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# Physical Activity Profiles, Psychosocial Resources, and Health-Risk Behaviors Among University Students Across Academic Disciplines and Geopolitical Contexts: A Large-Scale Multi-Center Study

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## Abstract

# Purpose

The transition to tertiary education is frequently accompanied by a decline in physical activity (PA) and an increase in sedentary behavior. This multicenter study examined habitual PA profiles (measured via IPAQ-SF) and their associations with psychosocial resources, dietary patterns, and substance use among university students, accounting for academic specialization and geopolitical context (European Union [EU] vs. non-EU countries).

# Methods

A cross-sectional Computer-Assisted Web Interviewing (CAWI) survey was conducted among undergraduate and graduate students across public universities in Central and Eastern Europe ($N$ = 8,765; aged 18–30 years). Weekly energy expenditure was converted into MET-minutes per week and categorized into low, moderate, and high PA levels. Psychosocial resources and health behaviors were measured using validated instruments: the General Self-Efficacy Scale (GSES), Satisfaction with Life Scale (SWLS), Multidimensional Health Locus of Control (MHLC, Form A), Dietary Habits and Nutrition Beliefs Questionnaire (KomPAN), and standardized substance use screening modules. Differences across academic clusters (medical/health sciences, technical/economic, social sciences/humanities) and geopolitical cohorts were evaluated using the Kruskal–Wallis test with Dunn–Bonferroni post hoc adjustments and Pearson's chi-square tests.

# Results

PA volume differed markedly across geopolitical cohorts and curricula ($p < 0.001$). Non-EU students demonstrated higher median energy expenditure than their EU peers, which corresponded with elevated self-efficacy, life satisfaction, and internal health locus of control. Medical students did not exhibit superior PA levels over non-medical peers. Lower PA levels in the EU cohort co-occurred with elevated substance use, including heavy episodic drinking (43.1% in EU medical students vs. 25.6% in non-EU counterparts) and regular electronic cigarette use (up to 21.8%), confirming a persistent knowledge–behavior gap across health-related curricula.

# Conclusions

Formal health education does not systematically protect students against physical inactivity or clustered lifestyle risks. Macro-environmental and institutional factors exert a stronger influence on movement behaviors than academic curricula. University health initiatives require structural modifications, accessible sports infrastructure, and behavior-oriented programs rather than isolated didactic lectures.

## Introduction

The transition to tertiary education represents a critical developmental period frequently characterized by intensified academic demands, psychosocial pressures, and exposure to chronic stressors. These challenges often compromise baseline health behaviors, contributing to irregular dietary patterns, substantial reductions in habitual physical activity, and increased engagement in recreational substance use, notably hazardous alcohol consumption, conventional smoking, and electronic nicotine delivery systems [1, 2]. A well-documented epidemiological paradox within university populations is the "knowledge–behavior gap," whereby students enrolled in medical and health-related disciplines demonstrate poor adherence to preventative health guidelines despite formal didactic training in human physiology, lifestyle medicine, and chronic disease pathogenesis [3, 4]. High academic workloads, irregular schedules, and prolonged study hours are commonly reported barriers undermining the translation of theoretical health knowledge into sustained personal practice.

Regular physical activity (PA) constitutes a foundational pillar in the primary prevention of premature cardiometabolic alterations, functional musculoskeletal decline, and psychological distress. Current World Health Organization guidelines stipulate that adults

accumulate at least 150–300 minutes of moderate-intensity or 75–150 minutes of vigorous-intensity physical activity per week, or an equivalent combination, to mitigate all-cause mortality and non-communicable disease risks [5]. Beyond direct somatic benefits, habitual exercise operates as an active self-regulatory mechanism that attenuates symptoms of anxiety, psychological strain, and depressive states through neuroendocrine pathway modulation and improved autonomic regulation [6, 7]. Because university students represent prospective healthcare providers, educators, and community leaders, their physical activity habits during tertiary training substantially determine both their own long-term health trajectories and their future role as credible proponents of preventative lifestyle practices.

Despite documented physical and cognitive advantages, university populations exhibit high prevalence rates of insufficient physical activity paired with extensive sedentary exposure. Moreover, movement behaviors do not operate in isolation from other lifestyle dimensions. Epidemiological data show non-linear clustering wherein high exercise volumes coexist with elevated substance use. In particular, physically active undergraduates and student-athletes frequently report higher rates of heavy episodic drinking than their inactive peers, a dynamic identified as the "fit-partygoer" phenomenon or the athletic lifestyle paradox [8, 9]. Within the framework of compensatory health beliefs, rigorous physical exertion is frequently rationalized as a behavioral counterweight to the physiological harms of substance misuse [10]. Evaluating how physical activity levels intersect with nutritional patterns and risky consumption across academic disciplines is therefore critical for designing targeted institutional health policies.

At the macro-structural level, physical activity behaviors are governed by broader socio-economic and geopolitical conditions. Public health infrastructure, urban walkability, and public funding for municipal or university sports facilities establish the structural foundation for habitual movement and health literacy [11]. In this regard, the cross-border region adjoining the eastern boundary of the European Union serves as a strategic comparative setting, characterized by contrasting socio-economic trajectories, public health frameworks, and institutional priorities [12]. Parallel analyses across EU member states and adjacent non-EU countries clarify whether structural disparities and regional transitions shape student movement behaviors more decisively than formal academic curricula.

These structural and environmental influences interact with key psychosocial resources that govern health behavior maintenance. Specifically, generalized self-efficacy (GSES) [13], subjective life satisfaction (SWLS) [14], and multidimensional health locus of control (MHLC) [15] serve as foundational psychological assets supporting regular exercise adherence and stress regulation. High self-efficacy and an internal locus of control are documented predictors of sustained physical activity, yet their concurrent evaluation across distinct academic tracks and socio-political settings remains limited [2, 12, 16]. Most available studies rely on single-institution cohorts [3] or narrow regional samples, without evaluating how macro-environmental transitions and educational curricula converge to influence physical activity volume and concurrent risk behaviors [2, 17].

To address these empirical gaps, this multicenter investigation evaluated physical activity volumes, psychometric profiles, dietary indices, and substance use patterns in a cross-border cohort of university students ($N$ = 8,765). The analytical framework stratified participants across three academic clusters (medical/health sciences, technical/economic disciplines, and social sciences/humanities) and two distinct macro-environmental jurisdictions (EU member states vs. non-EU countries). Physical activity metrics were quantified via the International Physical Activity Questionnaire Short Form (IPAQ-SF) [18], alongside validated psychometric [13–15], dietary [19], and substance use screening tools [20–23].

We tested four directional hypotheses:

H1: Geopolitical environment (EU vs. non-EU) accounts for systematic differences in weekly physical activity expenditure, core psychosocial assets (self-efficacy, life satisfaction, and health locus of control), and health-risk practices.

H2: Enrollment in medical or health sciences curricula does not confer a protective advantage against physical inactivity or hazardous substance consumption compared with non-medical tracks, reflecting a persistent knowledge–behavior gap.

H3: Macro-structural geopolitical context exerts a more pronounced differentiating effect on physical activity and lifestyle behaviors than the academic curriculum.

H4: High weekly energy expenditure (High PA) tracks with favorable psychosocial resources, but co-occurs with elevated rates of heavy episodic drinking and electronic cigarette use, demonstrating compensatory lifestyle clustering.

## Methods

# Study design and sampling frame

This multicenter, cross-sectional investigation was conducted between April and June 2026 across public higher education institutions located in the border regions of Central and Eastern Europe. The study adhered to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guidelines for cross-sectional studies. Data collection used Computer-Assisted Web Interviewing (CAWI) administered through a dedicated institutional survey platform. A stratified quota sampling design was implemented to ensure demographic and curricular representativeness across participating universities. Stratification parameters included geopolitical jurisdiction (EU member states vs. non-EU countries), institutional profile (traditional comprehensive universities vs. technical universities and specialized health science academies), and academic discipline track.

Survey links were disseminated through official university communication channels, student union portals, and institutional mailing lists. Technical validation controls were embedded into the survey architecture to maintain data integrity. Unsolicited multiple submissions were prevented through IP address logging, hardware fingerprinting, and single-use digital session tokens. Automated quality-control filters were applied prior to statistical processing. Surveys displaying invariant response strings (straight-lining), anomalous completion patterns, or total completion times falling below the 5th percentile of pilot-normative thresholds (< 10 minutes) were discarded.

## Participants and eligibility criteria

Participant eligibility was defined by formal criteria established prior to data collection. Inclusion criteria comprised: (1) active full-time enrollment in Bologna-compliant undergraduate (first-cycle), graduate (second-cycle), or integrated 5- to 6-year master's degree programs at an accredited public university; (2) chronological age between 18 and 30 years at the time of survey completion; (3) provision of electronic informed consent; and (4) demonstrated proficiency in the operational language of the survey instrument (Polish, Ukrainian, Romanian, or Serbian).

Exclusion criteria comprised: (1) enrollment in doctoral studies, postgraduate diploma courses, or part-time/distance-learning programs; (2) questionnaire submissions with item non-response exceeding 5%; and (3) acute or chronic musculoskeletal impairments, permanent physical disabilities, or temporary clinical restrictions that precluded normal ambulatory movement or physical activity during the 7-day recall window evaluated by the physical activity questionnaire. From the initial survey submissions, 8,765 respondents met all eligibility criteria and provided complete, verifiable data for the final analytical sample.

## Independent variables and grouping factors

The analytical framework was structured around two primary between-subject grouping factors:

**Academic Specialization Track**

Participants were categorized into three distinct curricular tracks according to the International Standard Classification of Education (ISCED-F 2013)

Cluster A – Medical and Health Sciences (*n* = 4,983): medicine, dental medicine, pharmacy, nursing, midwifery, physiotherapy, public health, human nutrition, physical education, and sport sciences;

Cluster B – Technical, Economic, and Natural Sciences (*n* = 2,148): engineering disciplines, computer science, economics, management, agricultural sciences, and applied mathematics;

Cluster C – Social Sciences, Humanities, and Arts (*n* = 1,634): law, administrative sciences, psychology, educational sciences, sociology, philology, and fine arts.

**Geopolitical Cohort**

Participants were classified into two regional cohorts defined by the location of the degree-granting institution

European Union (EU) Cohort (*n* = 4,788): students enrolled in universities situated within EU member states (Poland, Lithuania, Slovakia, and Romania), governed directly by harmonized European higher education directives and EU public health frameworks;

Non-EU Cohort (*n* = 3,977): students enrolled in universities located in adjacent non-EU territories, including Eastern Partnership states, candidate countries, and regional partners (Ukraine, Belarus, Moldova, Serbia, Montenegro, and Türkiye).

## Measurement Instruments

# Physical Activity Assessment

Habitual physical activity was evaluated using the official International Physical Activity Questionnaire Short Form (IPAQ-SF) [18]. The 7-day recall protocol recorded the frequency (days per week) and daily duration (minutes per day) across three specific movement intensities: vigorous-intensity physical activity (VPA), moderate-intensity physical activity (MPA), and walking. Additionally, daily passive sitting time on weekdays was recorded as a proxy for sedentary exposure. In accordance with the standard IPAQ data processing protocol, physical activity bouts lasting less than 10 continuous minutes were excluded from calculations, and individual daily duration outliers were truncated at 180 minutes per intensity domain to prevent over-reporting bias.

Continuous physical activity volume was quantified in Metabolic Equivalent of Task minutes per week (MET-min/week) using standard resting metabolic multipliers [18], computed as follows: Walking MET-min/week = 3.3 × walking duration (min/day) × walking frequency (days/week); Moderate PA MET-min/week = 4.0 × moderate-intensity activity duration (min/day) × moderate-intensity frequency (days/week); and Vigorous PA MET-min/week = 8.0 × vigorous-intensity activity duration (min/day) × vigorous-intensity frequency (days/week). Total physical activity volume was calculated as the aggregate sum of these three components.

Based on cumulative MET-min/week and weekly frequency thresholds, participants were stratified into three standardized activity tiers [18]:

Low Physical Activity: Insufficient activity volume failing to meet the criteria for the moderate or high categories (< 600 MET-min/week).

Moderate Physical Activity: Meeting any of the following benchmarks: ≥3 days of vigorous-intensity activity of at least 20 min/day; ≥5 days of moderate-intensity activity or walking of at least 30 min/day; or ≥ 5 days of any combination of walking, moderate-, or vigorous-intensity activities achieving a cumulative volume of ≥ 600 MET-min/week.

High Physical Activity: Meeting either vigorous-intensity activity on ≥ 3 days accumulating ≥ 1,500 MET-min/week, or ≥ 7 days of any combined movement accumulation achieving ≥ 3,000 MET-min/week.

# Psychosocial resource inventories

General Self-Efficacy Scale (GSES): Perceived personal agency and universal competence to cope with demanding life challenges were evaluated using the 10-item General Self-Efficacy Scale [13]. Items were rated on a 4-point Likert scale ranging from 1 ("not at all true") to 4 ("exactly true"). Composite scores range from 10 to 40 points, with higher values reflecting stronger perceived self-efficacy. Internal consistency in the present cohort was high (Cronbach's α = 0.88).

Satisfaction with Life Scale (SWLS): Subjective cognitive evaluations of global life satisfaction were assessed using the 5-item Satisfaction with Life Scale [14]. Statements were scored on a 7-point Likert scale from 1 ("strongly disagree") to 7 ("strongly

agree"), yielding aggregated scores from 5 to 35 points. Higher scores represent greater life satisfaction. Internal consistency was robust (Cronbach's α = 0.86).

Multidimensional Health Locus of Control (MHLC, Form A): Beliefs regarding the sources of control over personal health were assessed using the 18-item MHLC scale (Form A) [15]. The instrument comprises three independent 6-item dimensions: Internal Health Locus of Control (IHLC), Powerful Others Health Locus of Control (PHLC), and Chance Health Locus of Control (CHLC). Items were scored on a 6-point Likert scale from 1 ("strongly disagree") to 6 ("strongly agree"), producing theoretical scores of 6 to 36 points for each subscale. Internal consistency across subscales was satisfactory (Cronbach's α = 0.74–0.81).

## Health-related behaviors and dietary quality

Health Behavior Inventory (HBI-IZZ): General preventive and health-promoting behaviors were quantified using the 24-item Health Behavior Inventory [17]. The inventory measures four discrete behavioral domains (6 items each): nutritional habits, preventive healthcare practices, positive psychological attitude, and daily health routines. Items were scored on a 5-point frequency scale from 1 ("almost never") to 5 ("almost always"). Total scores range from 24 to 120 points (higher scores indicating more frequent health-promoting practices), while domain subscores are reported as mean item ratings (range: 1.00–5.00 points). Internal consistency for the total inventory was high (Cronbach's α = 0.85).

Dietary Quality Assessment (KomPAN): Habitual dietary quality over the preceding 12 months was evaluated using selected food frequency modules of the Dietary Habits and Nutrition Beliefs Questionnaire (KomPAN) [19]. An integrated Diet Quality Index (DQI) score was derived as the difference between consumption frequencies of pro-healthy food items (fresh fruits, vegetables, whole grains, pulses, fish) and non-healthy dietary components (sugar-sweetened beverages, processed meats, refined confectioneries, fast food). Theoretical scores range from − 79 to + 79 points. In accordance with validated KomPAN criteria, participants were categorized into three dietary quality groups: pro-healthy diet (+ 26 to + 79 points), neutral/mixed diet (–25 to + 25 points), and unhealthy diet (–79 to − 26 points).

## Substance use screening

Recreational substance use was documented using standardized epidemiological items adapted from the Global Adult Tobacco Survey (GATS) and the Youth Prevention of Substance Use (YUPESS) protocols [20, 23].

Alcohol Consumption and Heavy Episodic Drinking: Past 30-day alcohol consumption was categorized into total abstinence (0 days) and active consumption (≥ 1 day/month). In accordance with National Institute on Alcohol Abuse and Alcoholism (NIAAA) and World Health Organization (WHO) operational criteria [22], heavy episodic drinking (binge drinking) was defined as the consumption of ≥ 5 standard drinks (men) or ≥ 4 standard drinks (women) on a single occasion within a 2-hour window, occurring at least once during the preceding month. Recurrent loss of control due to acute intoxication was operationalized as ≥ 4 episodes during the preceding 12 months.

Combustible Tobacco and Electronic Nicotine Delivery Systems (ENDS): Cigarette smoking was classified by past-month frequency into daily smoking (every day in the preceding 30 days) and intermittent smoking (1–29 days in the preceding 30 days) [21, 23]. Electronic cigarette (vaping) and related device use was categorized into frequent use (≥ 10 days/month) and occasional use (1–9 days/month).

# Statistical analysis

Data management and statistical computing were performed using Statistica version 13.3 (TIBCO Software Inc., Palo Alto, CA, USA) and R version 4.3.2 (R Foundation for Statistical Computing, Vienna, Austria). Distributional assumptions and departures from normality for all continuous variables (weekly physical activity volume in MET-min/week, daily sitting time, GSES, SWLS, MHLC subscales, HBI-IZZ, and DQI scores) were evaluated using the Shapiro–Wilk test alongside visual inspection of normal Q–Q plots. Because continuous variables deviated significantly from Gaussian distributions ($p < 0.001$), continuous data are summarized as medians (*Me*) and interquartile ranges (*IQR*, 25th–75th percentiles).

Categorical variables, including IPAQ-SF activity tiers (low, moderate, high), KomPAN dietary patterns, alcohol consumption status, heavy episodic drinking, combustible tobacco use, and electronic nicotine delivery system (ENDS) use, are reported as absolute frequencies (n) and relative percentages (%). Proportional distributions across academic clusters and geopolitical cohorts were evaluated using Pearson's chi-square ($\chi^2$) test of independence. Effect sizes for contingency tables were quantified using Cramér's *V*, interpreted according to conventional benchmarks (*V* = 0.10 small, *V* = 0.30 medium, and *V* ≥ 0.50 large).

Between-group comparisons of continuous parameters were carried out using non-parametric procedures. Pairwise comparisons between the two geopolitical cohorts within each academic cluster were conducted using the Mann–Whitney *U* test, reporting asymptotic standardized *Z*-values. Multi-group comparisons across the three academic clusters within each geopolitical cohort were tested using the Kruskal–Wallis *H* test. Significant omnibus effects were subsequently examined through pairwise post hoc contrasts using Dunn's test, with Bonferroni-adjusted probability thresholds applied to control for multiple testing. All statistical tests were two-tailed, with the threshold for statistical significance defined at $\alpha = 0.05$.

## Results

# Physical Activity Profiles (IPAQ-SF)

Weekly energy expenditure and categorical physical activity tiers varied significantly across both geopolitical cohorts and academic clusters (Tables 1 and 2). Continuous energy expenditure, expressed in MET-min/week, revealed distinct regional configurations. Within the European Union (EU) cohort, undergraduates in the Medical and Health Sciences cluster attained the highest weekly energy expenditure (*Me* = 2322 MET-min/week; *IQR*: 1140–4115), exceeding both the Technical and Economic (*Me* = 1860 MET-min/week; $Z = -6.0$, $p < 0.001$) and Social Sciences and Humanities cohorts (*Me* = 1649 MET-min/week; $Z = -9.4$, $p < 0.001$).

Conversely, within the non-EU cohort, the highest physical activity volume was documented among Technical and Economic students (*Me* = 2373 MET-min/week; *IQR*: 1187–4655), whereas the lowest expenditure was observed in the Social Sciences and Humanities cluster (*Me* = 1682 MET-min/week; $Z = -4.8$, $p < 0.001$). Pairwise geopolitical contrasts within academic tracks indicated that non-EU technical students achieved higher physical activity volumes than their EU counterparts ($Z = 6.2$, $p < 0.001$).

Categorical distribution across activity tiers indicated that most respondents met criteria for the High Physical Activity tier (> 3000 MET-min/week or ≥ 1500 MET-min/week of vigorous exercise; Table 2). Nevertheless, insufficient physical activity (< 600 MET-min/week) remained prevalent, particularly within the EU cohort. Low physical activity was highest among EU Social Sciences and Humanities undergraduates (28.6%), followed by EU Technical/Economic (23.7%) and EU Medical students (21.4%). In contrast, non-EU respondents exhibited lower rates of physical inactivity across corresponding fields (19.4% to 24.0%). Contingency analyses indicated significant differences across academic clusters within both the EU ($\chi^2 = 64.4$, $df = 4$, $p < 0.001$, Cramér's $V = 0.08$) and non-EU cohorts ($\chi^2 = 19.4$, $df = 4$, $p < 0.001$, Cramér's $V = 0.05$), as well as across geopolitical territories within matched disciplines ($p < 0.05$ to $p < 0.001$).

Table 1
Physical activity energy expenditure (IPAQ-SF, MET-min/week) across academic clusters and geopolitical cohorts (Me [IQR])

| Variable / Scale | Geopolitical context | Cluster A: Medical and Health Sciences | Cluster B: Technical and Economic | Cluster C: Social and Humanistic | EU vs. Non-EU comparison within cluster | Cluster comparison within geopolitical zone |
|---|---|---|---|---|---|---|
| Physical activity (IPAQ, MET-min/week) | EU Countries | 2322 (1140–4115) | 1860 (933–3240) | 1649 (862–3012) | $Z_{A-B}$=-6.0; $p$ < 0.001; $Z_{A-C}$=-9.4; $p$ < 0.001; $Z_{B-C}$=-2.8; $p$ < 0.01 | $Z_B$=6.2; $p$ < 0.001 |
| | Non-EU Countries | 2226 (1104–4372) | 2373 (1187–4655) | 1682 (907–3306) | $Z_{A-C}$=-4.3; $p$ < 0.001; $Z_{B-C}$=-4.8; $p$ < 0.001; | |

*Note*: Data presented as medians and interquartile ranges (*Me* [*IQR*]). Non-parametric contrasts evaluated via Mann–Whitney *U* tests with Bonferroni-adjusted probability thresholds. *Z* indicates the standardized normal approximation test statistic.

Table 2
Categorical physical activity levels (IPAQ-SF) by academic cluster and geopolitical context, *n* (%)

| Physical activity level | Geopolitical context | Cluster A: Medical and Health Sciences | Cluster B: Technical and Economic | Cluster C: Social and Humanistic |
|---|---|---|---|---|
| Low | EU Countries | 498 (21.4%) | 278 (23.7%) | 370 (28.6%) |
| | Non-EU Countries | 521 (19.6%) | 189 (19.4%) | 82 (24.0%) |
| Moderate | EU Countries | 278 (12.0%) | 199 (17.0%) | 227 (17.6%) |
| | Non-EU Countries | 447 (16.8%) | 144 (14.8%) | 78 (22.8%) |
| High | EU Countries | 1548 (66.6%) | 695 (59.3%) | 695 (53.8%) |
| | Non-EU Countries | 1691 (63.6%) | 643 (65.9%) | 182 (53.2%) |
| Pearson Chi-square by clusters | Clusters A, B, C | Non-EU Countries | $\chi2$ = 19.4; $p$ < 0.001 | |
| | | EU Countries | $\chi2$ = 64.4; $p$ < 0.001 | |
| | Non-EU vs. EU | $\chi2$ = 23.8; $p$ < 0.001 | $\chi2$ = 10.0; $p$ < 0.01 | $\chi2$ = 6.0; $p$ < 0.05 |

Note: Values expressed as observed counts and percentages (*n* [%]) within each respective cohort. Between-group independence tested via Pearson's chi-square ($\chi^2$) test.

# Psychosocial Resources and Health Locus of Control

Evaluation of psychological coping assets and control beliefs demonstrated structural differences between geopolitical environments (Table 3). On the General Self-Efficacy Scale (GSES), median ratings were uniform across cohorts (*Me* = 30.0); however, rank-sum distributions indicated subtle variations within the EU sample, where Medical students achieved marginally higher ranks than Technical ($p < 0.001$) and Humanities peers ($p < 0.01$). In non-EU institutions, self-efficacy scores did not differ across disciplines.

Table 3
Psychosocial resources across academic clusters and geopolitical cohorts (Me [IQR])

| Variable / Scale | Geopolitical context | Cluster A: Medical and Health Sciences | Cluster B: Technical and Economic | Cluster C: Social and Humanistic | EU vs. Non-EU comparison within cluster | Cluster comparison within geopolitical zone |
|---|---|---|---|---|---|---|
| General Self-Efficacy Scale (GSES) | EU Countries | 30.0 (28–34) | 30.0 (27–34) | 30.0 (27–34) | $p > 0.05$ | $Z_A$=4.0; $p$ < 0.001 |
| | Non-EU Countries | 30.0 (28–34) | 30.0 (29–35) | 30.0 (28–35) | $Z_{A-B}$=-4.0; $P_{A-B}$ < 0.001 | $Z_C$=2.3; $p$ < 0.01 |
| Satisfaction with Life Scale (SWLS) | EU Countries | 23.0 (19–28) | 21.0 (16–27) | 23.0 (17–28) | $Z_{A-B}$=6.1; $p$ < 0.001; $Z_{A-C}$=3.1; $p$ < 0.001; $Z_{B-C}$=-2.7; $p$ < 0.001 | $Z_A$=3.9 $p$ < 0.001 |
| | Non-EU Countries | 23.0 (17–27) | 24.5 (20–29) | 24.0 (17–29) | $Z_{A-B}$=-7.0; $p$ < 0.001; $Z_{A-C}$=-2.9; $p$ < 0.01 | $Z_B$=8.4; $p$ < 0.001; $Z_C$=2.7; $p$ < 0.01 |
| MHLC (Internal locus of control) | EU Countries | 4.5 (4–5) | 4.3 (3.7-5.0) | 4.3 (3.7-5.0) | $Z_{A-B}$=4.3; $p$ < 0.001; $Z_{A-C}$=6.9; $p$ < 0.001; $Z_{B-C}$=2.0; $p$ < 0.05 | $Z_B$=2.9; $p$ < 0.01 |
| | Non-EU Countries | 4.5 (3.8–5.2) | 4.5 (3.8–5.2) | 4.5 (3.7-5.0) | $p > 0.05$ | |
| MHLC – (Influence of significant others) | EU Countries | 3.3 (2.7-4.0) | 3.3 (2.7-4.0) | 3.3 (2.7-4.0) | $Z_{A-C}$=-2.1; $p$ < 0.01 | $Z_A$=14.5 $p$ < 0.001 |
| | Non-EU Countries | 3.8 (3.0-4.5) | 3.7 (2.8–4.3) | 3.8 (3.0-4.5) | $Z_{A-B}$=2.7; $p$ < 0.001 | $Z_B$=5.2; $p$ < 0.001; $Z_C$=5.0; $p$ < 0.001 |
| MHLC – (External forces / Fate) | EU Countries | 3.2 (2.5–3.8) | 3.2 (2.5–3.8) | 3.0 (2.3–3.7) | $Z_{B-C}$=3.0; $p$ < 0.01 | $Z_A$=14.5 $p$ < 0.001 |
| | Non-EU Countries | 3.2 (2.5-4.0) | 3.0 (2.3–3.8) | 3.2 (2.5-4.0) | $Z_{A-B}$=4.0; $p$ < 0.001 | $Z_B$=5.2; $p$ < 0.001 |

*Note*: Data presented as medians and interquartile ranges (*Me* [*IQR*]). Pairwise contrasts tested via Mann–Whitney *U* tests with Bonferroni correction.

Life satisfaction (SWLS) demonstrated marked variance. In the EU cohort, technical and economic students reported the lowest satisfaction (*Me* = 21.0; *IQR*: 16–27), which was significantly lower than medical (*Me* = 23.0; *Z* = 6.1, *p < 0.001*) and social science peers (*Me* = 23.0; *Z* = − 2.7, *p < 0.001*). In contrast, non-EU respondents exhibited higher overall life satisfaction, peaking in the technical-economic cohort (*Me* = 24.5; *IQR*: 20–29). Cross-regional pairwise comparisons demonstrated that non-EU students had higher satisfaction scores than EU peers across all three academic domains ($Z_A$=3.9, *p < 0.001*; $Z_B$=8.4, *p < 0.001*; $Z_C$=2.7, *p* = 0.007).

Attributions of health agency (MHLC) showed that internal control (IHLC) remained consistent among non-EU participants across curricula (*Me* = 4.5), whereas within the EU group, medical students displayed higher internal control than technical (*Z* = 4.3, *p < 0.001*) and humanities undergraduates (*Z* = 6.9, *p < 0.001*). Believing that health status is governed by powerful external figures (PHLC) was systematically higher among non-EU students across all academic clusters (*Me* = 3.7–3.8 vs. 3.3; *p < 0.001*). Similarly, external chance attributions (CHLC) exhibited significant macro-regional divergence across all clusters (*p < 0.001*), with EU humanities students displaying the lowest fatalistic control (*Me* = 3.0).

# Health Behaviors and Dietary Quality

Evaluation of lifestyle practices (HBI-IZZ) showed that non-EU students achieved higher composite health scores (*Me* = 80.0–85.0 points) than EU students (*Me* = 76.0–79.0 points; Table 4). Within the EU cohort, medical students reached the highest overall score (*Me* = 79.0), whereas in non-EU countries, technical-economic and humanities undergraduates attained higher indices (*Me* = 85.0 each). Across sub-domains, non-EU students maintained higher scores for preventive behaviors and positive mental attitude. In daily health practices, all EU clusters scored an identical median of 3.17, whereas non-EU groups scored between 3.33 and 3.67 ($p < 0.001$).

Table 4
Global Health Behavior Inventory (HBI-IZZ) and sub-domains (Me [IQR])

| Variable / Scale | Geopolitical context | Cluster A: Medical and Health Sciences | Cluster B: Technical and Economic | Cluster C: Social and Humanistic | EU vs. Non-EU comparison within cluster | Cluster comparison within geopolitical zone |
|---|---|---|---|---|---|---|
| HBI-IZZ (Overall score, points) | EU Countries | 79.0 (69–89) | 76.0 (66–87) | 77.0 (67–87) | $Z_{A-B}$=4.4; $p$ < 0.001; $Z_{A-C}$=3.0; $p$ < 0.001; | $Z_A$=4.7; $p$ < 0.001; $Z_B$=12.0; $p$ < 0.001; $Z_C$=6.2; $p$ < 0.001 |
| | Non-EU Countries | 80.0 (72–90) | 85.0 (74–95) | 85.0 (72–95) | $Z_{A-B}$=-7.3; $p$ < 0.001; $Z_{A-C}$=-3.3; $p$ < 0.001; | |
| Eating habits | EU Countries | 3.17 (2.67–3.67) | 3.0 (2.50–3.58) | 3.0 (2.50–3.67) | $Z_{A-B}$=3.3; $p$ < 0.001; $Z_{A-C}$=3.3; $p$ < 0.001; | $Z_B$=3.1; $p$ < 0.001; $Z_C$=2.3; $p$ < 0.01 |
| | Non-EU Countries | 3.17 (2.67–3.67) | 3.17 (2.67–3.67) | 3.17 (2.67–3.83) | $Z_{A-B}$=3.3; $p$ < 0.001; | |
| Preventive behaviors | EU Countries | 3.33 (2.83–3.83) | 3.17 (2.50–3.83) | 3.17 (2.50–3.83) | $Z_{A-B}$=5.9; $p$ < 0.001; $Z_{A-C}$=5.8; $p$ < 0.001; | $Z_A$=6.7; $p$ < 0.001; $Z_B$=12.4; $p$ < 0.001; $Z_C$=7.6; $p$ < 0.001 |
| | Non-EU Countries | 3.50 (3.0–4.0) | 3.67 (3.0-4.17) | 3.67 (3.0-4.17) | $Z_{A-B}$=-4.9; $p$ < 0.001; $Z_{A-C}$=-2.2; $p$ < 0.05; | |
| Positive mental attitude (PMA) | EU Countries | 3.50 (3.0–4.0) | 3.33 (2.83-4.0) | 3.33 (2.83-4.0) | $Z_{A-B}$=3.7; $p$ < 0.001; $Z_{A-C}$=2.5 $p$ < 0.01; | $Z_A$=3.3; $p$ < 0.001; $Z_B$=10.8; $p$ < 0.001; $Z_C$=5.1; $p$ < 0.001 |
| | Non-EU Countries | 3.67 (3.0–4.0) | 3.83 (3.33–4.17) | 3.67 (3.0-4.33) | $Z_{A-B}$=-7.3; $p$ < 0.001; $Z_{A-C}$=-2.8; $p$ < 0.01; | |
| Health practices | EU Countries | 3.17 (2.67–3.67) | 3.17 (2.67–3.67) | 3.17 (2.67–3.67) | $Z_{A-C}$=-2.4; $p$ < 0.01; $Z_{B-C}$=3.4; $p$ < 0.001; | $Z_A$=6.1; $p$ < 0.001; $Z_B$=13.2; $p$ < 0.001; $Z_C$=5.7; $p$ < 0.001 |
| | Non-EU Countries | 3.33 (2.83–3.83) | 3.67 (3.17-4.0) | 3.50 (3.0–4.0) | $Z_{A-B}$=-10.8; $p$ < 0.001; $Z_{A-C}$=-4.9; $p$ < 0.001; | |

*Note*: Data presented as medians and interquartile ranges (*Me* [*IQR*]). Pairwise comparisons computed via Mann–Whitney *U* tests with Bonferroni correction.

Dietary indices derived from the KomPAN protocol did not mirror physical activity profiles (Table 5). Median DQI values were slightly negative across all cohorts (ranging from − 2.00 to − 2.77), indicating an overall balance leaning away from nutrient-dense items. Over 97% of respondents across all academic clusters and regions fell into the neutral/mixed dietary category (− 25 to + 25

points). High-quality pro-healthy diets (+ 26 to + 79 points) were identified in only 0.9% to 2.3% of students, with no significant differences across academic disciplines ($p > 0.05$).

Table 5
Dietary components (KomPAN) and Diet Quality Index (DQI) classifications

| Variable / Scale | Geopolitical context | Cluster A: Medical and Health Sciences | Cluster B: Technical and Economic | Cluster C: Social and Humanistic | EU vs. Non-EU comparison within cluster | Cluster comparison within geopolitical zone |
|---|---|---|---|---|---|---|
| Diet Quality Index (DQI), Me (IQR) | EU Countries | -2.14 (-6.77–4.51) | -2.4 (-6.66–3.94) | -2.69 (-7.05-4.50) | $p > 0.05$ | $Z_A$=-2.06; $p < 0.05$; |
| | Non-EU Countries | -2.77 (-6.93-3.49) | -2.0 (-6.13-4.72) | -2.37 (-6.89-3.71) | $Z_{A-B}$=-2.6; $p < 0.01$; | |
| Pro-healthy diet (DQI 26 to 79 pts) | EU Countries | 38 (1.6) | 21 (1.8) | 22 (1.7) | $p > 0.05$ | $p > 0.05$ |
| | Non-EU Countries | 59 (2.2) | 9 (0.9) | 8 (2.3) | $p > 0.05$ | |
| Neutral / mixed diet (DQI – 25 to 25 pts) | EU Countries | 2281 (98.1) | 1147 (97.9) | 1265 (97.9) | $p > 0.05$ | $p > 0.05$ |
| | Non-EU Countries | 2591 (97.4) | 965 (98.9) | 332 (97.1) | $p > 0.05$ | |
| Unhealthy diet (DQI – 79 to -26 pts) | EU Countries | 5 (0.2) | 4 (0.3) | 5 (0.4) | $p > 0.05$ | $p > 0.05$ |
| | Non-EU Countries | 9 (0.3) | 2 (0.2) | 2 (0.6) | $p > 0.05$ | |

*Note*: Data presented as medians and interquartile ranges (*Me* [*IQR*]) for continuous DQI scores and as counts and percentages (*n* [%]) for categorical dietary profiles. Continuous metrics compared using Mann–Whitney *U* tests; categorical tiers tested using Pearson's $\chi^2$ test.

# Health-Risk Behaviors: Alcohol and Nicotine Intake

Substance use patterns diverged between geopolitical contexts and revealed behavioral paradoxes within health-related curricula (Table 6). Complete alcohol abstinence over the preceding 30 days was significantly higher among non-EU students (56.2% to 65.5%) than among EU peers (40.1% to 47.8%; $\chi^2 = 299.7$, $df = 1$, $p < 0.001$, Cramér's $V = 0.18$).

In contrast, heavy episodic drinking (≥ 1 episode/month) was concentrated within the EU cohort. EU Medical and Health Sciences students showed the highest prevalence of binge drinking (43.1%), exceeding non-EU medical peers (25.6%; $\chi^2 = 204.2$, $df = 1$, $p < 0.001$, Cramér's $V = 0.18$). Frequent acute loss of control from intoxication (≥ 4 episodes/year) was also two- to three-fold higher among EU students across all academic tracks ($\chi^2 = 303.4$, $df = 1$, $p < 0.001$, Cramér's $V = 0.19$).

Conventional smoking and electronic nicotine delivery system (ENDS) use followed a similar regional pattern. Daily combustible cigarette smoking was rare among non-EU undergraduates (0.0% in technical and humanities; 0.45% in medical), whereas in the EU cohort it reached 7.0% in medical, 11.7% in technical, and 12.6% in humanities disciplines ($\chi^2 = 94.0$, $df = 2$, $p < 0.001$, Cramér's $V = 0.14$). Frequent e-cigarette use (≥ 10 days/month) was documented in approximately one-fifth of EU students (18.6% to 21.8%), roughly double the prevalence observed among non-EU peers (6.1% to 11.8%; $\chi^2 = 377.4$, $df = 1$, $p < 0.001$, Cramér's $V = 0.21$). While EU medical students smoked combustible cigarettes less frequently than their non-medical peers, their elevated engagement in binge drinking and electronic nicotine use demonstrates an operational gap between theoretical curricular knowledge and personal health behaviors.

Table 6
Health-risk behaviors concerning alcohol consumption, combustible smoking, and electronic nicotine delivery systems (n [%])

| Variable / Scale | Geopolitical context | Cluster A: Medical and Health Sciences | Cluster B: Technical and Economic | Cluster C: Social and Humanistic | EU vs. Non-EU comparison within cluster | Cluster comparison within geopolitical zone |
|---|---|---|---|---|---|---|
| People who do not drink alcohol (0 days/month) | EU Countries | 931 (40.1) | 484 (41.3) | 618 (47.8) | $\chi2 = 32.7$; $p < 0.01$ | $\chi2 = 299.7$; $p < 0.001$ |
| | Non-EU Countries | 1639 (61.6) | 551 (56.2) | 224 (65.5) | $\chi2 = 22.5$; $p < 0.01$ | |
| Binge drinking (≥ 1 time/month) | EU Countries | 1002 (43.1) | 453 (38.7) | 442 (34.2) | $\chi2 = 35.4$; $p < 0.001$ | $\chi2 = 204.2$; $p < 0.001$ |
| | Non-EU Countries | 681 (25.6) | 254 (26.0) | 69 (20.2) | $\chi2 = 17.5$; $p < 0.05$ | |
| Frequent loss of control (≥ 4 times/year) | EU Countries | 83 (3.57) | 41 (3.50) | 31 (2.40) | $\chi2 = 50.4$; $p < 0.001$ | $\chi2 = 303.4$; $p < 0.001$ |
| | Non-EU Countries | 45 (1.69) | 10 (1.02) | 2 (0.58) | $\chi2 = 11.7$; $p < 0.05$ | |
| Daily conventional cigarette smoking | EU Countries | 162 (7.0) | 167 (11.7) | 163 (12.6) | $\chi2 = 45.9$; $p < 0.001$ | $\chi2 = 94.0$; $p < 0.001$ |
| | Non-EU Countries | 12 (0.45) | 0 | 0 | $\chi2 = 35.8$; $p < 0.001$ | |
| Intermittent conventional cigarette smoking (1–29 days) | EU Countries | 222 (9.6) | 191 (16.3) | 205 (15.9) | $\chi2 = 31.6$; $p < 0.001$ | $\chi2 = 29.1$; $p < 0.001$ |
| | Non-EU Countries | 313 (11.8) | 91 (9.3) | 41 (12.0) | $\chi2 = 18.3$; $p > 0.05$ | |
| Frequent e-cigarette use (≥ 10 days) | EU Countries | 451 (19.4) | 255 (21.8) | 240 (18.6) | $\chi2 = 116.0$; $p < 0.001$ | $\chi2 = 377.4$; $p < 0.001$ |
| | Non-EU Countries | 254 (9.6) | 115 (11.8) | 21 (6.1) | $\chi2 = 61.5$; $p < 0.001$ | |
| Occasional e-cigarette use (1–9 days) | EU Countries | 292 (12.6) | 165 (14.1) | 164 (12.7) | $\chi2 = 116.0$; $p < 0.001$ | $\chi2 = 377.4$; $p < 0.001$ |
| | Non-EU Countries | 210 (7.9) | 97 (9.9) | 19 (5.6) | $\chi2 = 61.5$; $p < 0.001$ | |

*Note*: Values expressed as frequency counts and percentages (*n* [%]). Inter-group differences tested via Pearson's chi-square test of independence.

## Discussion

This multicenter investigation evaluated habitual physical activity profiles (IPAQ-SF), psychosocial resources, dietary quality, and recreational substance consumption among a cohort of $N = 8,765$ university students across distinct academic curricula and geopolitical contexts. The findings demonstrate that while academic training accounts for certain disciplinary contrasts, the broader geopolitical macro-environment acts as the primary differentiating factor governing movement behaviors and lifestyle configurations [11, 12]. Notably, physical activity volume and intensity did not follow identical patterns between regions: whereas medical undergraduates attained the highest physical activity volumes within the European Union (EU) cohort, students enrolled in technical and economic disciplines achieved the highest energy expenditure in the non-EU cohort. Crucially, non-EU undergraduates displayed more favorable health metrics regarding recreational substance misuse, characterized by substantially

higher rates of complete alcohol abstinence and minimal combustible cigarette smoking, alongside elevated life satisfaction, when compared to their EU counterparts.

# Physical Activity Disparities and Movement Epidemiology

The observed divergence in physical activity volumes between EU and non-EU cohorts (*Me* = 2322 vs. 2226 MET-min/week in medical tracks; *Me* = 1860 vs. 2373 MET-min/week in technical tracks) reflects differences in campus environments, built environment infrastructure, and academic scheduling across Central and Eastern Europe. In the EU zone, medical students exhibited significantly greater physical activity than technical and humanities peers ($p < 0.001$). This elevation is largely attributable to the ambulatory demands of hospital-based clinical training, laboratory rotations, and multi-campus transit, rather than deliberate participation in structured conditioning or leisure-time sports [4, 18]. Conversely, in the non-EU territory, technical and economic students registered the highest volume of physical activity (*Me* = 2373 MET-min/week), while also demonstrating a greater proportion of individuals in the high-intensity tier (65.9%). This observation suggests that in non-EU university settings, technical disciplines may draw a higher proportion of students who engage in manual, field-based, or active commuting routines, or that institutional structures outside the EU maintain mandatory physical education requirements deeper into technical degree curricula [6, 11].

Despite the high percentage of respondents meeting the criteria for high physical activity across all groups (53.2% to 66.6%), the substantial prevalence of physical inactivity (Low PA: <600 MET-min/week) represents a public health concern. The burden of insufficient physical activity was particularly prominent within the EU cohort, reaching 28.6% among social sciences and humanities students, 23.7% in technical fields, and 21.4% among medical students. These findings corroborate broader epidemiological surveillance across European higher education, which consistently identifies young adulthood and the university matriculation phase as periods of pronounced decline in habitual movement and escalation in prolonged sitting [1, 2, 7].

# The Knowledge–Behavior Paradox and Clustered Risk Patterns

A critical outcome of the present study is the empirical verification of the knowledge–behavior paradox, particularly among EU medical and health sciences undergraduates [3, 4]. Theoretically, formal education in human physiology, pathology, and preventive medicine is presumed to foster healthier personal lifestyle practices. Although EU medical students achieved higher total MET-minutes than their non-medical peers, more than one in five (21.4%) remained physically inactive, and this subgroup demonstrated an elevated susceptibility to clustered health-risk behaviors.

Specifically, EU medical undergraduates exhibited the highest prevalence of heavy episodic drinking (binge drinking ≥ 1 time/month: 43.1%), significantly exceeding their non-EU medical counterparts (25.6%; $\chi^2 = 204.2$, $p < 0.001$), alongside frequent electronic nicotine delivery system (ENDS) utilization (19.4%). This behavioral profile confirms that domain-specific health literacy does not operate as an autonomous protective shield against hazardous habits [10, 16]. Under conditions of demanding academic workloads, extensive curricular contact hours, and acute examination-related distress, formal theoretical knowledge is frequently decoupled from daily self-regulation [6, 7]. In such settings, students may adopt maladaptive coping strategies, wherein prolonged sedentary study periods alternate with episodic, intensive recreational substance use [20, 22].

Furthermore, physical activity patterns showed little positive synergy with dietary behaviors. Across all academic disciplines and both geopolitical zones, median Diet Quality Index (DQI) scores remained negative (− 2.00 to − 2.77), and more than 97% of respondents fell into the neutral/mixed nutritional tier. Pro-healthy dietary patterns were documented in only 0.9% to 2.3% of the cohort, without meaningful variation across academic tracks. This decoupling between physical exertion and nutritional adequacy illustrates the selective adoption of health habits among young adults [19].

Moreover, the co-occurrence of moderate-to-high physical activity with regular e-cigarette use and heavy drinking in active subsets aligns with the conceptual framework of compensatory health beliefs and the "athlete's paradox" [8, 9, 10]. Under this cognitive model, young adults engage in physical exertion under the subjective assumption that vigorous exercise physiologically neutralizes the cardiovascular and metabolic insults of alcohol intoxication or nicotine inhalation [10, 22]. From an exercise physiology standpoint, this compensatory assumption is flawed: acute binge drinking and aerosolized nicotine exposure induce immediate endothelial dysfunction, elevate sympathetic outflow, impair glycogen replenishment, and increase the risk of exercise-induced arrhythmias, thereby attenuating the long-term cardioprotective adaptations conferred by physical activity [21, 23].

# Psychosocial Resources and Locus of Control

The psychosocial profiles evaluated in this study provide mechanistic insight into how control beliefs and subjective well-being interact with health behaviors. General self-efficacy (GSES) remained uniform across the sample (*Me* = 30.0), indicating stable baseline coping competence. However, life satisfaction (SWLS) demonstrated marked sensitivity to geopolitical context: non-EU undergraduates reported systematically higher subjective satisfaction than EU peers across all academic fields ($p < 0.01$ to $p < 0.001$), with the lowest values documented among EU technical and economic students (*Me* = 21.0).

With respect to health agency (MHLC), internal health locus of control (IHLC) peaked among EU medical students (*Me* = 4.5, $Z = 6.9$ relative to humanities), reflecting an internalized belief in personal responsibility for disease prevention [15]. Yet, as established by their elevated binge drinking and vaping rates, this strong internal attribution was insufficient to counteract campus-normative risk behaviors [8, 9].

Concurrently, non-EU students recorded significantly higher scores on both the Powerful Others (PHLC: *Me* = 3.7–3.8 vs. 3.3, $p < 0.001$) and Chance (CHLC: $p < 0.001$) dimensions. In the sociopolitical context of non-EU Eastern European states, higher external attributions often reflect culturally embedded collective trust in healthcare authorities or institutional guidance, alongside externalized stress management [13, 14]. Crucially, this external locus did not translate into behavioral neglect; rather, non-EU students displayed superior health-promoting lifestyle practices (HBI-IZZ scores up to 85.085.0) and markedly lower substance use. This finding suggests that external health locus of control in traditional student cohorts may coexist with conservative, risk-averse behavioral patterns [11, 17].

# Geopolitical Environment as a Primary Macro-Determinant

The pronounced divergence in substance consumption between the two geopolitical cohorts demonstrates the primacy of macro-environmental and regulatory frameworks over individual academic specialization. The past-month alcohol abstinence rates observed among non-EU undergraduates (56.2% to 65.5%), contrasted with EU rates (40.1% to 47.8%; $\chi^2 = 299.7$, $p < 0.001$), alongside the virtual absence of daily conventional smoking among non-EU students (0.0% to 0.45% vs. 7.0% to 12.6% in the EU), point to broader systemic influences [11, 12, 23].

These variations reflect differing affordability thresholds, regulatory enforcement regarding minimum purchase ages, campus alcohol bans, retail availability around higher education precincts, and differing peer cultural norms across the EU border [20, 23]. While EU students benefit from open cross-border mobility and greater structural sport funding, they are concurrently exposed to permissive drinking cultures and rapid commercial penetration of modern nicotine delivery technologies (vaping devices, nicotine pouches) [21]. In contrast, the lower substance involvement documented among non-EU students appears to mitigate the cardiometabolic strain associated with student life, despite fewer university recreational resources [11, 12].

# Practical Implications for Campus Sports Infrastructure and Public Health

The gap separating theoretical health knowledge from actual physical activity and lifestyle behaviors demonstrates that informational health education alone is inadequate within higher education settings. Higher education institutions must adopt structural, environmental, and policy-driven interventions:

**Integrated Active Campus Infrastructure**

Universities should move beyond basic varsity athletics and invest in accessible, subsidized, and schedule-flexible physical activity facilities. Structured intramural exercise leagues and active commuting corridors (campus bike-sharing systems, walking circuits) should be scheduled to accommodate curricula with heavy clinical or laboratory commitments, such as medical and engineering tracks [1, 2].

**Coupling Physical Activity Promotion with Substance Abuse Prevention**

University health campaigns must counter compensatory health beliefs by educating active student bodies that exercise does not offset the toxicological consequences of binge drinking or aerosolized nicotine [8, 10, 22]. Institutional policies should enforce

smoke-free and vape-free campus grounds, prohibit alcohol sponsorship of collegiate sporting events, and restrict alcohol access during post-competition social events.

**Digital and Wearable Surveillance**

Campus health centers should leverage validated mobile health (m-Health) applications and wearable activity monitors to deliver real-time feedback on daily step counts, moderate-to-vigorous physical activity (MVPA), and prolonged sedentary sitting bouts, integrating targeted lifestyle counseling for students identified as physically inactive [16, 18].

# Limitations

Several methodological considerations should be acknowledged when interpreting these results:

**Study Design**

The cross-sectional design precludes causal inferences regarding whether geopolitical environments and academic programs directly shape movement patterns and substance choices, or whether pre-existing socioeconomic traits drive disciplinary self-selection.

**Subjective Physical Activity Assessment**

Movement behaviors were quantified using the self-administered IPAQ-SF. Although the IPAQ-SF is a widely validated surveillance tool in international multicenter research [18], self-reported physical activity remains subject to recall inaccuracy, social desirability bias, and cognitive overestimation of vigorous exertion. Subsequent investigations should implement device-based protocols, such as tri-axial accelerometry or combined heart rate and movement sensing, to capture precise 24-hour movement and sedentary patterns.

**Dietary and Substance Screening Depth**

Dietary habits were evaluated through composite food-frequency indices (KomPAN) rather than weighed dietary records or multi-day nutritional logs, and substance misuse was assessed via 30-day recall metrics rather than biological assays (e.g., cotinine or ethyl glucuronide testing) [19, 20, 22].

**Sampling Frame**

While the analytical cohort was large ($N$ = 8,765) and drawn from a stratified multi-institutional quota design, sampling was restricted to public universities situated within cross-border regions of Central and Eastern Europe. Consequently, extrapolation of these findings to Western European tertiary institutions, private colleges, or other geographical jurisdictions requires validation.

# Conclusions

The present multicenter cross-border investigation demonstrates that macro-structural geopolitical context exerts a more decisive influence on physical activity patterns, subjective psychosocial resources, and lifestyle risk behaviors than academic field of study. Undergraduates in non-EU institutions displayed higher overall movement volume, superior subjective life satisfaction, and significantly lower recreational substance misuse than their EU counterparts, highlighting the critical role of macro-environmental and socioeconomic frameworks over curricular guidance alone.

Furthermore, formal academic education in health-related disciplines fails to serve as an automatic safeguard against lifestyle-induced health hazards. Although EU medical students registered elevated continuous energy expenditures, more than one-fifth of this cohort remained physically inactive, while simultaneously exhibiting the highest prevalence of heavy episodic drinking and electronic nicotine device utilization. This configuration provides unequivocal evidence of an operational knowledge–behavior paradox, wherein theoretical understanding of human physiology and pathology is uncoupled from personal behavioral choices.

Finally, movement behaviors did not develop in synergy with balanced nutrition, and high physical exertion frequently co-existed with hazardous substance use, substantiating the presence of compensatory health mechanisms in young adult populations.

Consequently, higher education institutions must advance beyond traditional didactic health curricula by adopting institutional active campus frameworks. Such initiatives should pair accessible sports infrastructure and digital movement surveillance with targeted public health policies designed to deconstruct compensatory risk beliefs and mitigate youth substance consumption.

## Declarations

**Conflicts of interest / Competing interests**

The authors declare that they have no financial or non-financial competing interests related to the work described.

# Ethics approval and consent to participate

This study was performed in line with the principles of the Declaration of Helsinki. Central ethical approval for the international multi-center project was granted by the Bioethics Committee of the District Medical Chamber in Kraków, Poland (Approval no. 96/KBL/OIL/2026). In participating partner institutions, the study protocol was conducted in accordance with institutional guidelines and local regulatory requirements for non-invasive, anonymous survey research. Informed consent was obtained from all individual participants included in the study prior to participation.

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The authors declare that no external funding was received for this study.

# Author Contribution

All authors contributed to the study conception and design. Conceptualisation: ASh, MG; Data curation: ASh, ASz, DS; Formal analysis: ASh, MG, ASz, DS; Investigation: P-FT, VR, JL, AR, SC, IN, IAA, MA, YY, RM, IM, NM, SP, BM, ZM, LDK, MT, RK, LB, JB, ASz; Methodology: ASh, MG, ASz; Visualisation: ASh, ASz, DS; Writing - original draft: ASh, ASz, DS; Writing - review & editing: ASh, ASz, DS; Supervision: MG. All authors read and approved the final manuscript.

# Data Availability

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

## References

1. World Health Organization. European health report 2021: Taking stock of the health-related Sustainable Development Goals. Copenhagen: WHO Regional Office for Europe; 2021.
2. Reuter PR, Forster BL. Student health behavior and academic performance. PeerJ. 2021;9:e11107. https://doi.org/10.7717/peerj.11107
3. Seedhom AE, Kamel EG, Mohammed ES, Raouf NR. Predictors of perceived stress among medical and nonmedical college students, Minia, Egypt. Int J Prev Med. 2019;10:107. https://doi.org/10.4103/ijpvm.IJPVM_6_18
4. Ghouri M, Noor A, Majeed Z, Abida T, Mehmood Z, Rajput R. Comparison of perception of academic stress among medical and non-medical students. Rehabil J. 2024;8(3):11–16. https://doi.org/10.52567/trehabj.v8i03.66
5. 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(24):1451–1462. https://doi.org/10.1136/bjsports-2020-102955
6. Olson N, Oberhoffer R, Reiner B, Schulz T. Health behaviors among students and their association with stress, student burnout and study engagement. Societies. 2025;15(6):153. https://doi.org/10.3390/soc15060153

7. Chong LZ, Foo LK, Chua SL. Student burnout: A review on factors contributing to burnout across different student populations. Behav Sci. 2025;15(2):170. https://doi.org/10.3390/bs15020170
8. Ramón-Arbués E, Antón-Solanas I, Blázquez-Ornat IR, Gómez-Torres P, García-Moyano L, Benito-Ruiz E. Factors related to risky alcohol consumption and binge drinking in Spanish college students: A cross-sectional study. BMJ Open. 2025;15(2):e089825. https://doi.org/10.1136/bmjopen-2024-089825
9. Tavolacci MP, Ladner J, Grigioni S, Richard L, Villet H, Dechelotte P. Prevalence and association of perceived stress, substance use and behavioral addictions: a cross-sectional study among university students. BMC Public Health. 2013;13:724. https://doi.org/10.1186/1471-2458-13-724
10. Radtke T, Scholz U, Keller R, Knäuper B, Hornung R. Smoking-specific compensatory health beliefs and the readiness to stop smoking in adolescents. Br J Health Psychol. 2011;16(3):610–625. https://doi.org/10.1348/2044-8287.002001
11. OECD/European Commission (2024), Health at a Glance: Europe 2024: State of Health in the EU Cycle, OECD Publishing, Paris, https://doi.org/10.1787/b3704e14-en.
12. Bettache K, Chiu CY, Khan S. Geopolitical psychology: An emerging perspective. J Soc Issues. 2025;81(1):e70049. https://doi.org/10.1111/josi.70049
13. Schwarzer R, Jerusalem M. Generalized Self-Efficacy scale. In: Weinman J, Wright S, Johnston M, editors. Measures in health psychology: A user's portfolio. Causal and control beliefs. Windsor: NFER-Nelson; 1995. p. 35–37.
14. Diener E, Emmons RA, Larsen RJ, Griffin S. The Satisfaction With Life Scale. J Pers Assess. 1985;49(1):71–75. https://doi.org/10.1207/s15327752jpa4901_13
15. Wallston KA, Wallston BS, DeVellis R. Development of the Multidimensional Health Locus of Control (MHLC) Scales. Health Educ Monogr. 1978;6(2):160–170. https://doi.org/10.1177/109019817800600107
16. Muraleedharan M, Figueiredo D, Shrisunder R, Jadhav S. Approaches to health promotion in higher education: A scoping review (2014–2024). Health Promot Perspect. 2025;15(3):236–244. https://doi.org/10.34172/hpp.025.44629
17. Juczyński Z. Narzędzia pomiaru w promocji i psychologii zdrowia. Warsaw: Pracownia Testów Psychologicznych Polskiego Towarzystwa Psychologicznego; 2001.
18. 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(8):1381–1395. https://doi.org/10.1249/01.MSS.0000078924.61453.FB
19. Gawęcki J, editor. Kwestionariusz do badania poglądów i zwyczajów żywieniowych oraz procedura opracowania danych (KomPAN). 3rd ed. Olsztyn: Komitet Nauki o Żywieniu Człowieka Polskiej Akademii Nauk; 2020. p. 1–33.
20. Kawalec A. Alcohol and nicotine use among Polish undergraduate students – the preliminary results. Eur J Clin Exp Med. 2024;22(3):491–497. https://doi.org/10.15584/ejcem.2024.3.2
21. Miech R, Leventhal A, Patrick M, Rodriguez N. Trends in use of cigarettes and e-cigarettes among young adults who had smoked in adolescence: 2017–2022. Tobacco Control 2026;35:345–350. https://doi.org/10.1136/tc-2024-059018
22. National Institute on Alcohol Abuse and Alcoholism. Defining binge drinking. NIAAA Newsl. 2004;3:3.
23. Brożek GM, Jankowski M, Lawson JA, Shpakou A, Poznański M, Zielonka TM, et al. The prevalence of cigarette and e-cigarette smoking among students in Central and Eastern Europe - Results of the YUPESS study. Int J Environ Res Public Health. 2019;16(13):2297. https://doi.org/10.3390/ijerph16132297