep habits, the Pittsburgh Sleep Quality Index (PSQI) was employed, which was validated in Spanish populations by Royuela and Macías (1997) (Cronbach $\alpha = 0.81$). This questionnaire measures sleep quality and its possible clinical implications through 19 self-report items. Items are divided into seven components, as follows: subjective sleep quality (one item), sleep latency (two items), sleep duration (one item), sleep efficiency (three items), sleep disturbance (nine items), sleep medication use (one item) and daily dysfunction (two items). Components are rated along a scale that runs from 0 to 3. Summary scores for all components are summed to produce a total score that ranges between zero and 21, with higher values reflecting worse sleep quality. The Cronbach alpha obtained in the present study was 0.62, which is acceptable.

Screen time

In order to assess screen time, the questionnaire created by Vizcaíno et al. (2019) was employed with the aim of quantifying different types of screen use in adults (ICC = 0.50–0.90). This questionnaire comprises 18 items that measure average screen time via five different devices, namely television, devices connected to the television, desktop computer/laptop, smartphone, and tablet. Questionnaire outcomes are expressed as minutes per day on: 1) weekdays (Monday to Friday), 2) weekdays during out-of-work or evening hours (from 18:00 onwards), and 3) weekend days (Saturday and Sunday). For the aim of this study, which was to describe the hours of consumption, the hours of screen time were taken during weeks and weekends.

Mental disorders

For the study of mental disorders, the Depression, Anxiety and Stress Scale (DASS-21) was used, developed by Lovibond and Lovibond, translated into Spanish by Daza et al. (2002) and validated in Spanish university students by Fonseca-Pedrero et al. (2010) (Cronbach $\alpha = 0.90$). This questionnaire assesses the negative emotional state experienced in the previous week through 21 items on a four-point Likert scale, ranging from 0 ("it has not happened to me") to 3 ("it has happened to me a lot or most of the time"). The instrument is made up of three subscales of seven items each, which measure depression, anxiety, and stress. To make the results of the DASS-21 comparable with those of the DASS-42, the sum of the scores obtained in each subscale is multiplied by two. In this study, the Cronbach's alphas worked out revealed adequate values: stress ($\alpha = 0.89$), anxiety ($\alpha = 0.83$), and depression ($\alpha = 0.89$).

Academic stress

To analyze academic stress, the Academic Stress Questionnaire at University (CEAU) was used, developed and validated in Spanish university students by García-Ros et al. (2012) (Cronbach α from = 0.70 to 0.80). This questionnaire evaluates the level of stress perceived in different

situations in the university context through 21 items, which are answered on a five-option Likert scale, where 1 ="no stress"and 5 ="a lot of stress."The questionnaire is divided into four factors, each with seven items: (1) academic obligations: this assesses the stress associated with completing assignments and exams, as well as lack of time and academic workload, (2) academic record and future prospects: this assesses the stress related to the anticipation of future problematic situations, such as deadlines to finish studies, get good grades, scholarships, or family pressure for good academic performance, (3) interpersonal difficulties: this measures stress generated by conflicts with peers or teachers and academic competitiveness, and (4) expressing one's own ideas: this examines stress linked to the presentation of ideas or work in the presence of peers. Higher values in each dimension indicate a higher level of academic stress. In this study, a general factor of academic stress was computed reaching a Cronbach's alpha of 0.91.

Academic burnout

Academic burnout was assessed using the Spanish version of the Maslach Burnout Inventory–Student Survey (MBI-SS), adapted for Spanish university students by Schaufeli et al. (2002). This instrument measures the degree of exhaustion experienced by students in the academic context using fifteen items on a Likert scale ranging from 0 ("never") to 6 ("always"). The questionnaire is composed of three dimensions: emotional exhaustion, cynicism, and academic efficacy. Academic burnout is interpreted with higher scores on the emotional exhaustion and cynicism dimensions, and with lower scores on the academic efficacy dimension. As such, these last two dimensions were chosen to measure burnout: cynicism ($\alpha = 0.92$) and emotional exhaustion ($\alpha = 0.92$). The Cronbach's alphas obtained in the present study were suitable, which reveals the adequacy of this measure in this context.

Procedure

During the research process, the ethical principles established in the Declaration of Helsinki were respected at all times, and the approval of the Universidad Internacional de La Rioja (UNIR). Research Ethics Committee was also obtained in July 2023. Participants were invited to participate in the study through the University's institutional email, the virtual campus, and mobile messaging, under the coordination and authorization of the Faculties and the Vice-Rectorate for Research. The final instrument was created on the online platform SurveyMonkey, generating a link that was included in said messages, along with information about the purpose of the study and the request for informed consent online prior to accessing the questionnaire. Students responded individually from any device with an Internet connection (mobile phone, tablet, or computer), and responses could be sent from any location, allowing only one response per user. The confidentiality and anonymity of the participants'data were rigorously maintained throughout the research process. Responses were collected between May and June 2024.

Data analysis

The statistical analyses were computed with SPSS Statistics Version 27. First, the descriptive analysis of average, minimum, maximum, frequencies, percentage, and standard deviation were used to describe the sample characteristics. Second, Cronbach's alpha was computed to examine the reliability of the measures taken in the study. Third, to examine the differences in lifestyle habits and mental health variables with regard to PA levels and gender, a multivariate analysis of variance (MANOVA) was worked out. The Partial eta squared ($\eta 2$) was assessed for providing an index of effect size.

Results

Physical activity and daily habits in online university students

Results of MANOVA [Wilk's Lambda = 0.40, F (811.165) = 4.00, $p < 0.001$, $\eta^2 = 0.59$] indicated significant differences across the different levels of PA and the outcomes examined. In addition, it was also evaluated if there were differences depending on gender in lifestyle variables, and the model reported significant differences [Wilk's Lambda = 0.98, F (6.057) = 4.00, $p < 0.00$, $\eta^2 = 0.01$]. In Table 1, results of MANOVAs showed significant differences on sleeping problems and screentime. Furthermore, gender differences were observed in sleep problems, with men reporting higher scores across all levels of physical activity. The association between higher levels of physical activity and fewer sleep problems was more pronounced in women.

Physical activity and mental health in online university students

Results of MANOVA [Wilk's Lambda = 7.00, F (1704.62) = 9.00, $p < 0.001$, $\eta 2 = 0.875$] indicated significant differences across the different levels of PA and the outcomes examined about mental health. In addition, it was also evaluated whether there were differences depending on gender in mental health variables, and the model reported significant differences [Wilk's Lambda = 0.85, F

Table 1 Physical activity and daily habits in online university students

		Low PA ($n=539$)		Average PA ($n=1163$)		High PA ($n=502$)		P Value	Effect size
		M	*SD*	*M*	*SD*	*M*	*SD*		Eta^2
Sleeping problems	All	7.57	3.78	6.60	3.51	6.03	3.56	0.001**	.11
	Women	6.91	3.23	6.18	3.15	5.36	3.00	0.001**	0.07
	Men	7.70	3.86	6.73	3.61	6.35	3.75		
Screen time (weekdays)	All	332.75	195.93	298.95	191.41	269.89	175.53	0.001**	.15
	Women	325.89	178.80	327.48	204.62	280.30	172.02	.145	.001
	Men	334.13	199.33	289.38	185.92	264.93	177.21		
Screen time (weekend)	All	261.89	244.68	198.67	190.54	184.61	174.48	< 0.001**	.06
	Women	234.78	167.24	213.77	196.51	186.11	176.77	.759	0.00
	Men	267.33	257.21	193.61	188.34	183.90	173.58		

** $p < 0.01$

Table 2 Influence of physical activity on academic's aspects, interpersonal difficulties, expressing one's own ideas and mental health variables

		Low PA ($n=539$)		Average PA ($n=1163$)		High PA ($n=502$)		*P* value	Effect size
		M	*SD*	*M*	*SD*	*M*	*SD*		Eta^2
Academic record and future prospects	All	7.64	3.14	6.94	3.04	6.53	2.96	0.001**	.62
	Men	6.76	2.79	6.11	2.83	5.70	2.67	.92	.00
	Women	7.81	3.17	7.21	3.05	6.92	3.00		
Academic obligations	All	25.03	6.60	22.71	7.02	20.89	7.33	0.001**	.67
	Men	22.62	6.20	19.90	7.12	18.61	6.71	.63	.00
	Women	25.51	6.57	23.64	6.73	21.97	7.36		
Interpersonal difficulties	All	5.85	3.20	5.64	3.26	5.15	2.91	0,001**	.62
	Men	5.22	2.40	4.90	2.64	4.58	2.40	.819	.00
	Women	5.97	3.32	5.89	3.40	5.41	3.08		
Expressing one's own ideas	All	14.09	5.00	12.87	5.09	12.20	4.98	0.001**	.65
	Men	12.64	4.85	10.93	4.92	10.80	4.34	.386	.00
	Women	14.38	4.97	13.51	4.97	12.86	5.12		
Stress	All	6.80	4.39	5.85	4.62	4.87	4.39	0.001**	.65
	Men	5.98	3.92	4.41	3.88	3.69	3.70	.282	.001
	Women	6.97	4.46	6.34	4.74	5.43	4.59		
Anxiety	All	3.93	3.90	3.06	3.72	2.48	3.02	0.001**	.61
	Men	3.18	3.18	2.41	2.88	1.59	2.38	.545	.00
	Women	4.08	4.02	3.27	3.93	2.90	3.19		
Depression	All	4.18	4.30	3.39	4.20	2.52	3.37	0.001**	.58
	Men	4.58	4.71	2.99	3.71	1.79	2.91	.036*	.00
	Women	4.10	4.21	3.53	4.34	2.87	3.52		
Cynicism	All	4.18	5.80	3.89	5.93	3.55	5.58	0.001**	.63
	Men	6.00	6.70	4.57	6.46	3.79	5.67	.10	.00
	Women	3.81	5.54	3.65	5.72	3.42	5.53		
Emotional exhaustion	All	16.28	8.10	14.06	8.32	12.39	7.78	0.001**	.64
	Men	16.63	7.89	13.07	8.18	10.14	7.13	.056	.00
	Women	16.81	8.04	14.39	8.34	13.45	7.85		

** $p < 0.01$; * $p < 0.05$

(20.946) = 9.00, $p < 0.001$, η2 = 0.147]. In Table 2, results of MANOVAs showed significant differences in academic stress, stress, anxiety, depression, cynicism, and emotional exhaustion. However, significant differences were observed by gender with regard to depression. Both men and women showed lower levels of depression in the groups with the highest physical activity, although the magnitude of the association was greater in men.

Discussion

The aim of this study is to analyze the relationship between PA, mental health, and healthy habits in online education students, considering factors such as sleep quality, screen use habits, presence of mental disorders, stress, and academic burnout. In addition, it aims to assess the impact of online learning on students'general well-being and to provide updated evidence on the effects of this educational model on physical and mental health. The results indicate that higher PA levels are linked to better mental health and healthier lifestyle habits. In addition, gender differences were identified, suggesting that individual factors may influence this relationship.

The findings of this study provide valuable information for future research, helping to understand better the mechanisms through which PA influences mental health and lifestyle habits in online education environments. Furthermore, these results could be explained by considering the multiple health benefits of PA, such as stress reduction, its protective factor against mental disorders, improved sleep quality, and the promotion of healthy lifestyle habits (World Health Organization 2022). However, in the context of online education, these effects have been less studied, highlighting the need to investigate how PA can moderate the negative effects associated with this educational model, such as time spent on sedentary habits or excessive screen use. Understanding the relationship between PA and mental health will allow for the development of more effective strategies to promote student well-being in the context of online education.

First, with regard to the relationship with lifestyle habits, students with higher PA levels reported a lower incidence of sleep problems. Hence, a systematic review in face-to-face university contexts confirms that higher PA levels are associated with better sleep quality, recording a lower incidence of sleep disturbances (Memon et al. 2021). These findings support the relationship identified in our study in a virtual context, where physically active students reported fewer sleep problems. Wang et al. (2025) showed that high PA levels are associated with better overall sleep quality, as well as higher daytime performance and longer rest duration. In line with this, Kruk et al. (2021) indicates that PA stimulates the production of melatonin, an essential hormone in regulating the sleep–wake cycle. In addition, it promotes the release of endorphins and contributes to the regulation of circadian rhythms and body temperature, the increase and subsequent decrease of which facilitate sleep onset (Ye et al. 2022). In this context, PA has been established as an effective therapeutic and preventive strategy for various sleep disorders (Alnawwar et al. 2023).

Moreover, the results revealed gender differences in sleep quality, as women had more problems than men. Hence, gender differences in sleep quality represent a consistent finding across several studies, highlighting that women tend to report greater sleep difficulties, regardless of their PA level (Gerber et al. 2010; Regestein et al. 2010). During the COVID-19 lockdown, university women were found to have poorer sleep quality despite maintaining PA levels similar to those of men, highlighting the influence of psychosocial and sociodemographic factors on this difference (Bustamante-Ara et al. 2022; Dongol et al. 2023). These findings are partly justified by underlying hormonal differences between the sexes (Mallampalli and Carter 2014). These findings highlight the urgency of designing interventions that promote healthy habits, including sleep improvement, with a sex-differentiated approach to mitigate these disparities and their implications for physical and psychosocial health.

On the other hand, with regard to screen time, students with higher PA levels report less time in front of screens, both on workdays and weekends. This finding is consistent with previous studies that inversely associated PA levels and screen time (Mineshita et al. 2021). Likewise, Piola et al. (2024) identified that the relationship between screen time and factors such as nutritional status and mobile device use is moderated by PA level; in particular, those with low PA levels showed a higher probability of registering for high screen use. On the other hand, Lavados-Romo et al. (2023) found that screen time, especially during the evening and night hours, is negatively associated with sleep quality and with certain aspects of quality of life, such as physical health and social relationships. In this context, PA promotion becomes relevant as a strategy to mitigate the negative effects of excessive use of electronic devices (Ge et al. 2020). Although prolonged exposure to screens can promote sedentary behavior (Musa et al. 2022), PA not only moderates this impact (Kelly et al. 2017) but can also act as a protective factor against excessive screen use.

The results showed significant differences in academic stress, general stress, anxiety, depression, cynicism, and emotional exhaustion, with an association observed between higher levels of physical activity and a more favorable mental health profile. Gender differences were only significant in the depression variable. Although lower depression scores were observed in both sexes in the groups with the highest physical activity, this association was more pronounced in men. Although online education

can negatively affect students'mental and physical health (Agarwal and Agarwal 2022; Pohorilyak et al. 2023), the findings of this study indicate that a higher level of PA is associated with better mental health, highlighting the relevance of this habit for psychological well-being in an academic context. With regard to academic stress, the inverse relationship observed with the level of PA coincides with the findings of Yuan et al. (2022), who identified that regular exercise is associated with a reduction in academic stress. These results highlight the importance of implementing effective strategies to mitigate risk behaviors and promote healthy habits, which is in line with the recommendations of Schmidt et al. (2020), also considering gender differences. On the other hand, with regard to general stress, the systematic review by Alnawwar et al. (2023) showed that PA contributes to its reduction, consolidating itself as an effective mechanism to strengthen psychological resilience and promote positive social interactions (Amú-Ruiz et al. 2024). Likewise, its impact on the modulation of neurobiological mechanisms, such as neuronal plasticity, has been widely documented (Ahsan and Abualait 2024). Furthermore, Sánchez-Núñez et al. (2023) reinforce this perspective by pointing out that PA should be complemented with adaptive emotional regulation strategies (ERE-A), such as positive reframing, to maximize its beneficial effects. However, the use of maladaptive strategies, such as rumination, can counteract these effects.

With regard to anxiety, the inverse relationship observed with PA level has been widely documented in previous studies (Ahsan and Abualait 2025; Al-Wardat et al. 2024; Wrucke et al. 2022). These findings coincide with the evidence found during COVID-19, where PA contributed to mitigating the negative psychological effects of confinement, favoring emotional stability (Okuyama et al. 2021). In this sense, physical exercise not only acts as a stress buffer, but also modulates the autonomic nervous system, decreasing hyperactivation of the hypothalamic–pituitary–adrenal (HPA) axis and reducing cortisol levels, a hormone linked to the physiological response of anxiety (St-Pierre and Richard 2020). Furthermore, PA has been shown to be linked to neuroplasticity, increasing the production of neurotransmitters such as serotonin and dopamine, which play a key role in regulating mood and anxiety (Arazi et al. 2022). Similarly, neuroscience studies have indicated that intense physical exercise modulates the functional connectivity of the amygdala, a fundamental brain structure in the emotional response to stress and anxiety (Lohaus et al. 2024). Likewise, physical exercise promotes positive social interactions, which can reduce the predisposition to social anxiety and ruminative thoughts (Chen et al. 2023). In this sense, physical exercise plays a protective role by promoting emotional regulation and reducing stress-induced physiological activation (Ahsan and Abualait 2024), positioning itself as a key factor in reducing anxiety and promoting general well-being in university students (Rodríguez-Romo et al. 2022).

In relation to depression, an inverse association with PA was observed, in line with the findings of Herbert et al. (2020), who identified that, in university students, regular exercise and participation in a 6-week aerobic activity program correlated with a significant reduction in depressive symptoms. In this sense, the results of the present study, in line with those of Ahsan and Abualait (2025), suggest that PA may play a protective role in mental health within the academic field. From a neurobiological perspective, as previously noted, exercise stimulates the release of key neurotransmitters, such as serotonin, dopamine, and endorphins, which play a fundamental role in regulating mood and reducing depressive symptoms (Sieniawska et al. 2024). Furthermore, PA has been shown to promote neurogenesis in the hippocampus, a brain region whose dysfunction has been widely linked to depression (Zalouli et al. 2023). From a psychological perspective, PA also contributes to the development of self-efficacy and a sense of personal achievement, strengthening resilience to stressful situations and negative emotional states (Chen et al. 2022). Likewise, participation in exercise programs has been associated with an improvement in emotional regulation and a reduction in rumination, a maladaptive cognitive process characteristic of depression (Liu et al. 2023). Furthermore, the observed gender differences in depression levels highlight the importance of further research into the optimal intensity and volume of physical activity based on the characteristics of each population. Along these lines, Shan et al. (2025) emphasize the need to establish gender-differentiated guidelines to balance the physical and mental benefits. In our study, an association was identified between higher levels of physical activity and lower depression scores in both men and women, although this association was more pronounced in men. This reinforces the need to continue promoting active habits among online university students, taking into account possible individual differences. In this sense, these findings also underscore the importance of distinguishing between different types of sedentary behavior and considering the gender variable in the design of interventions aimed at preventing and treating depression (Kleidermacher and Olfson 2024).

Finally, with regard to academic burnout, it was observed that the levels of cynicism and emotional exhaustion were lower when the level of PA was higher, in line with the findings of Rosales-Ricardo and Ferreira (2022) in face-to-face meetings with university students. In particular, these authors concluded that the practice of aerobic exercise and strength training is effective in reducing academic burnout. Similarly, Alothman et al. (2021) found that PA is negatively correlated with emotional exhaustion and cynicism,

and positively correlated with academic efficiency. However, the results of Zhu et al. (2023) suggest that there is no direct relationship between PA levels and academic burnout, but that it is mediated by the use of digital devices, which introduces a new factor to consider in this relationship. In addition, the systematic review by Amú-Ruiz et al. (2024), carried out in a university population, indicates that regular PA improves sleep quality, contributing to a significant reduction in emotional exhaustion, especially in people with sedentary habits and excessive use of screens, which could justify the results obtained in the present study.

One of the main strengths of this study lies in the composition of its sample, which is made up of 2204 online university students in a normalized educational context that transcends the COVID-19 pandemic. Unlike most previous research, which focused on the impact of virtual education during exceptional periods, this study comprehensively analyzes the relationship between PA, mental health, and lifestyle habits in students who have chosen this learning modality. The simultaneous evaluation of variables such as academic stress, anxiety, depression, sleep quality, and screen time, along with PA levels, allows us to identify patterns that may be key to understanding the effects of a sedentary lifestyle and the benefits of an active lifestyle in students who pursue their education online. In addition, the inclusion of a gender-difference analysis broadens the understanding of how four factors and PA levels differentially affect men and women, providing valuable information for the design of personalized intervention strategies. Specifically, the mean of all factors decreased as PA levels increased, except for screen time on working days, which increases in women at a medium level of PA. On the other hand, men have higher mean sleep problems and cynicism, as well as, at a lower PA level, screen time and depression. Furthermore, the association between the three levels of physical activity and lower depression scores was stronger in men, suggesting that the response of these four variables to physical activity may not be identical across genders, and that tailored intervention strategies may be more effective if these patterns are taken into account, especially in online university populations, where individual variability in lifestyle is more pronounced.

However, the study has certain limitations that should be considered. First, the sample is made up exclusively of online university students, which could make it difficult to generalize the results to other populations. Nevertheless, the findings reflect the particular characteristics of students who pursue their studies in this modality. In addition, the use of self-report questionnaires to assess PA may involve biases that could affect the reliability of the data collected. For future research, it would be advisable to complement the study with other instruments of a more objective nature, such as accelerometers to measure PA, along with sleep-monitoring devices, which would allow for more precise data on students'habits. Likewise, the cross-sectional design of the study limits the ability to establish causal relationships between PA and the mental health factors and lifestyle habits analyzed. To address this limitation, it would be advisable to carry out longitudinal research and the inclusion of a control group, which would allow for better exploration and contrast of the effects of PA on the mental health and lifestyle habits of online students. Despite these limitations, the findings of this research offer a solid scientific basis for the development of strategies in online educational environments, promoting PA as a key element to improve mental health and sleep quality and reduce the negative effects of screen time in this population.

Conclusions

The findings of this study highlight the importance of PA in the mental health and lifestyle habits of online university students. Higher levels of PA were found to be associated with fewer sleep problems and less screen time, as well as better mental health indicators, including lower academic stress, general stress, anxiety, depression, cynicism, and emotional exhaustion. Gender differences were also identified in the mean relationship between the three levels of PA and the four variables—sleep problems, screen time, depression, and cynicism—suggesting the need for gender-differentiated approaches. In the case of depression, the association between these PA levels and lower scores was more pronounced among men. Thus, although both genders appear to benefit from higher levels of PA, these results suggest that their relationship with these four variables may vary, supporting the need for further research on whether tailored interventions could improve these outcomes in diverse populations of online learners. In this context, this research offers a key reference for promoting PA in online education students, considering their particular needs and characteristics. Awareness, training, and the development of personalized programs are fundamental strategies to promote the balance between physical and mental health in this group. These initiatives should not only be implemented at the university under study but also extended to other higher education institutions that offer online degrees.

Online universities have characteristics that can influence the health of their students, such as the lack of physical movement, intensive use of electronic devices, and flexible hours, which can lead to more sedentary habits and greater exposure to screens. These factors can affect sleep quality, mental well-being, and academic stress, making it essential for educational institutions to integrate strategies that address both physical and emotional well-being in the digital environment. It is not only about

promoting PA through specific programs but also in promoting healthy use of technology and the adoption of routines that reduce the negative effects of a sedentary lifestyle and screen time. Since teleworking shares many of these characteristics, the proposed strategies could be extended to this area, benefiting other groups facing similar challenges. To ensure their effectiveness, coordination between mental health, PA, and digital habits professionals is essential, as well as promoting interdisciplinary approaches and establishing monitoring mechanisms that allow evaluation of their long-term impact on the online university population.

Authors'contributions All authors have contributed equally to the conception of the study, as well as to the design of the manuscript, funding acquisition, resources, supervision, sample preparation and access, procedures with the Ethics Committee, material preparation, abstract, introduction, method, results, discussion, conclusions, and references. Finally, all authors read and approved the final manuscript.

All authors whose names appear on the submission:

1) made substantial contributions to the conception or design of the work, or the acquisition, analysis, or interpretation of data, or the creation of new software used in the work;

2) drafted the work or revised it critically for important intellectual content;

3) approved the version to be published, and

4) agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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Data availability The datasets generated and analyzed during the current research are not publicly available as individual privacy could be compromised, but are available from the corresponding author on reasonable request.

Declarations

Ethics approval Ethics approval of the Universidad Internacional de La Rioja (UNIR). Research Ethics Committee was obtained in July 2023 and the study was performed in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments.

Consent to participate Informed consent to participate in the present study was requested from participants' before initializing questionnaire.

Consent for publication Informed consent to publication data in the present study was requested from participants' before initializing questionnaire.

Conflict of interest The authors declare that they have no conflict of interest.

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