

24-Hour Movement Behaviors and Mental Health in University Students: Descriptive Data and Cluster Analysis of European Data

Alyzée Lebas

`alyzee.lebas@univ-pau.fr`

Université de Pau et des Pays de l'Adour

Julien Bois

Université de Pau et des Pays de l'Adour

Alberto Aibar Solana

Universidad de Zaragoza

Jessica Dagani

University of Brescia

Alberto Abarca-Sos

Universidad de Zaragoza

Chiara Buizza

University of Brescia

Rémi Castells

Université de Pau et des Pays de l'Adour

Nicolas Fabre

Université de Pau et des Pays de l'Adour

Silvia Nicoleta Mirica

West University of Timișoara

Adrian Alexandru Moșoi

Transylvania University of Brașov

Adrian Nagel

Transylvania University of Brașov

Luiza Meseșan Schmitz

Transylvania University of Brașov

Andrea Elena Neculau

Transylvania University of Brașov

Alberto Rodríguez Lorenzana

Universidad Pública de Navarra (UPNA)

Clara Sancho-Domingo

Universidad Pública de Navarra (UPNA)

Gautier Zunquin

Université de Pau et des Pays de l'Adour

Léna Lhuisset

Université de Pau et des Pays de l'Adour

Research Article

Keywords: 24-hour movement behaviors, mental health, Self-Determination Theory, physical activity, sedentary behavior, screen time, European university students, clustering, prevalence

Posted Date: August 23rd, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-10577240/v1>

License: © ⓘ This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

Additional Declarations: No competing interests reported.

Abstract

Background: In the post-pandemic context, university students' mental health has emerged as a major global public health concern. The university years are characterized by increased psychological vulnerability and the adoption of health behaviors that tend to persist over time, notably declining physical activity and rising sedentary behavior after entering university. The 24-hour Movement Behavior framework provides a lens for examining these behaviors jointly and their association with mental health. This study aimed to describe adherence to 24-hour movement guidelines and mental health outcomes, identify movement behavior profiles, and examine their association with mental health among European university students.

Methods: This cross-sectional study included 2,340 European university students (mean age = 20.94; 62.6% female). Self-reported 24-hour movement behaviors (physical activity, sedentary behavior, leisure screen time, and sleep) were collected via the ONAPS-PAQ and the Pittsburgh Sleep Quality Index. Mental health was assessed using the Depression, Anxiety and Stress Scale, the Basic Psychological Need Satisfaction and Frustration Scale and the Subjective Vitality Scale. Substance use was evaluated using the CAST (cannabis), AUDIT (alcohol), and Simplified Fagerström (tobacco) scales. Guideline adherence and mental health outcomes were first described; K-means clustering then identified movement behavior profiles, and binary logistic regressions tested associations between cluster membership, gender with mental health outcomes.

Results: Guideline adherence was 94.1% for physical activity, 66.4% for leisure screen time, 63.6% for sleep, and only 44.1% for sedentary behavior. Overall, 77.1% failed to meet all 24-hour guidelines simultaneously. Regarding mental health, 44.6% reported significant anxiety symptoms, 36.1% depression, and 34.7% stress. While 13.4% reported greater frustration than satisfaction of basic psychological needs. Female students reported poorer mental health outcomes. Cluster analysis revealed two movement behaviors profiles: a favorable profile associated with lower distress and higher well-being, and an unfavorable profile, with the reverse pattern. Binary logistic regressions confirmed unfavorable profile membership and female gender were significant predictors of poor mental health.

Conclusion: European university students struggle to meet all 24-hour movement guidelines, which is associated with poorer mental health. Movement behavior profiles are strongly associated with mental health, underscoring the importance of integrated interventions targeting both domains, particularly among female students.

Introduction

The World Health Organization (WHO) defines mental health (MH) as a state of well-being that enables individuals to cope with the stresses of daily life, realize their potential, learn effectively and contribute to their community [1]. Yet the MH of university students, particularly since the COVID-19 pandemic, has become a major global public health concern [2, 3]. The university period represents a critical stage for MH; indeed international data indicate alarming levels of psychological distress among university

students, and especially among females [4, 5]. A meta-analysis covering nine European countries reports particularly high rates of depression (55%), anxiety (63%) and stress (62%) among university students during the pandemic [6]. At the European level, a recent survey conducted in several countries indicated that one third of university students reported a MH problem, most often depressive and anxiety disorders, and between 37% and 58% reported poor well-being [7]. These results suggest a still-lasting deterioration in the MH of university students. MH can be approached as a dual continuum, in which psychological distress and well-being represent two related but distinct dimensions [8]. This model implies that the absence of psychological distress does not necessarily imply the presence of high well-being, and vice versa. According to the dual continuum model framework, MH should therefore be assessed using indicators of psychological distress (e.g., anxiety, stress and depression) as well as indicators of well-being (e.g., subjective vitality and satisfaction of basic psychological needs). In this regard, subjective vitality (*"conscious experience of possessing energy and vitality"*; [9] and satisfaction of basic psychological needs (BPN) are interesting indicators for assessing optimal well-being [10] and they are part of the Self-Determination Theory (SDT) [11]. SDT identifies three BPN: autonomy (sense of volition in one's actions), competence (the feeling of effectiveness in one's actions), and relatedness (sense of connection with others) [12, 13], whose satisfaction nourishes well-being and whose frustration, on the contrary, increases the risk of ill-being [11, 14].

The university period is also a critical time for adopting behaviors that may persist over time [15, 16], such as the consumption of substances including alcohol, cannabis or tobacco [17, 18]. For example, in Europe between 20% and 37% of university students report problematic alcohol consumption [19, 20]. Among university students, cannabis, tobacco and alcohol are frequently co-used and form part of higher-risk polysubstance use profiles [21, 22]. Physical activity (PA), sedentary behavior (SB) and sleep are central for students' health. In the literature, these behaviors are often studied in isolation, but they are increasingly integrated into the 24-hour paradigm, which recognizes their interdependence [23]. In this context, the "Canadian 24-Hour Movement Guidelines" provide a framework for guidelines regarding PA, SB, and sleep [24]. This paradigm promotes not only favorable movement behaviors but also their integration, emphasizing the importance of an active and balanced lifestyle. Thus, for PA, defined as *"any bodily movement produced by skeletal muscles that requires energy expenditure"* [25], the guidelines are *"at least 150 minutes per week of moderate-to-vigorous physical activity (MVPA)"*; for SB, defined as *"any waking behavior characterized by an energy expenditure of 1.5 METs or lower while sitting, reclining or lying"* [26], the guidelines call for *"a maximum of 8 hours of sedentary time per day, including a maximum of 3 hours of leisure screen time"*; and for sleep, *"7 to 9 hours of good-quality sleep per night, with regular bedtime and wake-up times"*. Alarming, more than 40% of university students are considered physically inactive [27], and a meta-analysis indicates that PA levels drop by nearly 12 min/day upon entering university [16]. Regarding SB, university students spend a mean of 9 to 11 h/day in SB [28], which is higher than non-university young adults [29]. It should be noted that a large proportion of this SB is dedicated to screen use for leisure purposes (i.e. excluding use for academic study or work) [30], which highlights the need to take this type of behavior into account in current society. Concerning sleep, the estimated prevalence of insomnia among European university students ranges from 40% to 57%, with a

mean prevalence of approximately 47% [31]. Moreover, a national Canadian study assessed prevalence of adherence to the 24-hour movement behavior guidelines among more than 20,000 students and found that 61.1% met MVPA guidelines, 56.3% met SB guidelines, 36.2% met leisure screen time guidelines, and 59.7% met sleep guidelines, but only 9.9% of students met all four guidelines simultaneously [32]. Nevertheless, it should be noted that this study was conducted pre-pandemic, and to our knowledge, no other study has examined these four prevalences among students since the pandemic, especially in a European context. These behaviors are also not without consequences for MH. Meta-analyses confirm that insufficient PA increases the risk of depression and anxiety, while being physically active reduces the risk of depression by 17% and anxiety by 29% [33, 34]. Conversely, excessive SB, particularly leisure screen time, is associated with increased psychological distress [35]. Regarding sleep, sufficient, high-quality sleep is a major predictor of well-being [36]. In the university population, insomnia is associated with significantly higher risk of depressive and anxiety disorders [37]. Furthermore, a longitudinal study among freshmen indicates that the symptoms of insomnia upon entry into university were strong predictors of depression and anxiety symptoms at the end of the academic year [38]. Although the impact on MH of movement behaviors, taken individually, is known, research remains limited when these behaviors are considered simultaneously, particularly among university students [39]. However, adopting a person-centered approach, such as clustering, can help identify subgroups of individuals who share similar movement behavior profiles, thereby capturing the heterogeneity of these behaviors within the population. Moreover, by grouping university students according to profiles of similar behaviors, this method can highlight potential synergistic effects of these habits on MH [40].

An updated assessment of MH and 24-hour movement behaviors among European students therefore appears essential to identify distinct profiles and to analyze associated variations in MH. Such an assessment would highlight more targeted prevention and intervention strategies, avoiding the pitfall of treating all students as a homogeneous population without acknowledging specific distinctions. In this context, the present study aims to address the following research questions:

1. What is the prevalence of adherence to the 24-hour movement behavior guidelines and of the MH outcomes?
2. Within the framework of a person-centered approach (clustering), are there distinct university student profiles based on 24-hr movement behaviors?
3. What is the link between these potential profiles and variables relating to MH?

Methodology

Study design

This cross-sectional study is based on data from an online survey on the health of European university students. Data collection took place between October 2024 and February 2026 in five European UNITA alliance universities: Spain (two universities), Romania (two universities), and Italy (one university). Recruitment was conducted through multiple channels, including university mailing lists, posters and

flyers displayed in common campus areas, and in-class presentations, all featuring a brief description of the project along with a web link and QR code for direct access to the online survey. Upon accessing the survey link, participants were required to provide informed consent and select their preferred language before answering the questions.

Participants

Out of the 2,427 responses collected, 2,340 were valid according to our criteria (96.4% valid response rate; see Data Cleaning and Filtering section below). The included participants (62.6% female; 36.6% male; and 0.8% non-binary) had a mean age of 20.94 years (SD = 4.24). Additionally, 43.5% of the students were from Romania, 34.2% from France, 12.1% from Italy, and 10.2% from Spain.

Instruments

The survey collected sociodemographic information and included validated tools to assess health behaviors and MH outcomes.

24-hour movement behaviors

ONAPS Physical Activity Questionnaire (ONAPS-PAQ) [41] : This self-reported questionnaire assesses participants' PA and SB over a typical week. This questionnaire is derived from the Global Physical Activity Questionnaire (GPAQ) [42] and the long version of the International Physical Activity Questionnaire (IPAQ) [43], which have shown good psychometric proprieties across different European countries [44, 45]. It has demonstrated good test-retest reliability and validity [41]. The questionnaire consists of four sections addressing activities in various domains: work/study, transport, leisure, and domestic tasks. In this study, three variables related to 24-hour movement behaviors were extracted from the ONAPS-PAQ: MVPA, SB, and leisure screen time. MVPA corresponded to the total weekly duration of activities of moderate and vigorous intensity, across different domains. SB corresponded to the total time spent sitting in these same domains. Finally, leisure screen time corresponded specifically to the domain of leisure, that is, the time spent on screens outside any academic or professional use (e.g., television, video games, smartphone use during leisure time). For this study, these variables were binary coded according to the thresholds defined by the guidelines of the 24-hour movement behavior framework [24]: 1 indicated non-adherence to the guideline, and 0 indicated adherence. Thus, the selected thresholds were as follows: MVPA < 150 min/week; SB > 3,360 min/week (> 8 h/day); leisure screen time > 180 min/day (> 3 h/day).

The Pittsburgh Sleep Quality Index (PSQI) [46] : This questionnaire assesses the sleep duration and quality of participants over a one-month period and it is widely used in the literature [47]. Comprising 19 items, it evaluates seven distinct components (e.g., subjective sleep quality or sleep duration), each scored from 0 to 3, with higher scores reflecting greater sleep disturbance. The sum of these components yields a global score ranging from 0 to 21. A total score greater than 5 identifies individuals

with poor sleep quality [46]. In this study, two variables derived from PSQI were used: the overall PSQI score (sleep quality) and sleep duration (derived from Component 3). This component was used independently to assess adherence to the 24-hour movement behavior guidelines [24]. Sleep duration was dichotomized: 1 when the duration was < 7h or > 9h/night (non-adherence) and 0 when it was 7-9h/night (adherence). Internal consistency was acceptable ($\alpha = .65$ and $\omega = .68$; α range .60-.72 and ω range .64-.71 across the different languages).

Substance use

Cannabis Abuse Screening Test (CAST) [48]: This questionnaire aims to assess problematic cannabis use and screens for the risk of cannabis use disorder. It consists of six binary-coded items (negative/positive response). The tool has demonstrated good psychometric properties among young people, as well as strong criterion validity with respect to the DSM-IV [48]. The final score corresponds to the number of positive responses across all items and is used to evaluate the presence/severity of problematic cannabis use. A score below 2 indicates non-problematic use, while a score of 2 or higher suggests at-risk or problematic use. Internal consistency was good ($\alpha = .80$ and $\omega = .94$; α range .76-.87 and ω range .92-.96).

Alcohol Use Disorders Identification Test (AUDIT) [49]: This questionnaire assesses participants' alcohol consumption and associated risks. It consists of 10 items, with questions 1 to 8 scored on a five-point scale (0 to 4) and questions 9 and 10 scored on a three-point scale (0, 2 or 4), yielding a total score between 0 and 40. The tool has demonstrated strong psychometric properties and good internal consistency across different languages, with Cronbach's alpha values ranging from .75 to .94 [50]. The total score is the sum of all 10 items. Higher scores indicate increasingly problematic alcohol use. In the present study, internal consistency was acceptable ($\alpha = .77$ and $\omega = .90$; α range .66-.78 and ω range .70-.82).

Simplified Fagerström Test [51]: This questionnaire assesses nicotine dependence using two items: (1) the number of cigarettes smoked per day (0 = 10 or fewer cigarettes/day to 3 = 31 or more cigarettes/day) ; (2) the time elapsed after waking up before smoking the first cigarette (0 = more than 60 minutes to 3 = within 5 minutes), yielding a total score ranging from 0 to 6. The traditional method involves adding the two items to obtain a global score, which indicates the level of dependence: the higher the score, the greater the dependence is considered to be.

Mental Health

The Basic Psychological Need Satisfaction and Frustration Scale (BPNSFS) [52] : This questionnaire was used to assess the satisfaction and frustration of BPN. The tool is grounded in SDT [11, 12], which posits that these needs are essential for individual well-being and balance [12, 53]. The questionnaire consists of 24 items in total, with each BPN evaluated by eight items: four items assessing satisfaction

and four items assessing frustration [52]. Participants rated their responses on a five-point Likert scale (ranging from 1 = "completely false" to 5 = "completely true"). In this study, for each BPN, a mean satisfaction score and mean frustration score were first calculated by averaging the corresponding four items. Composite scores were then calculated for each BPN by subtracting the mean frustration score from the mean satisfaction score (Autonomy Score, Competence Score, Relatedness Score), indicating the balance between these two dimensions for each need [54]. A General Composite Score was calculated as the difference between the total satisfaction score (mean of the three mean satisfactions scores) and the total frustration scores (mean of the three mean frustration scores). For this study, the composite scores were dichotomized: scores < 0 were coded as 1, indicating that BPN were more frustrated than satisfied, and scores ≥ 0 were coded as 0, indicating that BPN were more satisfied than frustrated (or neutral). Internal consistency, calculated using the classical difference score reliability approach [55], was good for all composite scores: General Composite Score ($\alpha = .88$, $\omega = .88$; α range .85-.89, ω range .86-.89), Autonomy ($\alpha = .81$, $\omega = .81$; α range .77-.87, ω range .78-.87), Relatedness ($\alpha = .84$, $\omega = .85$; α range .81-.86, ω range .79-.87) and Competence ($\alpha = .89$, $\omega = .88$; α range .87-.90, ω range .86-.90).

The Subjective Vitality Scale (SVS) [9]: This questionnaire was used as a positive indicator of well-being. Participants responded to seven items rated on a Likert scale ranging from 1 to 7 (from 1 = "not at all true" to 7 = "completely true"). The overall score corresponds to the mean of the seven responses. Internal consistency was satisfactory ($\alpha = .86$ and $\omega = .87$; α range .82-.88 and ω range .87-.90).

The Depression Anxiety Stress Scales-21 (DASS-21) [56]: This questionnaire assesses psychological distress and corresponds to the abbreviated version of the DASS-42 [57]. The DASS-21 has frequently been used among university student populations [58]. It evaluates three distinct dimensions of psychological distress (i.e., depression, anxiety, and stress). The DASS-21 consists of 21 items, divided into three subscales of seven items each, corresponding to the three assessed dimensions. Participants rated the frequency of symptoms they experienced over the previous week using a four-point Likert scale (ranging from 0 = "did not apply to me at all" to 3 = "applied to me very much or most of the time"). The score for each subscale was calculated by summing the corresponding seven items. The scores were then multiplied by 2 to bring them into line with the DASS-42 scale, in accordance with the guidelines [57]. The severity thresholds, as defined by Lovibond & Lovibond, (1995) for the DASS-42, classify symptoms as moderate (score ≥ 14 for depression, ≥ 10 for anxiety, ≥ 19 for stress), severe (score ≥ 21 for depression, ≥ 15 for anxiety, ≥ 26 for stress), and extremely severe (score ≥ 28 for depression, ≥ 20 for anxiety, ≥ 34 for stress). In this study, each subscale was dichotomized as follows: coded as 1 when the score reached the threshold for at least moderate symptoms, and 0 otherwise, indicating the absence of significant symptoms. Internal consistency was good across the subscales: depression ($\alpha = .90$ and $\omega = .90$; α range .85-.92 and ω range .86-.92), anxiety ($\alpha = .84$ and $\omega = .85$; α range .79-.88 and ω range .80-.89) and stress ($\alpha = .86$ and $\omega = .86$; α range .77-.90 and ω range .78-.90).

We used validated versions of the questionnaires in the respective languages when available. If no validated version existed in a particular language, the research team associated with the country

translated the corresponding items.

Data cleaning and filtering

Before conducting the analyses, the database was cleaned in two steps.

Quality control of questionnaire responses

An analysis was conducted to identify potential low-quality responses. Given that the mean response time was 23.7 minutes, it was inferred that responding in less than half that time would not allow for high-quality answers. Therefore, all participants who completed the survey in less than 600 seconds were excluded ($n = 87$).

Outliers

Regarding the ONAPS-PAQ measurements, the IPAQ guidelines were applied [43]. Thus, only MVPA sessions lasting at least 10 continuous minutes were counted, and any responses below this threshold were recoded to 0. Moreover, exclusion criteria were applied to rule out values considered implausible: MVPA > 6,720 min/week (16 h/day); leisure screen time > 6,720 min/week (16 h/day); SB > 10,080 min/week (24 h/day) or equal to 0. The $3 \times \text{IQR}$ method was then applied to the following variables: MVPA, SB, leisure screen time, sleep quality score, sleep duration, subjective vitality, DASS-21 scores (anxiety, stress, and depression), and BPNSFS scores (General Composite Score, Autonomy Score, Competence Score, and Relatedness Score). This step was used to identify extreme (but plausible) values. All identified outliers were removed from the database ($n = 86$) (see Additional file 1: Table S1).

Data analysis

Descriptive analyses and prevalence rates

To address the first research question concerning adherence levels to 24-hour movement behaviors and MH outcomes, descriptive analyses (mean and standard deviation) by gender (female; male; non-binary) were conducted. One-way analyses of variance (ANOVA) with gender as the factor were also performed to identify potential differences, using Tukey's post hoc tests. Moreover, Chi-square (χ^2) tests of independence were performed to examine the association between gender and adherence to 24-hour movement behavior guidelines [24], as well as MH outcomes. Post hoc analyses based on standardized residuals were conducted for each cell in the contingency tables, with values greater than ± 1.96 considered statistically significant. This identified which specific categories contributed significantly more or less than expected to the associations observed in the χ^2 tests between gender categories. Effect sizes for these χ^2 test associations were quantified using Cramér's V with following thresholds: .10 (low), .30 (medium) and .50 (large) [59]. For each guideline, adherence was coded as 0, and non-

adherence was coded as 1. For MH outcomes, the absence of significant symptoms of anxiety, depression and stress was coded as 0, and the presence was coded as 1; positive or neutral balance of BPN was coded as 0, and a negative balance was coded as 1.

Clustering analysis

To address the second research question, concerning the existence of 24-hour movement behavior profiles within the study population, cluster analyses were conducted. First, the optimal number of clusters was identified using the R package "NbClust" [60]. The analysis indicated that two clusters were optimal (see Additional file 2: Table S2). MVPA (ONAPS-PAQ), SB (ONAPS-PAQ), and sleep quality (PSQI) were selected as independent clustering variables and transformed into Z-scores, as these variables do not share the same units and exhibit high variability. Leisure screen time was not retained as a clustering variable due to its conceptual and statistical overlap with SB, but was kept as a characterization variable to help, confirm the coherence of cluster once identified. Subsequently, the non-hierarchical K-means method (Hartigan-Wong algorithm) was applied [61]. Once the clusters were identified, ANOVAs were used to confirm that they were significantly different. The clusters were then characterized using ANOVAs applied to MH outcomes (Depression, Stress, Anxiety, General Composite Score, Autonomy Score, Competence Score, Relatedness Score, and Subjective Vitality) and to certain other behaviors and substance use (Leisure Screen Time, Alcohol Score, Tobacco Score, and Cannabis Score). In addition, effect sizes (Cohen's d) were calculated for each cluster comparison from the F-value and group sample sizes [62], interpreted according to Cohen's (1988) conventions: .20 (small) ; .50 (medium) and .80 (large). To finalize the characterization of the clusters, a χ^2 test was performed to examine the association between gender and cluster membership. When a significant association was observed, post hoc analyses based on standardized residual examination were conducted to identify categories specifically over or underrepresented within each cluster.

Binary logistic regression analysis

To address the third research question, a series of binary logistic regression analyses was conducted to examine the predictive role of gender and cluster membership on MH outcomes. Given the small number of individuals identifying as non-binary (0.8% of the sample), this group was excluded from these analyses. Consequently, gender was dichotomized (female vs. male) to ensure reliable estimates. Cluster membership (reference: Cluster 1) and gender (reference: male) were included simultaneously as categorical predictors in a single block. The outcome variables were dichotomized using the same coding across all measures (0 = favorable MH outcomes and 1 = adverse MH outcomes); however, the reference modality selected for the analyses differed between the two types of outcomes. For psychological distress, the reference modality was set to the favorable outcome, so the odds ratio (OR) represented the probability of having an adverse outcome (coded 1) compared to its absence (coded 0); an OR > 1 indicated an increased risk of psychological distress. For BPN scores, the reference modality was set to the adverse outcome (1 = BPN more frustrated than satisfied), so that the OR instead reflected the odds of reporting the favorable outcome (0 = BPN more satisfied or neutral than frustrated) relative to the adverse one, with an OR > 1 indicating an increased probability of having BPN that were

more satisfied (or neutral) than frustrated. The regression coefficients (B), standard error (SE), Z-statistic, p-values and OR with 95% confidence intervals were reported.

The various analyses were conducted using Jamovi (version 2.6.44.0) and RStudio (version 2022.12.0 + 353). The significance threshold was set at $p < .05$ for all statistical tests.

Results

Descriptives

Population characteristics and gender differences

The final sample comprised 2,340 students, whose characteristics are presented in Table 1. The mean weekly durations of MVPA exceeded the recommended levels, as did SB and leisure screen time. Mean sleep duration was very slightly below the recommended level. However, the mean sleep quality score exceeded the threshold level (Buysse et al., 1989), indicating poor sleep quality. Furthermore, marked gender differences were found in the duration of several 24-hour movement behaviors. Although no significant gender differences were found in MVPA, female students reported significantly higher levels of SB than male students. Similarly, leisure screen time was higher among non-binary and female students than among male students. Regarding sleep, although actual sleep duration did not differ significantly by gender, female students had significantly higher sleep quality scores than male students, indicating poorer sleep quality among females.

Table 1
Descriptive characteristics of the total sample and by gender, with ANOVA and post hoc

Variables	Total	Female	Male	Non-binary	F
Age (year) (n = 2,340)	20.94 ± 4.24	20.95 ± 4.37	20.90 ± 4.02	21.28 ± 4.40	.09
BMI (n = 2,340)	22.69 ± 3.90	22.40 ± 4.02	23.12 ± 3.52	24.76 ± 7.36 _c	11.96***
MVPA (min/week) (n = 2,294)	1283.93 ± 1079.72	1303.10 ± 1086.18	1253.85 ± 1067.40	1182.67 ± 1166.50	.63
SB (min/week) (n = 2,308)	3741.77 ± 1804.72	3850.76 ± 1838.46 ^a	3545.71 ± 1727.47	4246.39 ± 1902.35	8.39***
Sleep duration (h/night) (n = 2,340)	6.92 ± 1.49	6.89 ± 1.49	6.96 ± 1.45	7.5 ± 2.69	1.96
Sleep quality (0–21) (n = 2,340)	6.15 ± 3.22	6.5 ± 3.27 ^a	5.41 ± 2.95	6.94 ± 5.15	36.78***
Leisure Screen Time (min/day) (n = 1,963)	189.13 ± 134.18	194.50 ± 134.58 ^a	178.50 ± 131.50	257.65 ± 178.45 ^b	5.50**
Tobacco Score (0–6) (n = 2,340)	.28 ± .85	.36 ± .94 ^a	.15 ± .63	.39 ± .92	15.92***
Cannabis Score (0–6) (n = 2,340)	.15 ± .71	.12 ± .63	.20 ± .82 ^a	.22 ± .55	3.64***
Alcohol Score (0–40) (n = 2,340)	3.83 ± 4.79	2.97 ± 4.00	5.29 ± 5.60 ^a	4.33 ± 5.30	66.65***
Anxiety (0–42) (n = 2,340)	10.30 ± 9.39	12.13 ± 9.73 ^a	7.14 ± 7.73	13.44 ± 12.81 ^b	82.8***
Stress (0–42) (n = 2,340)	15.70 ± 10.30	18.09 ± 10.30 ^a	11.59 ± 8.88	16.56 ± 10.76	119.0***
Depression (0–42) (n = 2,340)	11.60 ± 10.50	13.02 ± 10.76 ^a	9.11 ± 9.44	16.78 ± 14.84	41.0***
Subjective Vitality (1–7) (n = 2,319)	4.29 ± 1.23	4.15 ± 1.23	4.55 ± 1.17 ^a	3.91 ± 1.48	29.70***
General Composite Score (-4; +4) (n = 2,340)	1.45 ± 1.30	1.38 ± 1.33	1.59 ± 1.22 ^a	.97 ± 1.64	8.59***
Autonomy Score (-4; +4) (n = 2,340)	.77 ± 1.48	.68 ± 1.52	0.93 ± 1.38 _{ab}	.08 ± 2.10	9.72***
Competence Score (-4; +4) (n = 2,340)	1.29 ± 1.81	1.15 ± 1.84	1.56 ± 1.70 ^a	.69 ± 2.05	14.98***

Variables	Total	Female	Male	Non-binary	F
Relatedness Score (-4; +4) (n = 2,340)	2.29 ± 1.49	2.30 ± 1.52	2.28 ± 1.43	2.12 ± 1.91	.16

p-value: $p < .05^*$; $p < .01^{**}$; $p < .001^{***}$

Note

Values in the “Mean” column are presented as mean ± SD. One-way ANOVA was used to compare groups by gender. Tukey’s post hoc test results are presented as follows: ^a = difference between female and male; ^b = difference between male and non-binary; ^c = difference between female and non-binary. MVPA = moderate to vigorous physical activity; SB = sedentary behavior. Leisure screen time had a higher proportion of missing responses than the other ONAPS-PAQ variables. The non-binary group comprised only 18 participants in the overall sample; therefore, results for this group should be interpreted with caution.

Prevalence of adherence to 24-hour movement guidelines and mental health risk (Question 1)

Adherence to the 24-hour movement behavior guidelines showed mixed results (see Fig. 1 and Additional file 3: Table S3). A very large majority of the sample met the MVPA guidelines and was therefore classified as physically active. In contrast, fewer than half of the students met the SB guidelines. Adherence rates for leisure screen time and sleep guidelines were 66.4% and 63.6%, respectively. However, only 22.9% of participants met all guidelines simultaneously. Furthermore, χ^2 tests revealed no association between gender and adherence to MVPA and SB guidelines (see Additional file 3: Table S3). In contrast, significant associations were observed between gender and adherence to leisure screen time and sleep guidelines. Moreover, analysis of standardized residuals showed that male students were significantly over-represented among students adhering to these guidelines (residual = + 2.56 for leisure screen time and + 2.41 for sleep) and under-represented among those not adhering to them. Conversely, female students were significantly overrepresented among those not adhering to these guidelines (residual = + 2.32 for leisure screen time and + 2.27 for sleep) and underrepresented among those adhering to them. However, these associations were small in magnitude, with Cramer’s V values all below .10 (see Additional file 4: Table S4).

Bars represent the percentage (%) of participants meeting guidelines for MVPA, SB, leisure screen time, sleep duration, and all four guidelines combined. Results are presented for male, female and non-binary participants, and for the total sample.

Regarding the prevalence of MH outcomes, the results are displayed in Fig. 2. and see Additional file 3: Table S3. A substantial proportion of students exhibited moderate to extremely severe symptoms of psychological distress, with 44.6% reporting anxiety symptoms, 36.1% reporting depressive symptoms, and 34.7% reporting stress symptoms. Furthermore, 13.4% of students reported greater frustration than

satisfaction of their BPN (General Composite Score ≤ 0). Moreover, marked gender disparities were observed: for anxiety, more than one in two female students exceeded the threshold compared with 28.1% of male students; for depression, 41.8% of female students exceeded the threshold compared with 26.1% of male students; and finally, for stress, 43.5% of female students exceeded the threshold compared with 19.4% of male students. With respect to BPN, 15.1% of female students had a General Composite Score ≤ 0 , compared with 10.3% of male students. In addition, χ^2 tests revealed significant associations between all MH outcomes and gender (see Additional file 3: Table S3). Analysis of standardized residuals showed that male students were significantly over-represented among those scoring below the significant thresholds for depression (residual = 7.64), anxiety (residual = 12.2), stress (residual = 11.8) and the General Composite Score (residual = 3.36) and under-represented among those exceeding these thresholds. Conversely, female students were significantly over-represented among students exceeding the significant thresholds (residuals = 7.38; 12.0; 11.6 and 3.14, respectively) and under-represented among those scoring below them. These associations were of moderate magnitude, with Cramer's V values ranging from .072 (General Composite Score) to .25 (anxiety) (see Additional file 5: Table S5).

The bars represent the percentage (%) of participants reporting moderate to extremely severe levels of anxiety, stress, and depression, as well as a General Composite Score below 0 (greater frustration than satisfaction of BPN). Outcomes are presented separately for male, female, non-binary participants, and for the total sample.

Clustering (Question 2)

Identification of clusters

The analyses indicated that most validation metrics pointed toward an optimal choice of two clusters. Subsequently, K-means analyses identified two distinct 24-hour behavior profiles (MVPA, SB, sleep quality). Cluster 1 comprised 1,250 participants (55.1% of the sample), while Cluster 2 comprised 1,017 participants (44.9% of the sample). The cluster plot (Fig. 3) showed a clear separation between the different groups, accounting for 71.9% of the explained variance (Dim1 = 37.6% and Dim2 = 34.3%). Furthermore, the two clusters appeared relatively compact and distinct with little overlap, supporting the validity of the clusters.

Validation of clusters

The mean values (Table 2) for the 24-hour movement behavior variables indicated that Cluster 1 was characterized by higher MVPA, lower SB and better sleep quality compared with Cluster 2. ANOVAs confirmed that the two clusters differed significantly on the dependent variables used for clustering, clearly indicating two distinct 24-hour movement behavior profiles within this university student population. Effect sizes for these variables were large, indicating differences of substantial practical significance beyond their statistical significance.

Table 2
Mean values of the 24-hour movement behaviors of the clusters and ANOVA results

	Cluster	N	Mean	Standard error	F	Cohen's d
MVPA (min/week)	1	1250	1574.05 ± 1159.37	32.80	232***	.62
	2	1017	932.02 ± 846.02	26.53		
SB (min/week)	1	1250	2758.15 ± 1253.25	35.45	1212***	1.47
	2	1017	4911.26 ± 1616.30	50.68		
Sleep quality (0–21)	1	1250	4.56 ± 2.46	.07	885***	1.26
	2	1017	8.02 ± 2.97	.09		

p-value: p<.05*; p<.01; p<.001*****

Note

The “Mean” column reports mean ± SD. One-way ANOVA was used to compare clusters

MVPA = moderate to vigorous physical activity; SB = sedentary behavior.

Characterization of clusters

Further analyses were carried out to characterize the identified clusters in greater detail. Table 3 presents the mean values for variables relating to substance use and MH outcomes. Cluster 1 exhibited the most favorable indicators: lower leisure screen time, lower scores for cannabis and alcohol use, lower scores for anxiety, stress and depression, higher subjective vitality and higher scores for BPN, compared with Cluster 2. In contrast, Cluster 2 exhibited less favorable patterns of substance use, leisure screen time and MH outcomes. ANOVA analyses confirmed that the two clusters differed significantly for all dependent variables except the tobacco use score, clearly indicating two distinctly different profiles of MH and substance use within the study population. Effect sizes were small for alcohol and cannabis scores but moderate to large for leisure screen time and MH outcomes.

Table 3

Leisure screen time, substance use and mental health outcomes by clusters and ANOVA results

	Cluster	N	Mean	Standard error	F	Cohen's d
Leisure Screen Time (min/day)	1	962	138.79 ± 83.66	2.70	304.38***	.80
	2	953	231.98 ± 142.33	4.61		
Tobacco Score (0–6)	1	1250	.26 ± .81	.02	2.05	.06
	2	1017	.31 ± .89	.03		
Cannabis Score (0–6)	1	1250	.11 ± .58	.02	11.92***	.15
	2	1017	.21 ± .85	.03		
Alcohol Score (0–40)	1	1250	3.66 ± 4.72	.13	5.27*	.10
	2	1017	4.12 ± 4.86	.15		
Depression (0–42)	1	1250	8.78 ± 9.08	.26	199.51***	.60
	2	1017	14.88 ± 11.08	.35		
Anxiety (0–42)	1	1250	7.94 ± 8.29	.23	179.87***	.57
	2	1017	13.14 ± 9.84	.31		
Stress (0–42)	1	1250	12.88 ± 9.49	.27	220.46***	.63
	2	1017	19.10 ± 10.20	.32		
Subjective Vitality (1–7)	1	1240	4.62 ± 1.13	.03	210.53***	.62
	2	1006	3.89 ± 1.22	.04		
General Composite Score (-4; +4)	1	1250	1.79 ± 1.17	.03	196.14***	.59
	2	1017	1.05 ± 1.33	.04		
Autonomy Score (-4; +4)	1	1250	1.11 ± 1.35	.04	147.54***	.51
	2	1017	.37 ± 1.51	.05		
Competence Score (-4; +4)	1	1250	1.74 ± 1.62	.05	181.70***	.57
	2	1017	.74 ± 1.86	.06		
Relatedness Score (-4; +4)	1	1250	2.52 ± 1.38	.04	60.35***	.33
	2	1017	2.03 ± 1.59	.05		

p-value: $p < .05^*$; $p < .01^{**}$; $p < .001^{***}$

Note: The “Mean” column reports mean $\pm$ SD. One-way ANOVA was used to compare clusters

In addition, contingency tables were produced to examine the distribution by gender according to the clusters (see Table 4). The results of the χ^2 tests indicated significant association between gender and cluster membership. Thus, the post hoc analysis of standardized residuals revealed that females were distributed relatively evenly across the two clusters (Cluster 1: 51.2% vs Cluster 2: 48.8%), unlike males, who were predominantly in Cluster 1 (62.2% vs 37.8%). For non-binary individuals, the distribution was reversed, with a large majority in Cluster 2. The observed effect sizes by gender appear small (Cramer's $V = .12$), indicating significant but small-scale associations (see Additional file 6:Table S6).

Table 4
Breakdown by gender according to clusters.

Variables	Modality	Cluster 1 n (%)	Cluster 2 n (%)	χ^2 (df)	p-value	Cramer's V
Gender	Female	721 (51.2%) ^a	686 (48.8%) ^a	31.2 (2)	< .001	.12
	Male	524 (62.2%) ^a	318 (37.8%) ^a			
	Non-binary	5 (27.8%) ^a	13 (72.2%) ^a			

Post hoc results: ^a = significant deviation between observed and expected frequencies ($|z| > 1.96$; $p < .05$).

Binary logistic regressions (Question 3)

The results of binary logistic regressions are presented in Table 5. The results indicated that membership of Cluster 2 (a less favorable profile) and being female were consistent predictors of an increased risk of poor MH, reflected in indicators of increased psychological distress and reduced well-being. With respect to cluster membership, students in Cluster 2 had significantly higher odds of reporting critical levels of depression, anxiety and stress than students in Cluster 1. Conversely, membership of Cluster 2 was associated with significantly lower probability of having more satisfied (or neutral) than frustrated BPN scores. This negative association was observed for all BPN: autonomy, competence, and relatedness. In terms of gender, females were significantly more likely to report critical symptoms of depression, anxiety and stress. Similarly, being female was also associated with lower probability of having more satisfied (or neutral) than frustrated BPN. These associations were all significant, except for relatedness.

Table 5
Binary logistic regressions for mental health (Female vs Male; Cluster)

Predictor	B	SE	Z	p-value	OR (95% CI)
<i>Depression</i>					
Intercept	-1.52	.09	-16.39	< .001	.22 (.18-.26)
Cluster (2 vs 1)	1.06	.09	11.57	< .001	2.90 (2.42–3.47)
Female vs Male	.62	.10	6.27	< .001	1.85 (1.53–2.25)
<i>Anxiety</i>					
Intercept	-1.33	.09	-14.96	< .001	.26 (.22-.31)
Cluster (2 vs 1)	.90	.09	10.04	< .001	2.46 (2.06–2.94)
Female vs Male	1.06	.10	11.11	< .001	2.90 (2.40–3.49)
<i>Stress</i>					
Intercept	-1.90	.10	-18.67	< .001	.15 (.12-.18)
Cluster (2 vs 1)	1.02	.09	10.89	< .001	2.79 (2.32–3.35)
Female vs Male	1.14	.10	10.86	< .001	3.14 (2.55–3.86)
<i>General Composite Score</i>					
Intercept	2.91	.15	19.65	< .001	18.30 (13.69–24.46)
Cluster (2 vs 1)	-1.36	.14	-9.78	< .001	.26 (0.19-.34)
Female vs Male	– .36	.14	-2.56	.01	.70 (.53-.92)
<i>Autonomy Score</i>					
Intercept	1.75	.10	17.48	< .001	5.78 (4.73–6.99)
Cluster (2 vs 1)	– .93	.10	-9.18	< .001	.40 (.32-.48)
Female vs Male	– .34	.11	-3.18	.001	.71 (.58-.88)
<i>Competence Score</i>					
Intercept	2.12	.11	18.97	< .001	8.37 (6.72–10.42)
Cluster (2 vs 1)	-1.00	.11	-9.36	< .001	.37 (.23-.45)
<i>Note: For psychological distress scores, the reference modality is the favorable outcome (0); estimates represent the log-odds of the adverse outcome (1) relative to the favorable one, and an OR > 1 indicates a higher risk of psychological distress. For BPNSFS scores, the reference modality is the adverse outcome (1); estimates represent the log-odds of the favorable outcome (0) relative to the adverse one, and an OR < 1 indicates a reduced probability of BPN being more satisfied (or neutral) than frustrated. Reference: Male and Cluster 1.</i>					

Predictor	B	SE	Z	p-value	OR (95% CI)
Female vs Male	– .48	.11	-4.14	< .001	.62 (.50-.78)
<i>Relatedness Score</i>					
Intercept	2.98	.16	18.23	< .001	19.65 (14.27–27.07)
Cluster (2 vs 1)	– .74	.16	-4.59	< .001	.48 (.35-.66)
Female vs Male	– .21	.17	-1.22	.22	.81 (.58-1.13)
<i>Note: For psychological distress scores, the reference modality is the favorable outcome (0); estimates represent the log-odds of the adverse outcome (1) relative to the favorable one, and an OR > 1 indicates a higher risk of psychological distress. For BPNSFS scores, the reference modality is the adverse outcome (1); estimates represent the log-odds of the favorable outcome (0) relative to the adverse one, and an OR < 1 indicates a reduced probability of BPN being more satisfied (or neutral) than frustrated. Reference: Male and Cluster 1.</i>					

Discussion

The aim of this study was to address three key questions: the prevalence of adherence to the 24-hour movement behaviors and the MH outcomes; the existence of distinct university student profiles based on 24-hour movement behaviors; and finally, the links between these profiles and MH outcomes.

Overview of the prevalence of adherence to 24-hour movement behaviors among European university students (Question 1)

Overall, the results revealed contrasting prevalence: although university students were largely active, they were often sedentary and had difficulty adhering simultaneously to all movement behavior guidelines. This high MVPA compliance is a surprising finding compared with the study by Weatherson et al., (2021) [32] who reported that 61.1% of students met these guidelines, with a mean duration of 283.6 min/week. This discrepancy could be partly explained by the data cleaning method, as this Canadian study applies a truncation rule capping any MVPA exceeding 180 min/day, which we chose not to apply, as it seems entirely possible for a university student to report more than 3 h/day of MVPA (e.g. if they are studying sports, participate in a club sport and/or engage in active travel). Furthermore, self-reported tools assess personal perception of their PA levels and thus exhibit certain biases, such as recall bias or social desirability bias [63], which may explain why MVPA prevalence rates are higher when self-reported than those from accelerometry-based measures [64]. Nevertheless, regarding SB, adherence remained markedly lower than for MVPA, and below the rate in the Canadian study (56.3%) ([32]. However, other studies using objective measurements such as accelerometry reported higher durations, ranging from 9 to 11 h/day [28, 65], highlighting a discrepancy between self-reported and objective durations [29], which suggests that compliance with this guideline may be overestimated. Furthermore, regarding leisure screen time, adherence was markedly higher than in the study by Weatherson et al., (2021) [32], where only 36.2% of students met the guideline. These results confirm that high MVPA does not guarantee low SB. Although these two behaviors are interdependent within a shared 24-hour timeframe, the data show

that they can coexist. Indeed, although students report high levels of MVPA, they adopt highly sedentary habits, imposed by the nature of academic work (lectures, revision, etc.) but also due to the significant time spent on leisure screens, accounting for around a third of students' SB [30]. These results align with the "Active Couch Potato" phenomenon: being simultaneously active and sedentary [66]. According to Lepp & Barkley, (2019) [67], smartphone use was significantly associated with this profile, with each additional hour per day associated with an 11.4% higher probability of also being classified as very sedentary (> 8h/day). This contradiction could have consequences for their physical health [29, 68] as well as MH [69], making it essential to implement targeted actions to reduce SB [70] particularly the use of leisure screens. Finally, regarding sleep guidelines, despite an adherence rate above 60%, sleep quality appears impaired, with a mean score above the critical threshold, indicating poor-quality sleep [46]. Sleep quality may be compromised for several reasons, such as screen use in the evening, exposure to stress, or exam periods [71, 72]. Furthermore, good-quality sleep is associated with improvements in mental well-being [36]. Finally, when all guidelines are considered together, only 22.9% of European students complied simultaneously, a rate nevertheless higher than the 9.9% reported in the Canadian national study [32]. It therefore seems essential to adopt a comprehensive approach based on the 24-hour paradigm: replacing SB (such as leisure screen use) with sleep or even light PA, which would have beneficial effects on physical health and MH [73].

Furthermore, it is worth highlighting gender differences in movement behaviors over a 24-hour period. While no significant gender differences in MVPA were found in the results, regarding SB, leisure screen time and sleep, female students adhered less to the guidelines than male students. They were significantly more sedentary (although there was no difference in adherence to the guideline), spent significantly more time in front of screens, and had poorer sleep quality compared to their male counterparts. These gender-specific patterns indicated greater difficulties in achieving healthier and more balanced movement behavior patterns over a 24-hour period among female students compared to male students, highlighting the need for targeted intervention in this population.

Overview of mental health outcomes among European university students: alert regarding female students (Question 1)

Analysis of our sample points to a deeply concerning situation regarding the psychological distress of European students in line with the global trend observed. A Europe-wide survey shows similar, though slightly lower, prevalence: around 33% of university students report MH problems, mainly depressive and anxiety disorders [7]. Moreover, a worldwide meta-analysis shows lower prevalence for European countries than in the present study: 35.9% for anxiety and 24.1% for depression [58]. These differences could be explained by the methodological heterogeneity of meta-analysis, as well as its period of data collection (2004–2021), which does not reflect the current situation of university students in terms of MH. These worrying figures can partly be explained by a social and environmental context that is a source of concern for young people, particularly with regard to international current affairs,

environmental and climate issues, or their own personal future [74]. However, this worrying picture of psychological distress coexists with a more nuanced picture of well-being, in line with the dual continuum model of MH [8], whereby psychological distress and well-being represent related but distinct dimensions rather than opposite ends of a single continuum. Thus, regarding subjective vitality, in the present study, the sample had a moderate mean score, suggesting that university students retain a relative sense of energy and vitality despite their high level of distress. Regarding BPN, the General Composite Score was positive with most university students having a score ≥ 0 , indicating that a majority perceived their BPN as more satisfied (or neutral) than frustrated, but 13.4% had an inverse balance. A closer look at the three BPN reveals that the relatedness need was the most satisfied, suggesting that students generally felt connected to others in their environment. For the competence need, a lower mean composite score was observed, reflecting a moderate sense of effectiveness. Regarding the autonomy need, the mean composite score was the lowest, reflecting a lack of perceived autonomy or a feeling of being controlled. Nishimura & Suzuki, (2016) [75] highlighted that BPN satisfaction predicts well-being and vitality, but that BPN frustration also uniquely predicts depressive affects among Japanese students. Thus, if we rely on these results, to optimize student MH, promoting well-being (and therefore the satisfaction of BPN) is not sufficient; we must also take into account the frustration of BPN, because it directly and independently negatively impacts MH [75].

Moreover, a major and significant difference is observed between the genders for almost all MH outcomes, with female students consistently exhibiting a higher prevalence of anxiety, stress and depression symptoms than male students. More than one in two female students suffered from anxiety (54.1%), which represents a considerable proportion. This disparity also seems to extend to indicators of well-being, where the BPN of 15.1% of female students were more frustrated than satisfied, compared to 10.3% of male students. In more detail, the composite scores for autonomy and competence were significantly lower among female students than among male students, indicating that these BPN were more proportionally frustrated than satisfied among female students. However, the relatedness need did not show any significant difference between genders. These results are consistent with the findings in the literature, which highlight a gender difference in the satisfaction of autonomy and competence needs [76].

Identification of existing profiles among European university students and variations in mental health: a striking dichotomy (Question 2 and 3)

Clustering analyses revealed two significantly distinct profiles within the sample studied, dividing it almost equally: Cluster 1 (55.1% of the sample) corresponded to a favorable 24-hour movement behavior profile (MVPA, SB and sleep quality), and Cluster 2 (44.9%) corresponded to an unfavorable profile. Characterization of the clusters using indicators of substance use, leisure screen use and MH outcomes showed that Cluster 2 stood out unfavorably across all these indicators. Indeed, Cluster 2 exhibited more pronounced psychological distress, as well as lower indicators of well-being. Furthermore, Cluster 2 had higher leisure screen time and substance use scores (alcohol, cannabis) than Cluster 1. These results appear to be consistent with recent literature on 24-hour movement behaviors and MH [73, 77]. Thus, the

study by Maitiniyazi et al. (2025) [77], involving Chinese students, identified the “Negative Engagement” profile (characterized by low MVPA and high SB) as the profile associated with the highest levels of psychological distress. Furthermore, the binary logistic regressions carried out in our study highlighted that, compared to the favorable profile (Cluster 1), membership of the unfavorable profile (Cluster 2) was consistently associated with markedly higher odds of psychological distress across all three indicators, as well as with a substantially reduced likelihood of a favorable BPN balance. These results are consistent with the systematic review by Groves et al., (2024) [73], which examines the links between 24-hour movement behaviors and MH across the lifespan, indicating that the healthiest combination (adequate sleep, high MVPA and low SB) is systematically associated with better MH outcomes.

Finally, it is worth noting that female students were significantly overrepresented in Cluster 2 compared to male students (48.8% vs. 37.8%). This cluster corresponds to the unfavorable behavioral profile, associated with an increased risk of psychological distress in all three dimensions (as previously discussed). Even more striking, the results reveal that female gender, regardless of movement behavior profile, is associated with a significantly higher probability of psychological distress, with a risk up to nearly three times higher for anxiety and stress, and about twice as high for depression. In the same vein, female gender was associated with a lower probability of having more satisfied than frustrated BPN. Specifically, females had a reduced probability of 38% for the competence need, 29% for the autonomy need and 30% for the general level. The relatedness need was the only BPN for which gender did not appear to be a significant predictor, which suggests that relatedness may function more independently of gender than the other BPN. These results raise a crucial question regarding the need for intervention with female students who have an unfavorable movement behavior profile, as they combine two potential risk factors for their MH: their movement behaviors and their gender. However, the fact that this gender effect persists regardless of profile suggests that other mechanisms, independent of movement behaviors, should be explored to better explain this MH disparity.

Limitation

This study has certain limitations that are important to note. Firstly, all variables are based on self-reported measures, which may lead to discrepancies between perception and reality due to bias, particularly regarding behaviors (MVPA, SB and leisure screen time) [29, 63, 64]. Consequently, future studies could incorporate objective methods, such as accelerometry or the use of tracking software, to obtain a more detailed assessment of 24-hour movement patterns. Furthermore, as participants were recruited on a voluntary basis, we cannot rule out a self-selection bias, which may have led to an overrepresentation of students who were already aware of health-related behaviors. In addition, the unequal distribution of participants across countries may have introduced heterogeneity within the sample; country-specific analyses would constitute a relevant avenue for future research. Factors related to studies, such as student’s year of study or field of study were not controlled, so we believe they should be considered in this future research. Thirdly, to assess nicotine dependence, this study used the simplified Fagerström test. Although it has demonstrated sufficient validity [78], its limited number of

items may restrict the accuracy of the assessment of dependence compared with the full Fagerström scale [79]. Moreover, the cross-sectional nature of this study does not allow for the identification of causal links between movement behaviors and students' MH. Furthermore, these behaviors and psychological indicators vary significantly throughout university life (exam periods, seasons, internships, future deadlines, etc.) [80]. Measurements taken at a single point in time provide only a snapshot of students' behaviors and MH. For a more robust analysis, it would be appropriate to adopt longitudinal designs in future research, enabling the tracking of changes in movement behaviors and refining the validity of the results. Finally, the data collected on movement behaviors rely mainly on quantitative measures, whereas their psychological effects also depend on the qualitative aspects of these behaviors. Although sleep was also assessed using a quality-related variable, qualitative data is lacking, particularly regarding SB and leisure screen time. Incorporating qualitative criteria into future research would help refine our understanding of the links between 24-hour behaviors and MH.

Conclusion

Firstly, our results indicated mixed patterns of adherence to 24-hour movement behavior guidelines: European university students were mostly active but had high levels of SB; sleep duration was acceptable, but quality was affected, and compliance with all guidelines was limited. Secondly, this study highlights a deeply concerning situation regarding MH, with alarming levels of psychological distress despite comparatively favorable indicators of well-being. Furthermore, clustering analyses divided this population into two distinct movement behavior profiles, and binary logistic regression analyses confirmed that belonging to the unfavorable profile was significantly associated with poorer MH. These associations highlight the need to integrate these behavioral habits into strategies for promoting university students' MH. Finally, the results reveal an increased vulnerability among female students, both in terms of movement behaviors and MH. These findings highlight the need to develop targeted interventions that integrate 24-hour movement behaviors and MH, to address the observed inequalities and promote a sustainable balance between physical health and MH. Thus, universities could contribute by implementing health promotion strategies, including sleep health programs, opportunities to reduce SB during classes (e.g. active breaks or sit-stand workstations), and training in more intentional digital use (e.g. managing notifications, leisure screen time or digital pauses).

Abbreviations

AUDIT

Alcohol Use Disorders Identification Test

BMI

Body mass index

BPN

Basic psychological need(s)

CAST

Cannabis Abuse Screening Test

DASS-21
Depression Anxiety Stress Scales – 21-item version
GPAQ
Global Physical Activity Questionnaire
IPAQ
International Physical Activity Questionnaire
MH
Mental health
MVPA
Moderate to vigorous physical activity
ONAPS-PAQ
ONAPS Physical Activity Questionnaire
OR
Odds Ratio
PA
Physical activity
PSQI
Pittsburgh Sleep Quality Index
SB
Sedentary behavior
SDT
Self-determination theory
SVS
Subjective Vitality Scale
UNITA
Universitas Montium (European Universities Alliance)
WHO
World Health Organization

Declarations

Ethics approval and consent to participate

This study was validated by the Ethics Committee for Research in Sports and Exercise Sciences (CERSTAPS), established under the auspices of the French Conference of Directors and Deans of STAPS (C3D) and the 74th section of the National Council of Universities (CNU), France. The project was carried out by the MEPS laboratory (UR 4445, Mouvement, Equilibre, Performance et Santé) of the University of Pau et les Pays de l'Adour (UPPA) and received a favorable opinion from CERSTAPS on October 14, 2024 (IRB registration number: IRB00012476-2024-14-10-345). CERSTAPS is officially recognized by the Office for Human Research Protections (OHRP) of the United States.

Consent for publication

Informed consent was obtained from all participants before they completed the online questionnaire. At the beginning of the survey, participants were informed about the processing of their personal data, in accordance with Law No. 78 – 17 of 6 January 1978 relating to information technology, files and freedoms. Participants had to actively select *“I authorize the University of Pau et les Pays de l'Adour to collect and use the information provided in this form in accordance with the above data protection information”*.

Funding

This work was supported by a cross-border grant from the University of Pau et des Pays de l'Adour (UPPA) and the University of Zaragoza (UNIZAR), and the UNITA Alliance and the Erasmus + funding, and by the European Union-NextGeneration EU, Mission 4 Component 1 CUP D82B23004200001

Author Contribution

A.L. conducted the data collection, carried out the statistical analyses, and wrote the manuscript. L.L., J.B. and A.A.S. reviewed and corrected the present manuscript. All authors have read, revised and approved the final manuscript.

Acknowledgement

Not applicable

Data Availability

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

References

1. World Health Organization. Mental Health Determinants and Populations. Mental health atlas : 2005. World Health Organization; 2005.
2. Daniel Eisenberg. Sarah Ketchen Lipson, Justin Heinze, Sasha Zhou. Healthy Minds Study 2023–2024 Data Report. Healthy Minds Netw; 2024.
3. The Lancet Global Health. Mental health matters. Lancet Glob Health. 2020;8:e1352. [https://doi.org/10.1016/S2214-109X\(20\)30432-0](https://doi.org/10.1016/S2214-109X(20)30432-0).

4. Auerbach RP, Alonso J, Axinn WG, Cuijpers P, Ebert DD, Green JG, et al. Mental disorders among college students in the World Health Organization World Mental Health Surveys. *Psychol Med*. 2016;46:2955–70. <https://doi.org/10.1017/S0033291716001665>.
5. Auerbach RP, Mortier P, Bruffaerts R, Alonso J, Benjet C, Cuijpers P, WHO World Mental Health Surveys International College Student Project, et al. Prevalence and distribution of mental disorders. *J Abnorm Psychol*. 2018;127:623–38. <https://doi.org/10.1037/abn0000362>.
6. Oliveira Carvalho P, Hülsdünker T, Carson F. The Impact of the COVID-19 Lockdown on European Students' Negative Emotional Symptoms: A Systematic Review and Meta-Analysis. *Behav Sci*. 2022;12:3. <https://doi.org/10.3390/bs12010003>.
7. Cuppen J, Muja A, Geurts R. Well-being and mental health among students in European higher education. 2024;EUROSTUDENT 8 Topical module report.
8. Keyes CLM. The mental health continuum: from languishing to flourishing in life. *J Health Soc Behav*. 2002;43:207–22.
9. Ryan RM, Frederick C. On Energy, Personality, and Health: Subjective Vitality as a Dynamic Reflection of Well-Being. *J Pers*. 1997;65:529–65. <https://doi.org/10.1111/j.1467-6494.1997.tb00326.x>.
10. Deci EL, Ryan RM. *Intrinsic Motivation and Self-Determination in Human Behavior*. Boston, MA: Springer US; 1985. <https://doi.org/10.1007/978-1-4899-2271-7>.
11. Ryan RM, Deci EL. *Self-Determination Theory and the Facilitation of Intrinsic Motivation, Social Development, and Well-Being*. 2000.
12. Deci EL, Ryan RM. The What and Why of Goal Pursuits: Human Needs and the Self-Determination of Behavior. *Psychol Inq*. 2000;11:227–68. https://doi.org/10.1207/S15327965PLI1104_01.
13. Vansteenkiste M, Niemiec CP, Soenens B. The development of the five mini-theories of self-determination theory: an historical overview, emerging trends, and future directions. In: Urdan TC, Karabenick SA, editors. *The Decade Ahead: Theoretical Perspectives on Motivation and Achievement*. Emerald Group Publishing Limited; 2010. [https://doi.org/10.1108/S0749-7423\(2010\)000016A007](https://doi.org/10.1108/S0749-7423(2010)000016A007).
14. Vansteenkiste M, Ryan RM. On psychological growth and vulnerability: Basic psychological need satisfaction and need frustration as a unifying principle. *J Psychother Integr*. 2013;23:263–80. <https://doi.org/10.1037/a0032359>.
15. Sundqvist AJE, Nyman-Kurkiala P, Ness O, Hemberg J. The influence of educational transitions on loneliness and mental health from emerging adults' perspectives. *Int J Qual Stud Health Well-Being*. 2024;19:2422142. <https://doi.org/10.1080/17482631.2024.2422142>.
16. Winpenny EM, Smith M, Penney T, Foubister C, Guagliano JM, Love R, et al. Changes in physical activity, diet, and body weight across the education and employment transitions of early adulthood: A systematic review and meta-analysis. *Obes Rev*. 2020;21:e12962. <https://doi.org/10.1111/obr.12962>.
17. Arria AM, Caldeira KM, O'Grady KE, Vincent KB, Fitzelle DB, Johnson EP, et al. Drug exposure opportunities and use patterns among college students: Results of a longitudinal prospective cohort

- study. *Subst Abuse Off Publ Assoc Med Educ Res Subst Abuse*. 2008;29:19–38.
<https://doi.org/10.1080/08897070802418451>.
18. La Torre G, Kirch W, Bes-Rastrollo M, Ramos RM, Czaplicki M, Gualano MR, et al. Tobacco use among medical students in Europe: Results of a multicentre study using the Global Health Professions Student Survey. *Public Health*. 2012;126:159–64.
<https://doi.org/10.1016/j.puhe.2011.10.009>.
 19. Cooke R, Beccaria F, Demant J, Fernandes-Jesus M, Fleig L, Negreiros J, et al. Patterns of alcohol consumption and alcohol-related harm among European university students. *Eur J Public Health*. 2019;29:1125–9. <https://doi.org/10.1093/eurpub/ckz067>.
 20. Davoren MP, Demant J, Shiely F, Perry IJ. Alcohol consumption among university students in Ireland and the United Kingdom from 2002 to 2014: a systematic review. *BMC Public Health*. 2016;16:173.
<https://doi.org/10.1186/s12889-016-2843-1>.
 21. Hatch MR, Bravo AJ, Looby A, Hurlocker MC. Who's at greatest risk? Latent profiles of alcohol and cannabis use and related consequences among college students. *Addict Behav*. 2023;137:107536.
<https://doi.org/10.1016/j.addbeh.2022.107536>.
 22. Sokolovsky AW, Rubenstein D, Gunn RL, White HR, Jackson KM. Associations of daily alcohol, cannabis, combustible tobacco, and e-cigarette use with same-day co-use and poly-use of the other substances. *Drug Alcohol Depend*. 2023;251:110922.
<https://doi.org/10.1016/j.drugalcdep.2023.110922>.
 23. Chaput J-P, Carson V, Gray CE, Tremblay MS. Importance of all movement behaviors in a 24 hour period for overall health. *Int J Environ Res Public Health*. 2014;11:12575–81.
<https://doi.org/10.3390/ijerph111212575>.
 24. Ross R, Chaput J-P, Giangregorio LM, Janssen I, Saunders TJ, Kho ME, et al. Canadian 24-Hour Movement Guidelines for Adults aged 18–64 years and Adults aged 65 years or older: an integration of physical activity, sedentary behaviour, and sleep. *Appl Physiol Nutr Metab*. 2020;45(10):S57–102.
<https://doi.org/10.1139/apnm-2020-0467>.
 25. Caspersen CJ, Powell KE, Christenson GM. Physical activity, exercise, and physical fitness: definitions and distinctions for health-related research. *Public Health Rep Wash DC* 1974. 1985;100:126–31.
 26. Bull FC, Al-Ansari SS, Biddle S, Borodulin K, Buman MP, Cardon G, et al. World Health Organization 2020 guidelines on physical activity and sedentary behaviour. *Br J Sports Med*. 2020;54:1451–62.
<https://doi.org/10.1136/bjsports-2020-102955>.
 27. Pengpid S, Peltzer K, Samuels T, Gasparishvili A. Factors associated with self-rated health status among university students from 26 low, middle and high income countries. *J Psychol Afr*. 2015;25:448–53. <https://doi.org/10.1080/14330237.2015.1101274>.
 28. Keating R, Ahern S, Bisgood L, Mernagh K, Nicolson GH, Barrett EM. Stand up, stand out. Feasibility of an active break targeting prolonged sitting in university students. *J Am Coll Health*. 2022;70:2237–43. <https://doi.org/10.1080/07448481.2020.1847119>.

29. Castro O, Bennie J, Vergeer I, Bosselut G, Biddle SJH. How Sedentary Are University Students? A Systematic Review and Meta-Analysis. *Prev Sci*. 2020;21:332–43. <https://doi.org/10.1007/s11121-020-01093-8>.
30. Carpenter C, Byun S-E, Turner-McGrievy G, West D. An Exploration of Domain-Specific Sedentary Behaviors in College Students by Lifestyle Factors and Sociodemographics. *Int J Environ Res Public Health*. 2021;18:9930. <https://doi.org/10.3390/ijerph18189930>.
31. Spyridonidis S, Lad D, Peters H, Ellis J, Robinson LJ. Global prevalence of insomnia symptoms in undergraduate university students: a systematic review and meta-analysis. *Sleep Adv J Sleep Res Soc*. 2025;6:zpaf083. <https://doi.org/10.1093/sleepadvances/zpaf083>.
32. Weatherson KA, Joopally H, Wunderlich K, Kwan MYW, Tomasone JR, Faulkner G. Post-secondary students' adherence to the Canadian 24-Hour Movement Guidelines for Adults: Results from the first deployment of the Canadian Campus Wellbeing Survey (CCWS). *Health Promot Chronic Dis Prev Can*. 2021;41:173–81. <https://doi.org/10.24095/hpcdp.41.6.01>.
33. Schuch FB, Vancampfort D, Firth J, Rosenbaum S, Ward PB, Silva ES, et al. Physical Activity and Incident Depression: A Meta-Analysis of Prospective Cohort Studies. *Am J Psychiatry*. 2018;175:631–48. <https://doi.org/10.1176/appi.ajp.2018.17111194>.
34. Schuch FB, Stubbs B, Meyer J, Heissel A, Zech P, Vancampfort D, et al. Physical activity protects from incident anxiety: A meta-analysis of prospective cohort studies. *Depress Anxiety*. 2019;36:846–58. <https://doi.org/10.1002/da.22915>.
35. Keles B, McCrae N, Grealish A. A systematic review: the influence of social media on depression, anxiety and psychological distress in adolescents. *Int J Adolesc Youth*. 2020;25:79–93. <https://doi.org/10.1080/02673843.2019.1590851>.
36. Scott AJ, Webb TL, Martyn-St James M, Rowse G, Weich S. Improving sleep quality leads to better mental health: A meta-analysis of randomised controlled trials. *Sleep Med Rev*. 2021;60:101556. <https://doi.org/10.1016/j.smrv.2021.101556>.
37. Hysing M, Harvey AG, Skrando Knudsen AK, Skogen JC, Reneflot A, Sivertsen B. Mind at rest, mind at risk: A prospective population-based study of sleep and subsequent mental disorders. *Sleep Med X*. 2025;9:100138. <https://doi.org/10.1016/j.sleepx.2025.100138>.
38. Lindsay JAB, McGowan NM, King N, Rivera D, Li M, Byun J, et al. Psychological predictors of insomnia, anxiety and depression in university students: potential prevention targets. *BJPsych Open*. 2022;8:e86. <https://doi.org/10.1192/bjo.2022.48>.
39. Li D, Li X. Independent and Combined Associations between Physical Activity and Sedentary Time with Sleep Quality among Chinese College Students. *Int J Environ Res Public Health*. 2022;19:6697. <https://doi.org/10.3390/ijerph19116697>.
40. Ottevaere C, Huybrechts I, Benser J, De Bourdeaudhuij I, Cuenca-Garcia M, Dallongeville J, et al. Clustering patterns of physical activity, sedentary and dietary behavior among European adolescents: The HELENA study. *BMC Public Health*. 2011;11:328. <https://doi.org/10.1186/1471-2458-11-328>.

41. Charles M, Thivel D, Verney J, Isacco L, Husu P, Vähä-Ypyä H, et al. Reliability and Validity of the ONAPS Physical Activity Questionnaire in Assessing Physical Activity and Sedentary Behavior in French Adults. *Int J Environ Res Public Health*. 2021;18. <https://doi.org/10.3390/ijerph18115643>.
42. Armstrong T, Bull F. Development of the World Health Organization Global Physical Activity Questionnaire (GPAQ). *J Public Health*. 2006;14:66–70. <https://doi.org/10.1007/s10389-006-0024-x>.
43. Craig CL, Marshall AL, Sjöström M, Bauman AE, Booth ML, Ainsworth BE, et al. International physical activity questionnaire: 12-country reliability and validity. *Med Sci Sports Exerc*. 2003;35:1381–95. <https://doi.org/10.1249/01.MSS.0000078924.61453.FB>.
44. Bull FC, Maslin TS, Armstrong T. Global physical activity questionnaire (GPAQ): nine country reliability and validity study. *J Phys Act Health*. 2009;6:790–804. <https://doi.org/10.1123/jpah.6.6.790>.
45. Sember V, Meh K, Sorić M, Starc G, Rocha P, Jurak G. Validity and Reliability of International Physical Activity Questionnaires for Adults across EU Countries: Systematic Review and Meta Analysis. *Int J Environ Res Public Health*. 2020;17:7161. <https://doi.org/10.3390/ijerph17197161>.
46. Buysse DJ, Reynolds CF, Monk TH, Berman SR, Kupfer DJ. The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research. *Psychiatry Res*. 1989;28:193–213. [https://doi.org/10.1016/0165-1781\(89\)90047-4](https://doi.org/10.1016/0165-1781(89)90047-4).
47. Carpi M. The Pittsburgh Sleep Quality Index: a brief review. *Occup Med*. 2025;75:14–5. <https://doi.org/10.1093/occmed/kqae121>.
48. Legleye S, Karila L, Beck F, Reynaud M. Validation of the CAST, a general population Cannabis Abuse Screening Test. *J Subst Use*. 2007;12:233–42. <https://doi.org/10.1080/14659890701476532>.
49. Saunders JB, Aasland OG, Babor TF, De La Fuente JR, Grant M. Development of the Alcohol Use Disorders Identification Test (AUDIT): WHO Collaborative Project on Early Detection of Persons with Harmful Alcohol Consumption-II. *Addiction*. 1993;88:791–804. <https://doi.org/10.1111/j.1360-0443.1993.tb02093.x>.
50. Reinert DF, Allen JP. The Alcohol Use Disorders Identification Test: An Update of Research Findings. *Alcohol Clin Exp Res*. 2007;31:185–99. <https://doi.org/10.1111/j.1530-0277.2006.00295.x>.
51. Heatherton TF, Kozlowski LT, Frecker RC, Rickert W, Robinson J. Measuring the Heaviness of Smoking: using self-reported time to the first cigarette of the day and number of cigarettes smoked per day. *Br J Addict*. 1989;84:791–800. <https://doi.org/10.1111/j.1360-0443.1989.tb03059.x>.
52. Chen B, Vansteenkiste M, Beyers W, Boone L, Deci EL, Van der Kaap-Deeder J, et al. Basic psychological need satisfaction, need frustration, and need strength across four cultures. *Motiv Emot*. 2015;39:216–36. <https://doi.org/10.1007/s11031-014-9450-1>.
53. Ryan RM. Psychological needs and the facilitation of integrative processes. *J Pers*. 1995;63:397–427. <https://doi.org/10.1111/j.1467-6494.1995.tb00501.x>.
54. Van der Kaap-Deeder. Soenens, Ryan, Vansteenkiste. Manual of the Basic Psychological Need Satisfaction and Frustration Scale (BPNSFS). Ghent Univ. 2020.

55. Lord FM. The utilization of unreliable difference scores. *J Educ Psychol.* 1958;49:150–2. <https://doi.org/10.1037/h0045456>.
56. Henry JD, Crawford JR. The short-form version of the Depression Anxiety Stress Scales (DASS-21): construct validity and normative data in a large non-clinical sample. *Br J Clin Psychol.* 2005;44(Pt):227–39. <https://doi.org/10.1348/014466505X29657>.
57. Lovibond PF, Lovibond SH. The structure of negative emotional states: Comparison of the Depression Anxiety Stress Scales (DASS) with the Beck Depression and Anxiety Inventories. *Behav Res Ther.* 1995;33:335–43. [https://doi.org/10.1016/0005-7967\(94\)00075-U](https://doi.org/10.1016/0005-7967(94)00075-U).
58. Li W, Zhao Z, Chen D, Peng Y, Lu Z. Prevalence and associated factors of depression and anxiety symptoms among college students: a systematic review and meta-analysis. *J Child Psychol Psychiatry.* 2022;63:1222–30. <https://doi.org/10.1111/jcpp.13606>.
59. Cohen J. *Statistical power analysis for the behavioral sciences.* 2. ed., reprint. New York, NY: Psychology Press; 1988.
60. Malika Charrad N, Ghazzali V, Boiteau. Azam Niknafs. Determining the Best Number of Clusters in a Data Set. 2015.
61. Ikotun AM, Ezugwu AE, Abualigah L, Abuhaija B, Heming J. K-means clustering algorithms: A comprehensive review, variants analysis, and advances in the era of big data. *Inf Sci.* 2023;622:178–210. <https://doi.org/10.1016/j.ins.2022.11.139>.
62. Thalheimer W, Cook S. *How to calculate effect sizes.* 2002.
63. Arumugam A, Alsaafin N, Shalash RJ, Qadah RM, Al-Sharman A, Moustafa IM, et al. Concurrent validity between self-reported International Physical Activity Questionnaire Short Form and Fibion accelerometer data among young adults in the UAE. *Eur J Med Res.* 2024;29:426. <https://doi.org/10.1186/s40001-024-01975-5>.
64. Nelson MC, Taylor K, Vella CA. Comparison of Self-Reported and Objectively Measured Sedentary Behavior and Physical Activity in Undergraduate Students. *Meas Phys Educ Exerc Sci.* 2019;23:237–48. <https://doi.org/10.1080/1091367X.2019.1610765>.
65. Peiris CL, O'Donoghue G, Rippon L, Meyers D, Hahne A, De Noronha M, et al. Classroom Movement Breaks Reduce Sedentary Behavior and Increase Concentration, Alertness and Enjoyment during University Classes: A Mixed-Methods Feasibility Study. *Int J Environ Res Public Health.* 2021;18:5589. <https://doi.org/10.3390/ijerph18115589>.
66. Owen N, Healy GN, Matthews CE, Dunstan DW. Too Much Sitting: The Population-Health Science of Sedentary Behavior. *Exerc Sport Sci Rev.* 2010;38:105–13. <https://doi.org/10.1097/JES.0b013e3181e373a2>.
67. Lepp A, Barkley JE. Cell phone use predicts being an active couch potato: results from a cross-sectional survey of sufficiently active college students. *Digit Health.* 2019;5:2055207619844870. <https://doi.org/10.1177/2055207619844870>.
68. Dempsey PC, Biddle SJH, Buman MP, Chastin S, Ekelund U, Friedenreich CM, et al. New global guidelines on sedentary behaviour and health for adults: broadening the behavioural targets. *Int J*

- Behav Nutr Phys Act. 2020;17:151. <https://doi.org/10.1186/s12966-020-01044-0>.
69. Runacres A, Mackintosh KA, Knight RL, Sheeran L, Thatcher R, Shelley J, et al. Impact of the COVID-19 Pandemic on Sedentary Time and Behaviour in Children and Adults: A Systematic Review and Meta-Analysis. *Int J Environ Res Public Health*. 2021;18:11286. <https://doi.org/10.3390/ijerph182111286>.
70. Moulin MS, Truelove S, Burke SM, Irwin JD. Sedentary time among undergraduate students: A systematic review. *J Am Coll Health*. 2019;69:237–44. <https://doi.org/10.1080/07448481.2019.1661422>.
71. Bouloukaki I, Tsiligianni I, Stathakis G, Fanaridis M, Koloi A, Bakiri E, et al. Sleep Quality and Fatigue during Exam Periods in University Students: Prevalence and Associated Factors. *Healthcare*. 2023;11:2389. <https://doi.org/10.3390/healthcare11172389>.
72. Brautsch LAS, Lund L, Andersen MM, Jennum PJ, Folker AP, Andersen S. Digital media use and sleep in late adolescence and young adulthood: A systematic review. *Sleep Med Rev*. 2023;68:101742. <https://doi.org/10.1016/j.smr.2022.101742>.
73. Groves CI, Huong C, Porter CD, Summerville B, Swafford I, Witham B, et al. Associations between 24-h movement behaviors and indicators of mental health and well-being across the lifespan: a systematic review. *J Act Sedentary Sleep Behav*. 2024;3:9. <https://doi.org/10.1186/s44167-024-00048-6>.
74. Delage V, Tellier-Poulain M. Lou Vincent. Santé mentale des jeunes de l'Hexagone aux Outre-mer Cartographie des inégalités. Institut Montaigne, Institut Terram, Mutualité Française; 2025.
75. Nishimura T, Suzuki T. Basic Psychological Need Satisfaction and Frustration in Japan: Controlling for the Big Five Personality Traits. *Jpn Psychol Res*. 2016;58:320–31. <https://doi.org/10.1111/jpr.12131>.
76. Dasinger TM, Gibson DJ. Perceptions of mental health and need satisfaction/frustration among rural university students. *J Am Coll Health J ACH*. 2024;72:253–60. <https://doi.org/10.1080/07448481.2022.2032089>.
77. Maitiniyazi G, Dilimulati M, Abulaiti R, Nijiati Z, Tuerhong N, Ma T, et al. Clustering of lifestyle factors and the relationship with mental health among college students: a latent profile analysis. *BMC Public Health*. 2025;25:3181. <https://doi.org/10.1186/s12889-025-24501-6>.
78. Heatherton TF, Kozlowski LT, Frecker RC, Fagerstrom K-O. The Fagerström Test for Nicotine Dependence: a revision of the Fagerstrom Tolerance Questionnaire. *Br J Addict*. 1991;86:1119–27. <https://doi.org/10.1111/j.1360-0443.1991.tb01879.x>.
79. Fagerström K-O. Measuring degree of physical dependence to tobacco smoking with reference to individualization of treatment. *Addict Behav*. 1978;3:235–41. [https://doi.org/10.1016/0306-4603\(78\)90024-2](https://doi.org/10.1016/0306-4603(78)90024-2).
80. Johnston J, Thosar S, Agle J, Gassman R, Middlestadt S, Van Puymbroeck M et al. Physical activity and sedentary patterns during college transition years. 2010.

Figures

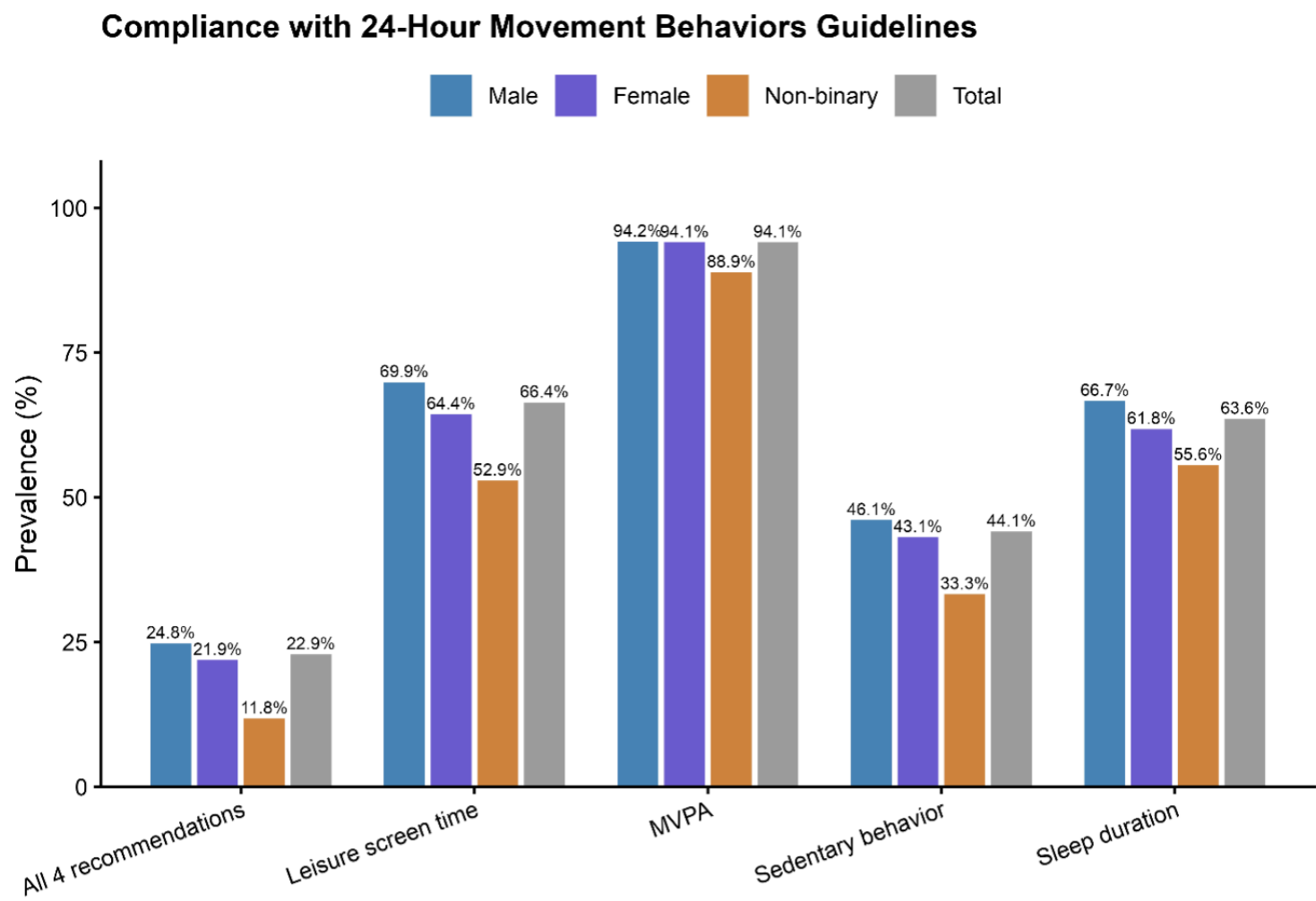


Figure 1

Compliance with 24-hour movement guidelines by gender and in the total sample.

Bars represent the percentage (%) of participants meeting guidelines for MVPA, SB, leisure screen time, sleep duration, and all four guidelines combined. Results are presented for male, female and non-binary participants, and for the total sample.

Prevalence of Mental Health outcomes

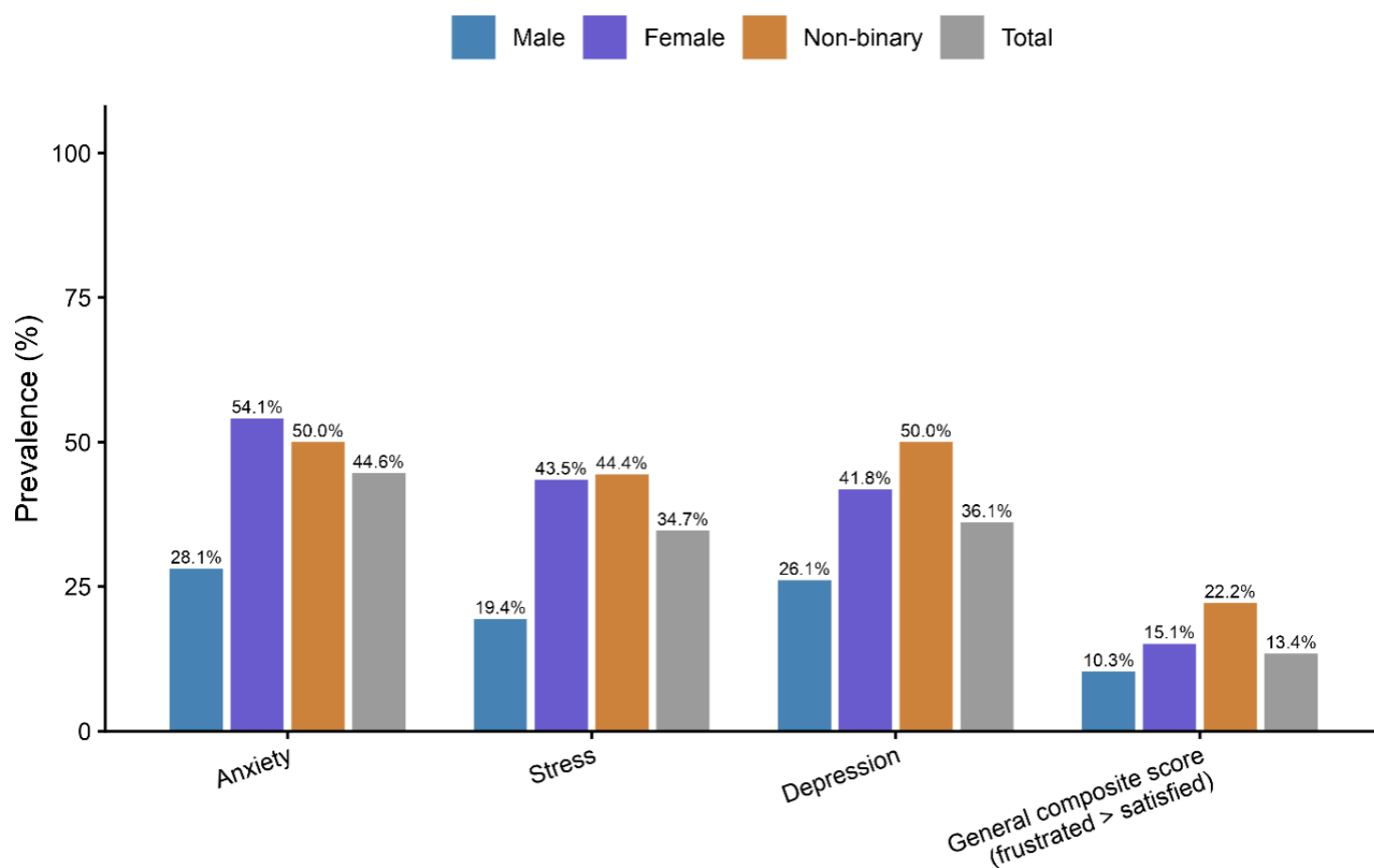


Figure 2

Prevalence of mental health outcomes by gender and in the total sample.

The bars represent the percentage (%) of participants reporting moderate to extremely severe levels of anxiety, stress, and depression, as well as a General Composite Score below 0 (greater frustration than satisfaction of BPN). Outcomes are presented separately for male, female, non-binary participants, and for the total sample.

