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Higher education fatigue and its associated factors among healthcare undergraduates in post-COVID-19

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Introduction: Fatigue is a universal complaint among university students. It has contributed to poor academic outcomes and unhealthy conditions. The modification of teaching and learning modalities in response to the COVID-19 pandemic has been identified as a key contributor to increased fatigue among students, which is linked to rising mental health concerns in this population. These changes have also influenced students' health behaviors. Despite these challenges, online and hybrid classrooms have become increasingly prevalent due to their advantages. This study aimed to systematically assess fatigue and related health behavior issues among undergraduates in the context of educational disruptions.

Methods: Purposive sampling was applied, and an analytical observational study was conducted among 1,108 undergraduate healthcare professional students, including those enrolled in nursing, physical therapy, and public health programs. The severity of fatigue, history of musculoskeletal complaints, body mass index, and daily sedentary time were assessed using self-administered questionnaires delivered via Microsoft forms, and correlation analyses were conducted among these variables.

Results and discussion: Fatigue was commonly observed among students in post-COVID-19 learning, with online, face-to-face, and hybrid classroom settings, and its severity was also associated with higher musculoskeletal complaint and higher body mass index. In conclusion, university students are vulnerable to higher education-related fatigue, which may be linked to educational disruptions and lifestyle changes. They also face elevated risks of obesity and sedentary behavior. Moreover, fatigue was associated with students' self-reported health conditions, underscoring its multifaceted impact. Therefore, early detection of fatigue and continuous support through lifestyle modifications should be prioritized to promote both learning capacity and health among undergraduates.

KEYWORDS

fatigue, learning, education, COVID-19, adolescent health, well-being

Introduction

Fatigue has become a notable public health concern, especially within the population of young adults and university students. It adversely affects daily functioning and overall well-being. Although fatigue has a significant impact, it remains inadequately understood. Fatigue is defined as a sense of tiredness or lack of energy that does not relate to exertion (Brown and Schutte, 2006; Tanaka et al., 2008; de Oliveira Kubrusly Sobral et al., 2022). States of prolonged fatigue are presented as more than a month of living with nonrestorative sleep, headaches, and musculoskeletal and neuropsychiatric symptoms (Dirzyte et al., 2021; Vassend et al., 2018; Findlay, 2008). In the absence of therapeutic intervention, the prognosis for patients experiencing fatigue is typically unfavorable (Farragher et al., 2017; Sasangohar et al., 2020; Harper et al., 2021), as persistent fatigue tends to endure over time and is closely linked to the onset of depressive symptoms (Dirzyte et al., 2021; Vassend et al., 2018; Findlay, 2008; Farragher et al., 2017; Sasangohar et al., 2020; Harper et al., 2021). Among adolescents, there is evidence showing that physical and mental conditions initially come after prolonged fatigue (Dirzyte et al., 2021; Vassend et al., 2018; Findlay, 2008). This suggests that monitoring and alleviating fatigue may be integral to promoting overall well-being and addressing global sustainable development challenges, especially young people whose physical and mental maturation is ongoing.

Higher education fatigue has been a widespread concern among undergraduate students for the past decade (Brown and Schutte, 2006; Tanaka et al., 2008) because it has contributed to learning motivation repression and poor academic outcomes (Brown and Schutte, 2006; Tanaka et al., 2008; de Oliveira Kubrusly Sobral et al., 2022; Dirzyte et al., 2021; Vassend et al., 2018; Findlay, 2008). During the COVID-19 pandemic, videoconferencing was instrumental in maintaining the continuity of education on a global scale (Samara and Monzon, 2021; Kulikowski et al., 2021; Labrague and Ballad, 2021; Mohammed et al., 2022). While online platforms ensured academic continuity, they also increased risks of fatigue through extended screen time, physical inactivity, and reduced in-person interaction. Several studies have indicated that students were highly faced with Zoom fatigue due to online learning (Samara and Monzon, 2021). In the post-pandemic era, online and hybrid classrooms have remained integral to teaching and learning, because of their various advantages. Despite the educational environment has been reshaped, students' perceptions of fatigue within these diverse instructional modalities remain unclear.

Although fatigue has been reported to reduce learning ability (Brown and Schutte, 2006; Tanaka et al., 2008; de Oliveira Kubrusly Sobral et al., 2022; Dirzyte et al., 2021; Vassend et al., 2018; Findlay, 2008), there are not many studies on how to relieve fatigue among students. However, among patients that have experienced high levels of fatigue, intervention through behavioral-based physical activity has been acceptable to target fatigue with self-management (Harper et al., 2021). Regarding health behavior, university students are a vulnerable population group with health risk behaviors, especially in health professional students (Ruiz-Zaldibar et al., 2022; Salameh et al., 2022; Rahman et al., 2022; Tavalacci et al., 2021; Gadi et al., 2022; Xiang et al., 2022). Healthcare undergraduates face unique academic and clinical

demands, further compounded by educational disruptions and health risks. However, little is known about higher education-related fatigue in this population, particularly in the post-COVID-19 era. Understanding these factors is essential, as healthcare undergraduates represent future health professionals and role models. By identifying factors associated with fatigue, the present study aimed to fill an important gap in literature and provide evidence to support targeted interventions that promote student well-being and academic success. Specifically, this study examined fatigue and its related symptoms, i.e., musculoskeletal complaints among healthcare undergraduates. Body mass index and sedentary time, which were affected by COVID-19 (Ruiz-Zaldibar et al., 2022; Salameh et al., 2022; Rahman et al., 2022; Tavalacci et al., 2021; Gadi et al., 2022; Xiang et al., 2022; Morgan and Wilson Van Voorhis, 2007), were also assessed in relation to fatigue. Additionally, data from students who were fully engaged in online learning were analyzed and reported to provide further insight into the impact of virtual education on fatigue-related outcomes.

Materials and methods

Research design

This study employed a cross-sectional design, which involves collecting data from participants at a single point in time to examine associations among specific outcomes. This approach enabled the simultaneous assessment of fatigue, musculoskeletal complaints, body mass index, and sedentary time, thereby providing a snapshot of the relationships among these factors in a large cohort of healthcare undergraduates in the post-COVID-19 context. A purposive sampling strategy was used to recruit students from healthcare disciplines, including nursing, physical therapy, and public health. Their study activities were similar across programs, ensuring a relatively comparable academic workload within the sample. However, the specific class schedules varied across curricula. Research information was announced online through the university intranet. Data was collected via the Zoom online meeting platform between April and June 2022, during which all classes were conducted from 2 April to 12 June 2022. Furthermore, data collected from students who participated exclusively in online learning during the 2021 academic year were examined to enhance understanding of fatigue and associated health risks.

Participants

The study population included healthcare profession undergraduates from three curriculums of Walailak University (i.e., nursing, physical therapy, and public health students) of which there were 1,331 students. The number of participants was calculated using a finite population formula (i.e., $n = 1,331$) according to Equation 1. The minimal sample size thus was 767, where p was 0.25, z was 1.96, and d was 0.02. This sample size was also profitable regarding the rules of thumb for determining relationships among independent variables ($n > 50 + 8m$, where

TABLE 1 Characteristics of the study participants.

Characteristics (<i>n</i> = 1,108)	Minimum	Maximum	Frequency	Percent
Age (years)	18	25	-	-
Sex				
Female	-	-	1,010	91
Male	-	-	98	9
Undergraduate years				
Freshman	-	-	313	28
Sophomore	-	-	361	33
Junior	-	-	219	20
Senior	-	-	215	19

TABLE 2 Self-reported body mass index, daily sedentary time, and musculoskeletal complaint sites among undergraduates.

Measures (<i>n</i> = 1,108)	Minimum	Maximum	Frequency	Percent
BMI (kg/m ²)				
Underweight (<18.5)	-	-	193	17
Normal (18.5–22.9)	-	-	575	52
Overweight (23.0–24.9)	-	-	132	12
Obese (25.0–29.9)	-	-	144	13
Extremely obese (>30)	-	-	64	6
Daily sedentary time (minutes)				
Least sedentary lifestyle (<120)	-	-	218	20
Moderately sedentary lifestyle (120–239)	-	-	329	30
Sedentary lifestyle (≥240)	-	-	561	51
Number of musculoskeletal complaint sites	0	4	-	-

BMI is body mass index, kg is kilogram, and m is meter.

m is the number of independent variables) (Dittner et al., 2004). The inclusion criterion was Thai undergraduates aged 17–25 years old, who were university students for at least 6 months. The exclusion criterion was students who had to withdraw from the study; were pregnant or within a year of their postpartum period; or had a history of kidney disease, gout, rheumatoid arthritis, spinal deformities, or back surgery. Non-proportional stratified purposive sampling, based on the number of students in each academic year and curriculum, resulted in the recruitment of 1,108 undergraduates, including nursing (*n* = 542), physical therapy (*n* = 274), and public health (*n* = 292) students who responded to the questionnaires. No students declined participation.

$$n = \frac{Np(1-p)z_{1-\frac{\alpha}{2}}^2}{d^2(N-1) + p(1-p)z_{1-\frac{\alpha}{2}}^2}$$

(1)

Data collection and questionnaires

Three research members provided the questionnaires and the instructions through a “Zoom” meeting (about 50–60 students

per meeting). Then, the participants were asked to complete the Microsoft form by using their own devices. All of them completely answered the questionnaires and submitted a response within 30 min. No students requested additional instructions. The Microsoft form set included: (1) sociodemographic questions, where body mass index (BMI) was reported and classified according to the Asian-Pacific cutoff points, in which underweight was <18.5 kg/m², normal was 18.5–22.9 kg/m², overweight was 23.0–24.9 kg/m², obese was 25.0–29.9 kg/m², and extremely obese was more than 30 kg/m²; (2) Visual Analog Scale to Evaluate Fatigue Severity (VAS-F); (3) Global Physical Activity Questionnaire (GPAQ); and (4) a checklist of musculoskeletal complaint sites with a body region diagram (i.e., head, neck, shoulders, upper back, lower back, arms, elbows, forearms, wrists/hands, hips and thighs, knees, legs, ankles, and feet).

The Visual Analog Scale to Evaluate Fatigue Severity (VAS-F) was designed to be a simple and quick measurement of fatigue and energy levels in the general medical population (Lee et al., 1991). The VAS-F consists of 18 items relating to the subjective experience of fatigue (i.e., feeling tired, sleepy, drowsy, fatigued, worn out, energetic, active, vigorous, efficient, lively, bushed, exhausted, keeping eyes open, moving body, concentrating,

TABLE 3 Body mass index, daily sedentary time, and number of musculoskeletal complaint sites and self-reported fatigue in undergraduates enrolled in online learning during the 2021 academic year.

Measures (<i>n</i> = 165)	Minimum	Maximum	Frequency	Percent
BMI (kg/m²)				
Underweight (<18.5)	-	-	31	18.8
Normal (18.5–22.9)	-	-	91	55.2
Overweight (23.0–24.9)	-	-	19	11.5
Obese (25.0–29.9)	-	-	17	10.3
Extremely obese (>30)	-	-	7	4.2
Daily sedentary time (minutes)				
Least sedentary lifestyle (<120)	-	-	36	21.8
Moderately sedentary lifestyle (120–239)	-	-	38	23.0
Sedentary lifestyle (≥240)	-	-	91	55.2
Number of musculoskeletal complaint sites	0	3	-	-
Self-reported fatigue (VAS-F)				
Items 1–5 (fatigue)	27 (26.22 ± 12.29)		-	-
Items 6–10 (energy)	28 (27.72 ± 9.80)		-	-
Items 11–18 (fatigue behaviors)	39 (38.22 ± 16.67)		-	-

BMI is body mass index, kg is kilogram, and m is meter. Self-reported fatigue scores for the other students (*n* = 943), expressed as median (mean ± SD), were as follows: Items 1–5 (fatigue), 30 (28.73 ± 11.70); Items 6–10 (energy), 25 (25.50 ± 9.47); and Items 11–18 (fatigue behaviors), 39 (38.50 ± 15.20). The minimum and maximum scores in both groups ranged from 0 to the full scale.

carrying on a conversation, no desire to close eyes, and no desire to lie down). There are two subscales in the VAS-F: Items 1 to 5 and Items 11–18 indicate fatigue, whereas Items 6 to 10 determine energy. Each item asks the respondents how they currently feel, along a visual analog scale that extends from 0 to 10 (Lee et al., 1991). The population for testing the scale was validated with adults aged 18–55 years (Lee et al., 1991). Lee and colleagues (Lee et al., 1991) demonstrated a high internal reliability ranging from 0.94 to 0.96. Concurrent validity was established with the Stanford Sleepiness Scale and the Profile of Mood States scale.

Time spent on sedentary activities in this study was assessed using the Global Physical Activity Questionnaire (GPAQ) (Dogra and Stathokostas, 2012; Singh and Purohit, 2011). The GPAQ is a validated instrument commonly employed to estimate daily sedentary time and classify physical activity levels across different behavioral domains, including work, transportation, and leisure-time activities (Dogra and Stathokostas, 2012; Kizhakkeveetil et al., 2017).

Statistical analysis

Data analysis was performed using SPSS version 28. The correlations between fatigue, the number of musculoskeletal complaint sites, body mass index, and daily sedentary time were examined with Spearman's correlation test. Data obtained from students enrolled in virtual learning during 2021 were extracted, and their VAS-F scores were compared with those of other students using the Mann-Whitney U test. Factor analysis was also conducted on the VAS-F

responses from university students. A *p* < 0.05 was considered statistically significant.

Ethical approval and consent to participate

The study protocol in the present study was approved by the Ethics Committee in Human Research Walailak University. The approval number is WUEC-22-077-01. Active informed consent for participation was obtained from all participants, who received the information sheet through the online platform and provided the consent before responding to the questionnaires. The research presented here is part of a larger research project that collects data from nursing, physical therapy, and public health students across four countries: Thailand, Indonesia, Laos, and Vietnam. The data analyzed and presented in this manuscript specifically focus on the sample group in Thailand only. This does not involve changes to the methodology or research approach.

Results

The average age of participants was 21 years, and the majority were female. The distribution across academic years was relatively balanced, with approximately 20–30% in each year (Table 1). About half of the students presented with abnormal BMI and a sedentary lifestyle. A total of 146 students reported a history of musculoskeletal complaints, with a maximum of four affected sites (Table 2). Additional analyses were conducted among students enrolled in online learning during the 2021 academic year. As summarized in Table 3,

TABLE 4 Self-reported fatigue scores from VAS-F items among undergraduates.

VAS-F ($n = 1,108$)	Minimum	Maximum	Median	Mode (percent)
Item 1: Tired	0	10	7	8 (21)
Item 2: Sleepy	0	10	7	8 (19)
Item 3: Drowsy	0	10	4	0 (19)
Item 4: Fatigued	0	10	6	8 (15)
Item 5: Worn out	0	10	6	5 (13)
Item 6: Energetic	0	10	5	5 (25)
Item 7: Active	0	10	5	5 (22)
Item 8: Vigorous	0	10	5	5 (25)
Item 9: Efficient	0	10	5	5 (25)
Item 10: Lively	0	10	5	5 (25)
Item 11: Bushed	0	10	5	5 (26)
Item 12: Exhausted	0	10	5	5 (15)
Item 13: Keeping eyes open	0	10	5	0 (14)
Item 14: Moving body	0	10	3	0 (31)
Item 15: Concentrating	0	10	5	0 (14)
Item 16: Carrying on a conversation	0	10	2	0 (31)
Item 17: Having a tremendous desire to close eyes	0	10	7	10 (20)
Item 18: Having a tremendous desire to lie down	0	10	7	10 (25)
Items 1–5 (fatigue)	0	50	29.50	39 (5)
Items 6–10 (energy)	0	50	25.00	25 (8)
Items 11–18 (fatigue behaviors)	0	80	39.00	48 (3)

VAS-F is Visual Analog Scale to Evaluate Fatigue Severity.

this subgroup demonstrated health risk patterns, including overweight and prolonged sedentary behavior, which may have contributed to fatigue. However, mean fatigue scores did not differ significantly between this group and other students (Table 3). Students reported fatigue, i.e., most of them felt tired, sleepy, drowsy, fatigued, and worn out at about midpoint or higher. Fatigue behaviors in the students were also reported at higher scores. However, the average scores of Items 14 (moving body) and 16 (carrying on a conversation) were small. Students mostly reported their energy perception at about 5 out of 10 (Table 4).

Since there are various items in the VAS-F, factor analysis was performed to classify items in determining fatigue among undergraduates. It was found that Item 11 (bushed) was classified the same as Items 6 to 10 (energy) (Supplementary Table S1), whereas Items 13, 14, 15, and 16 were classified to other items rather than the items of fatigue, energy, and fatigue behaviors (Supplementary Table S1). It was found that BMI was associated with the daily sedentary time and fatigue behavior score but negatively related to Item 11 (bushed). It implied that feeling bushed may be related to exertion in the students. Negative associations between sedentary time and the number of musculoskeletal complaint sites were observed. The number of musculoskeletal complaint sites was associated with fatigue behaviors. Nonetheless, the present study demonstrated that statistically significant associations were observed even with the

correlation coefficients being quite low. The VAS-F showed that higher fatigue severity (Items 1–5) correlated positively with fatigue behaviors (Items 13–16), but negatively with Item 11. Perceived energy (Items 6–10) was negatively linked to both fatigue severity and related behaviors (Table 5).

Discussion

This study examined subjective fatigue among undergraduates in the post-COVID-19 era across various teaching and learning strategies, including face-to-face, online, and hybrid classrooms, which continue to be utilized today and in the future. The effects of fatigue among undergraduates were supported by the number of musculoskeletal complaint sites (Vassend et al., 2018), it was found that around 20% of the participants reported a history of musculoskeletal complaints. Besides fatigue, musculoskeletal pain among students also has been reported to be associated with postural habits, which were changed by distance learning (Labrague and Ballad, 2021). University students experience significant levels of study-related fatigue (Brown and Schutte, 2006; Tanaka et al., 2008; de Oliveira Kubrusly Sobral et al., 2022). Regarding face-to-face learning, it was reported that fatigue levels among students correlated with psychological health, academic demands, and conflicts between studies and other activities (Kizhakkeveetil et al., 2017). In contrast, fatigue from online learning was caused by

TABLE 5 Associations between fatigue scores (VAS-F factor analysis), body mass index, daily sedentary time, and musculoskeletal complaint sites among undergraduates.

Measures (<i>n</i> = 1,108)	BMI (kg/m ²)	DST (minutes)	NMSC	I1–5	I6–10	I11–18	I11	I13	I14	I15	I16
BMI (kg/m ²)											
<i>r</i>	1.000	0.073*	−0.008	0.036	−0.061	0.062*	−0.068*	0.051	0.040	0.097*	0.049
<i>p</i> -value	–	0.015	0.796	0.227	0.044	0.039	0.024	0.089	0.183	0.001	0.101
DST (minutes)											
<i>r</i>	0.073*	1.000	0.048	0.029	−0.051	0.023	−0.025	0.049	−0.016	−0.007	−0.011
<i>p</i> -value	0.015	–	0.111	0.337	0.093	0.444	0.412	0.102	0.600	0.821	0.717
NMSC											
<i>r</i>	−0.008	0.048	1.000	0.047	−0.053	0.073*	−0.51	0.070*	0.050	0.53	0.081**
<i>p</i> -value	0.796	0.111	–	0.115	0.076	0.016	0.090	0.019	0.095	0.081	0.007
I1–5											
<i>r</i>	−0.041	0.036	0.029	0.047	1.000	−0.729**	0.047	−0.262**	0.581**	0.499**	0.554**
<i>p</i> -value	0.174	0.227	0.337	0.115	–	<0.001	0.115	<0.001	<0.001	<0.001	<0.001
I6–10											
<i>r</i>	−0.005	−0.061	−0.051	−0.053	−0.729**	1.000	−0.096**	0.842**	−0.168**	−0.104**	−0.189**
<i>p</i> -value	0.873	0.044	0.093	0.076	<0.001	–	0.001	<0.001	<0.001	<0.001	<0.001
I11–18											
<i>r</i>	−0.037	0.062*	0.023	0.073*	0.047	−0.096**	1.000	−0.111**	0.790**	0.778**	0.806**
<i>p</i> -value	0.222	0.039	0.444	0.016	0.115	0.001	–	<0.001	<0.001	<0.001	<0.001
I11											
<i>r</i>	−0.018	−0.068*	−0.025	−0.51	−0.262**	0.842**	−0.111**	1.000	−0.186**	−0.154**	−0.188**
<i>p</i> -value	0.550	0.024	0.412	0.090	<0.001	<0.001	<0.001	–	<0.001	<0.001	<0.001
I13											
<i>r</i>	−0.041	0.051	0.049	0.070*	0.581**	−0.168**	0.790**	−0.186**	1.000	0.629**	0.566**
<i>p</i> -value	0.174	0.089	0.102	0.019	<0.001	<0.001	<0.001	<0.001	–	<0.001	<0.001
I14											
<i>r</i>	−0.001	0.040	−0.016	0.050	0.499**	−0.104**	0.778**	−0.154**	0.629**	1.000	0.690**
<i>p</i> -value	0.967	0.183	0.600	0.095	<0.001	<0.001	<0.001	<0.001	<0.001	–	<0.001
I15											
<i>r</i>	−0.014	0.097*	−0.007	0.53	0.554**	−0.189**	0.806**	−0.188**	0.566**	0.690**	1.000
<i>p</i> -value	0.642	0.001	0.821	0.081	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	–
I16											
<i>r</i>	−0.005	0.049	−0.011	0.081**	0.446**	−0.142**	0.699**	−0.165**	0.446**	0.652**	0.657**
<i>p</i> -value	0.871	0.101	0.717	0.007	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	–

NMSC is the number of musculoskeletal complaint sites, DST is daily sedentary time, and I is item. **p* < 0.05; ***p* < 0.01.

the overuse of videoconferencing (Olasina, 2019; Dumford and Miller, 2018; Assareh and Hosseini Bidokht, 2011). The failing technological aspects of online courses among both students and teachers also frustrated students (Olasina, 2019; Dumford and Miller, 2018; Assareh and Hosseini Bidokht, 2011; Rattanawan and Pakdee, 2024). Regarding the learning process during the COVID-19 global pandemic, Mohammed et al. (2022) reported that students from tertiary institutions in Iraq (*n* = 819, electronic

respondents) had a high level of fatigue due to lockdown measurements. Lower levels of lockdown fatigue were shown to be associated with higher levels of personal resilience and coping abilities (Mohammed et al., 2022).

The present study found no significant differences in fatigue levels between students engaged in online learning and those in other modalities, including face-to-face instruction. This may be due to students' accumulated experience with online learning since

the pandemic, which likely enabled them to adapt and mitigate the potential impact of virtual modalities on fatigue. It has been observed that fatigue was quite high among students, even with improvements in the COVID-19 situation. This suggests that fatigue is a common occurrence among undergraduates across all educational approaches (i.e., face-to-face, online, and hybrid learning) and may be influenced by multiple factors. A lack of structured, multifaceted teaching methods could contribute to student fatigue both post-pandemic and in the future. Therefore, prioritizing the development of effective teaching strategies and student support policies is essential to alleviate and prevent prolonged fatigue among university students.

Although subjective fatigue is one of the significant factors contributing to the inhibition of learning motivation, the paths and contributing factors of fatigue are under-researched. The present study revealed the associations between the fatigue items from the VAS-F and health reports among undergraduates. Items 1–5 showed that greater fatigue severity correlated positively with fatigue behaviors (Items 13–16), while Items 6–10 demonstrated that higher perceived energy was negatively associated with both fatigue severity and fatigue behaviors among students. The fatigue behavior score was also associated with BMI as related with daily sedentary time; however, no direct correlation was observed between daily sedentary time and any of the individual VAS-F items. This may reflect the relatively uniform sedentary patterns among participants, which limited variability and reduced the ability to detect associations. In relation to fatigue interventions, it is therefore essential to further investigate fatigue management strategies in higher education to establish a stronger foundation for promoting students' well-being and supporting their academic achievement (Compton et al., 2020; Räisänen et al., 2021; Cosentino et al., 2024; Buneviciene et al., 2021).

In agreement with previous studies, the present study revealed that half of the students had abnormal BMI and a sedentary lifestyle (Ruiz-Zaldibar et al., 2022; Salameh et al., 2022; Rahman et al., 2022; Tavalacci et al., 2021; Gadi et al., 2022; Xiang et al., 2022). Weight gain during the COVID-19 pandemic had been reported to be associated with higher baseline BMI, mental symptoms, maladaptive eating behaviors, less sleep, and physical inactivity (Buneviciene et al., 2021; Almandoz et al., 2022). Together, obesity and prolonged sedentary time are of particular concern among health sciences students. With multiple learning modalities and other educational disruptions persisting beyond the pandemic, these patterns are likely to continue, underscoring the need for sustainable strategies that foster healthy behaviors in this population.

Limitations and future research directions

Although the VAS-F provided a useful measure of subjective fatigue, it cannot identify the underlying causes of fatigue among students. Future studies should therefore consider incorporating fatigue questionnaires that specifically address the learning process in higher education, as well as examining the effects of targeted fatigue interventions. In addition, BMI, daily sedentary time,

and musculoskeletal complaints should be confirmed through objective physical examinations rather than relying solely on self-reports. Although some correlations in the present study reached statistical significance, the effect sizes were negligible, as statistical significance alone does not imply clinical relevance. The present study also highlights the need for further research that employs comprehensive assessments of the diverse factors contributing to fatigue among health professional students in contemporary educational contexts.

Conclusion

Our study highlights the importance of systematically monitoring fatigue among undergraduates. Implementing effective interventions such as lifestyle modifications and advancing teaching methods through research and policy development may help alleviate fatigue and, in turn, support both student well-being and academic performance.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving humans were approved by the Ethics Committee in Human Research Walailak University. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

YW: Methodology, Validation, Investigation, Conceptualization, Data curation, Formal analysis, Writing – original draft, Writing – review & editing, Funding acquisition, Project administration. PP: Data curation, Methodology, Investigation, Conceptualization, Formal analysis, Writing – original draft, Writing – review & editing. TP: Conceptualization, Writing – original draft, Writing – review & editing, Validation, Methodology. PK: Writing – original draft, Writing – review & editing, Methodology, Validation, Conceptualization. MAI: Conceptualization, Validation, Writing – original draft, Writing – review & editing, Methodology. NP-a: Writing – original draft, Formal analysis, Writing – review & editing, Methodology, Conceptualization, Data curation, Validation, Investigation.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/feduc.2025.1667303/full#supplementary-material>

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