**RESEARCH**

# Food insecurity and lifestyle behaviours in university students amidst the COVID-19 pandemic: a comparative survey across three countries

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## Abstract

**Background**  University students, often unemployed and reliant on low-nutrition foods, are susceptible to food insecurity (FI) with potential physical and mental health challenges. This study explores FI and its impact on lifestyle behaviours among university students.

**Methods**  A cross-sectional web-based study was performed by sending an online questionnaire to university students in Lebanon, Cyprus, and Germany during the COVID-19 pandemic. Using validated measures, i.e., the Household Food Insecurity Access Scale, International Physical Activity Questionnaire, Pittsburgh Sleep Quality Index, and Mediterranean Diet Adherence Screener, adjusted linear regression models were performed to assess the associations between country, FI and physical activity, sleep quality, and diet.

**Results**  In a convenience sample of 611 individuals (350 in Germany, 214 in Lebanon, and 47 in Cyprus) enrolled in the study, 547 provided complete response. 190 (34.7%) experienced FI, of whom 52 (9.5%) were severely food-insecure, with variation of FI prevalence between countries (18.9% in Germany, 14.9% in Cyprus, and 60.3% in Lebanon). Lifestyle behaviours also differed between participants from the three countries, with students in Germany exhibiting the highest physical activity level and the lowest adherence to the Mediterranean diet compared with Lebanon and Cyprus. On the other hand, participants from Lebanon and Cyprus had similar physical activity and diet behaviours. Concerning sleep, students in Cyprus showed the poorest quality. FI significantly correlated with reduced physical activity (beta − 0.171, 95% Confidence Interval (-0.313, -0.029)), but not with sleep or diet. The country of residence independently predicted lifestyle behaviours ($p < 0.05$).

**Conclusions**  This study suggests that FI impacts university students in countries of varying income levels, and the country of residence independently influences lifestyle behaviours. Larger-size studies are essential to confirm these findings and further explore FI's impact on university students outside the context of the pandemic.

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## Background

Over the years, food insecurity (FI) has become a growing issue both in developing and developed countries. FI is experienced when people do not have consistent access to sufficient, safe, and nutritious food for regular growth, development, and a healthy, active life. It can result from a lack of available food and/or insufficient resources to acquire it, including crises, climate change, poverty, employment status, income, or low level of education [1].

Lower parental education and coming from an ethnic minority also seem to increase the incidence of FI [2]. In a low-income household, there may be a lack of access to healthy food due to its high costs and lack of proper infrastructure for necessities. Lack of awareness and education can limit knowledge about food and nutrition, thus contributing to FI [3]. More recently, the COVID-19 pandemic has impacted income and employment, resulting in increased FI worldwide. In 2022, the United Nations reported a 112 million increase in people who are not able to afford a healthy diet, adding up to approximately 3.1 billion [1]. For example, FI increased by 23% in the United States between 2018 and 2020, with the principal cause being unemployment due to COVID-19 [4].

University students are particularly vulnerable to FI: they may struggle financially due to limited or no income, rising tuition, and housing costs, and, in general, they also lack cooking skills [5, 6]. As also seen in the general population, an increase in FI was described among university students following the pandemic, given the loss of income, housing, and accessibility to campus resources [7–9]. Furthermore, FI among university students became a significant concern during the COVID-19 pandemic, with varying impacts across countries of different development levels. In developed nations like the United States and the United Kingdom, studies showed a marked increase in food insecurity rates among college students during the pandemic [8, 10]. For instance, one study found that 29% of responding students at a private U.S. university became less food secure during the pandemic, with the overall reported FI rate increasing by 130.77% [11]. Moreover, the growing global trend of economic disparity has significantly impacted educational settings, particularly in the post-pandemic recovery period, where inequalities have become more pronounced: students from lower-income backgrounds face greater challenges in accessing resources [12]. We thus hypothesize that developing countries may have experienced more severe impacts due to limited institutional resources and social safety nets. Additionally, the effectiveness of university and government responses to student FI during and after the pandemic likely varied based on available resources and existing support structures in different countries; these hypotheses are based on limited studies conducted in a developing country (Malaysia) [13] and a high middle income one (Saudi Arabia) [14].

On another hand, in any setting, FI is a serious condition among university students, disrupting their physical and mental well-being. FI may affect cardiovascular and endocrine systems [15] and is associated with mental health problems like depression, anxiety, and sleep disorders [16, 17]. Additionally, FI negatively affects academic performance, as students who need to worry about their next meal have generally lower grade point average than their food-secure peers [18]. Finally, FI may also be associated with suboptimal lifestyle behaviours. To illustrate, a higher Body Mass Index is related to the lower physical activity observed in FI students, amongst other factors [19]. Also, there seems to be an inverse relationship between FI and adherence to the Mediterranean diet. A survey among Greek university students underlined a poorer adherence to the Mediterranean diet in those with severe FI [20]. Regarding sleep quality, university students are frequently reported to have short sleep durations, which have also been linked to higher rates of FI [21].

While Germany is a high-income economy, with Gross National Income (GNI) per capita of 51,660, Lebanon has been classified as a lower-middle-income country due to the recent collapse in the Lebanese economy, with GNI per capita 5,110. Cyprus lies between the two, with a GNI per capita of 28,470 [22]. A previous publication found that German students had a lower percentage of FI compared to students in Lebanon. They also had better diet quality and higher physical activity but worse adherence to the Mediterranean diet. Moreover, FI was associated with worse sleep and stress [23].

Although studies comparing prevalence and predictors of FI between regions of the same country or subgroups (e.g. public vs. private universities, rural vs. urban etc.) exist, currently this is the only country level comparative study on FI, while other studies assessing the relationship between lifestyle behaviours and FI during COVID-19 in different countries are lacking. A comparative approach to studying FI across diverse economic landscapes offers valuable insights into how these disparities manifest in different contexts and could be managed. By examining the intersections of FI and lifestyle, such studies contribute uniquely to understanding global social inequalities and their long-term implications for students' well-being.

## Methods

### Aim

Including data from Cyprus, a country with an intermediate economic level, we aimed to explore the prevalence of FI and its association with physical activity, sleep quality, and adherence to the Mediterranean diet among university students from Lebanon, Cyprus, and Germany during the COVID-19 pandemic. The specific objectives were as follows:

1. To assess the prevalence of FI among university students in Lebanon, Cyprus, and Germany during the COVID-19 pandemic, comparing rates across these countries with distinct economic and cultural contexts.
2. To compare how FI relates to selected lifestyle behaviours (physical activity, sleep, and dietary adherence) across Lebanon, Cyprus, and Germany, highlighting the role of each country's unique economic situation and cultural context in shaping these relationships.

### Study design and setting of the study

This web-based cross-sectional study was carried out between September 2021 and September 2022 in Lebanon, Cyprus, and Germany using convenience sampling. The survey was disseminated using a standard Google Form through various social media platforms (Facebook, WhatsApp, Instagram, and LinkedIn) and in-class announcements. The questionnaire was piloted with university students (five from each country) to guarantee clarity and acceptability. Responses from the pilot were incorporated into the final dataset since they did not affect the study's findings; no changes were made to the questionnaire and no discrepancies between students from different countries were noted.

Participation was entirely voluntary and anonymous, and participants could end their involvement at any point. No identification number was required to be declared to maintain participants' confidentiality and non-traceability. Before taking part, participants were informed of the study's purpose and were only included after providing consent on the first page of the online survey. Although this increased the challenge to reach the required sample size, no compensation, financial or otherwise, was provided to participants for their participation.

### Minimum sample size calculation

The minimum sample size required for the study was determined using G-Power software, version 3.0.10, with an expected squared multiple correlation of 0.05 (R [2] deviation from 0) related to the Omnibus test of multiple regression and an effect size of 0.0526. To achieve a power of 80% and a 5% alpha error rate, while allowing for up to 25 predictors in the model, a minimum sample size of $n=454$ was calculated. Additionally, 20% more participants were targeted to account for potential missing values.

### Eligibility criteria

The inclusion criteria involved recruiting undergraduate or postgraduate students pursuing their university education from any academic discipline aged 17 years and above, with no exclusion criteria. Local and international students from various universities in Cyprus, Lebanon, and Germany were invited to participate. In some cases, imposing exclusion criteria could significantly reduce the available pool of participants, making it difficult to recruit a sufficient sample size. This can be particularly relevant in studies with limited resources or those conducted in specific settings such as the pandemic period and student populations. Including all potential participants without exclusions allows the study to capture a comprehensive view of FI and lifestyle behaviours under investigation, considering the full spectrum of variations within the university student population. Also excluding certain groups might unintentionally perpetuate biases or disparities, therefore we invited any student from both private and public universities to include a diverse population that mirrors the real-world scenario more closely. This enhances the external validity and generalizability of the findings, making them applicable to a wider audience. However, we acknowledge that without exclusion criteria, the study might include participants with characteristics that could confound the results, but we address confounding in the analysis.

### Study collection tool

The questionnaire included publicly available instruments (as shown in supplementary materials) and was designed on both Google Forms and the SoSci Survey platform. It necessitated 20 to 30 min to be completed and was accessible in English and German languages [24]. It included sociodemographic characteristics and instruments for assessing FI, sleep quality, physical activity, and adherence to the Mediterranean diet (Supplement 1). For every validated scale, data from the full subset for every country was used to assess the reliability through a Cronbach alpha calculation.

### *The International Physical Activity Auestionnaire (IPAQ)-Short Form*

The IPAQ-Short Form was employed to evaluate physical activity over the preceding seven days. This validated instrument comprises seven questions about the duration and frequency of physical activity, categorized into intensity levels, i.e., light, moderate, and vigorous [25].

This tool is validated in Lebanon and Germany. In Lebanon, it showed a robust internal consistency (reliability) with Cronbach's alpha ranging from 0.769 to 1.00 and an intraclass correlation coefficient ranging from 0.625 to 0.999 [26]. The German version of the IPAQ-Short Form shows satisfactory validity properties among adults [27], while an adapted long version was used in German adolescents [28]. Moreover, the IPAQ-Short Form has long been used in Cyprus [29]. A logarithmic transformation was applied to improve the normality of the scale. Higher IPAQ scores suggest higher physical activity levels.

### The Household |Food Insecurity Access (HFIAS) Scale

The Household Food Insecurity Access Scale (HFIAS) comprises two sets, each containing nine questions. The first set of questions evaluates instances of FI linked to anxiety and uncertainty regarding the household's food supply, insufficient quality, and inadequate food intake with its associated physical consequences. The questions about occurrence are dichotomous, with a rating of 0 for "no" and 1 for "yes." The other set consists of frequency-of-occurrence questions that assess the occurrence of the specific condition over the preceding four weeks on a 3-point Likert scale, i.e., rarely (1), sometimes (2), and often (3) [30]. The HFIAS score is derived by summing the codes assigned to each frequency-of-occurrence question, ranging from a minimum possible score of 0 to a maximum possible score of 27, whereby higher scores indicate a higher level of FI. The final score is categorized into food-secure (0 to 1 point) and food-insecure groups using the algorithm devised by the tool developers. Furthermore, students facing FI were classified into three categories: mild (2 to 8 points), moderate (9 to 16 points), and severe (17 to 27 points) FI [30]. The validity of the HFIAS scale has been confirmed in Lebanon, with a Cronbach's alpha of 0.91 and a moderate agreement in test-retest reliability (ICC of 0.58) [31]. The scale has not been validated in Germany or Cyprus. Nevertheless, it demonstrated good reliability in this study, with a Cronbach's alpha of 0.920 in the total sample, 0.750 in the sample from Germany, and 0.858 in the sample from Cyprus.

### The Pittsburgh Sleep Quality Index (PSQI)

The assessment of sleep quality over the past month was conducted using the PSQI. The reliability and validity of the PSQI were confirmed in a study involving 9284 German adults residing in the community, demonstrating a Cronbach's alpha of 0.75 [32]. In a distinct study carried out in Arab countries, the PSQI exhibited satisfactory reliability (Cronbach's alpha=0.65) and strong convergent validity ($r=0.76$) when compared with the Insomnia Severity Index [33]. The tool validity has also been confirmed in Cyprus [34]. This validated 9-item instrument includes four questions focused on sleep duration (usual sleep time, time to fall asleep, usual wake-up time, and actual sleep hours) and five questions on the factors related to sleep issues [32]. A higher PSQI score indicates lower sleep quality. In this study, Cronbach's alpha was 0.824 for the overall sample, 0.791 for the German subset, 0.756 for the Cypriot subset, and 0.836 for the Lebanese subset.

### The Mediterranean Diet Adherence Screener (MEDAS)

The MEDAS was utilized to evaluate adherence to the Mediterranean diet, recognized as a healthful dietary pattern [35]. This 14-item survey gauges the regularity of intake or amount consumed for 12 key components and two dietary habits associated with the Mediterranean diet. Responses favoring the Mediterranean diet receive a score of one, while unfavorable responses are assigned a score of zero. The cumulative score ranges from 0 to 14, with higher scores signifying greater adherence to the Mediterranean diet. In Germany, the MEDAS has undergone validation among 68 women, revealing fair or higher agreement between the food frequency questionnaire and MEDAS for approximately half of the MEDAS questions [36]. Despite its application in various studies in Lebanon [37, 38], the MEDAS is not yet validated. As for Cyprus, the scale has been validated in comparison with other European countries and showed adequate validity results [39]. In this research, Cronbach's alpha was 0.390 for the entire sample, 0.430 for the German subset, 0.301 for the Cyprus subset, and 0.319 for the Lebanese subset.

### The inCharge Financial Distress/Financial Well-being (IFDFW) Scale

The IFDFW scale, a self-reported tool comprising eight items, was used to assess financial well-being [40]. This validated instrument assesses perceived financial distress or well-being on a scale spanning from overwhelming financial distress (indicating the lowest level of wellbeing) to no financial distress (reflecting the highest level of well-being). It demonstrated high internal consistency and reliability [41]. Previously validated in Lebanon with a Cronbach's alpha of 0.925 [42], this scale had not undergone validation in Germany or Cyprus. In the current study, Cronbach's alpha for the scale was 0.850 in the overall sample, 0.895 in the German subset, 0.868 in the Cypriot subset, and 0.844 in the Lebanese subset.

### The Perceived Stress Scale

The 10-point Perceived Stress Scale (PSS-10) was employed to evaluate stress experienced in the preceding month, with respondents characterizing their current life as unpredictable, uncontrollable, and stressful [43]. Validated in Germany with a participant pool of 2,527, this tool demonstrated robust internal consistency

(Cronbach's alpha = 0.84) and construct validity [44]. In Lebanon, validation was conducted in a sample of 268 women, revealing a Cronbach's alpha of 0.74. The test-retest reliability was found to be moderately high, as indicated by a Spearman correlation coefficient of 0.74 [45]; similarly, the scale showed appropriate validity among Cypriot adults [46]. Response choices vary from never (0) to very often (4), yielding a total score ranging from 0 to 40. Higher scores indicate higher levels of perceived stress. In this study, Cronbach's alpha was 0.835 for the overall sample, 0.860 for the German subset, 0.795 for the Cyprus subset, and 0.756 for the Lebanese subset.

### Statistical analysis

Data analysis utilized SPSS software version 25. Descriptive statistics were computed using means and standard deviations for continuous variables and counts with percentages for categorical variables. Before conducting One-Way ANOVA for means, assumptions of normality of the dependent variables and homoscedasticity (variances homogeneity) were verified. The Chi-square test was conducted to compare counts, provided that expected counts were higher than 5. In instances where assumptions were not met, logarithmic transformations or non-parametric tests such as the Kruskal-Wallis test and Fisher's exact test were employed, respectively.

A Multivariate Analysis of Covariance (MANCOVA) was conducted to compare means of continuous variables among groups after adjustment over potential confounders selected according to existing literature; it allowed the modelling of independent variables and calculation of adjusted means. The assumptions of the MANCOVA were appropriately tested and met, including the linearity of associations, the multivariate normality of the dependent residuals, the absence of multicollinearity between independent variables, the homogeneity of variances and covariances, and the absence of outliers (Supplement 2). In the global model, the primary independent variables were country, and FI and the covariates were age, gender, marital status, income, employment status, PSS, and IFDFW. The significance level was set at $p < 0.05$.

### Results

A total of 611 students (350 from Germany, 214 from Lebanon, and 47 from Cyprus) filled out the questionnaire. Table 1 summarizes the sociodemographic characteristics of study participants, which significantly differed between participants from the three countries, except for age.

From the total sample, 64 (10.5%) participants had missing information on the HFIAS score and were excluded from the analysis. In order to make sure that missing values happened at random, without causing selection bias, we compared characteristics (gender, age,

marital status, age, and BMI group) between students with and without HFIAS score missing values and there were no differences (data not shown). Of the remaining 547 students, 357 (65.3%) individuals were food-secure and 190 (34.7%) experienced FI, of whom 52 (9.5%) were severely food-insecure. A low percentage of university students struggled with some degree of FI in Germany (18.9%) and Cyprus (14.9%), while this proportion was significantly higher in Lebanon (60.3%) (Fig. 1, Table 1).

Lifestyle behaviours seemed to differ between participants from the three countries in the bivariate analysis (Fig. 2; Table 1): students in Germany exhibited the highest physical activity level and the lowest adherence to the Mediterranean diet compared with Lebanon and Cyprus. On the other hand, participants from Lebanon and Cyprus had similar physical activity and diet behaviours. Concerning sleep, students in Cyprus showed the poorest quality.

Table 2 shows the adjusted associations with lifestyle behaviours based on the multivariate analysis. FI was significantly associated with lower physical activity but not with adherence to the Mediterranean diet or sleep quality. Country of residence was a significant independent correlate of all three lifestyle behaviours in the adjusted global models, with students in Germany having significantly higher physical activity but lower adherence to the Mediterranean diet and poorer sleep quality compared with students in Lebanon.

Physical activity was significantly different between the three countries, with students in Cyprus showing the lowest levels, followed by Lebanon and then Germany. Regarding sleep quality, Germany ranked significantly higher than the two other countries, with Cyprus following and Lebanon last (although $p = 0.06$). As for Mediterranean diet adherence, students from Cyprus and Lebanon exhibited similar behaviours, both significantly better than those in Germany (Table 2).

### Discussion

In this study, FI during the COVID-19 pandemic varied between countries: students in Lebanon showed the highest FI, followed by students living in Germany and Cyprus. This result was expected, given the current economic instability, political unrest, and conflict in Lebanon and their impact on food availability, distribution, and access [47]. The stronger economy and higher stability in middle-income Cyprus and high-income Germany could explain the overall comparable low FI rates. Yet, even in these countries, a notable percentage of students with severe FI was observed, especially in Germany.

Our findings reinforce university students as a vulnerable population regarding FI, irrespective of the country's economic status [48]. Tuition, accommodation, and academic expenses create a financial burden, limiting

**Table 1** Sociodemographic Characteristics of University Students in 3 countries (*N* = 611)

| | All countries (*n* = 611) | Lebanon (*n* = 214) | Germany (*n* = 350) | Cyprus (*n* = 47) | |
|---|---|---|---|---|---|
| | Frequency (%) | Frequency (%) | Frequency (%) | Frequency (%) | *p*-value |
| **Gender** | | | | | |
| Male | 125 (20.7) | 44 (20.6) | 63 (18.3) | 18 (38.3) | **0.016** |
| Female | 478 (79.3) | 170 (79.4) | 279 (80.9) | 29 (61.7) | |
| **Marital status** | | | | | |
| Single | 429 (70.8) | 183 (85.5) | 214 (62.0) | 32 (68.1) | **< 0.001** |
| Solid partnership/not married | 152 (25.1) | 15 (7.0) | 122 (35.4) | 15 (31.9) | |
| Married | 21 (3.5) | 12 (5.6) | 9 (2.6) | 0 (0) | |
| Widowed | 1 (0.2) | 1 (0.5) | 0 (0) | 0 (0) | |
| Divorced | 3 (0.5) | 3 (1.4) | 0 (0) | 0 (0) | |
| **Financial independence** | | | | | |
| Yes | 133 (22.4) | 67 (31.3) | 62 (18.6) | 4 (8.5) | **< 0.001** |
| No | 462 (77.6) | 147 (68.7) | 272 (81.4) | 43 (91.5) | |
| **Monthly income** | | | | | |
| No income | 168 (28.2) | 82 (38.3) | 86 (25.7) | 0 (0) | **< 0.001** |
| Low | 276 (46.4) | 55 (25.7) | 188 (56.3) | 33 (70.2) | |
| Intermediate | 113 (19.0) | 45 (21.0) | 56 (16.8) | 12 (25.5) | |
| High | 38 (6.4) | 32 (15.0) | 4 (1.2) | 2 (4.3) | |
| **Source of income** | | | | | |
| Parents or guardians | 303 (50.9) | 132 (61.7) | 134 (40.1) | 37 (78.7) | **< 0.001** |
| Parents plus own occupation | 167 (28.1) | 32 (15.0) | 129 (38.6) | 6 (12.8) | |
| Own occupation | 125 (21.0) | 50 (23.3) | 71 (21.3) | 4 (8.5) | |
| **Financial support** | | | | | |
| Yes | 155 (26.1) | 65 (30.4) | 64 (19.2) | 26 (55.3) | **< 0.001** |
| No | 440 (73.9) | 149 (69.6) | 270 (80.8) | 21 (44.7) | |
| **Employment status** | | | | | |
| Full time employed | 57 (9.6) | 41 (19.2) | 15 (4.5) | 1 (2.1) | **< 0.001** |
| Part time / marginally employed | 228 (38.3) | 42 (19.6) | 181 (54.2) | 5 (10.6) | |
| Not employed | 310 (52.1) | 131 (61.2) | 138 (41.3) | 41 (87.2) | |
| **Place of residence** | | | | | |
| On campus | 56 (9.4) | 7 (3.3) | 35 (10.5) | 14 (29.8) | **< 0.001** |
| Off campus, not with parents/guardians | 249 (41.8) | 16 (7.5) | 203 (60.8) | 30 (63.8) | |
| Off campus, with parents/guardians | 290 (48.7) | 191 (89.2) | 96 (28.7) | 3 (6.4) | |
| **Region of residence** | | | | | |
| In the city or rather urban | 468 (78.7) | 140 (65.4) | 281 (84.1) | 47 (100) | **< 0.001** |
| In the countryside or rather rural | 127 (21.3) | 74 (34.6) | 53 (15.9) | 0 (0) | |
| | All countries (*n* = 611) | Lebanon (*n* = 214) | Germany (*n* = 350) | Cyprus (*n* = 47) | |
| | Mean ± SD | Mean ± SD | Mean ± SD | Mean ± SD | |
| Age | 22.75 ± 4.99 | 22.34 ± 5.09 | 22.87 ± 5.15 | 23.81 ± 2.72 | 0.152 |
| BMI | 22.51 ± 4.21 | 22.77 ± 4.57 | 22.09 ± 3.90 | 23.78 ± 4.01 | **0.021** |
| IPAQ (log10)* | 3.20 ± 0.50 | 3.05 ± 0.54 | 3.37 ± 0.38 | 2.76 ± 0.42 | **< 0.001** |
| PSQI* | 6.81 ± 3.06 | 6.86 ± 3.23 | 6.77 ± 2.85 | 6.83 ± 3.49 | **0.941** |
| MEDAS* | 5.01 ± 2.06 | 5.51 ± 1.91 | 4.52 ± 2.07 | 5.76 ± 1.84 | **< 0.001** |
| HFIAS* | 4.91 ± 4.51 | 6.16 ± 5.07 | 3.57 ± 3.24 | 3.12 ± 3.24 | **< 0.001** |
| Financial well-being scale | 48.58 ± 14.63 | 39.78 ± 9.15 | 56.07 ± 14.89 | 45.59 ± 9.18 | **< 0.001** |

IPAQ: International Physical Activity Questionnaires; PSQI: Pittsburgh Sleep Quality Index; MEDAS: Mediterranean Diet Adherence Screener; HFIAS: The Household Food Insecurity Access Scale

*Adjusted for: age, gender, marital status, income, employment status, stress (PSS), financial well-being (IFDFW)
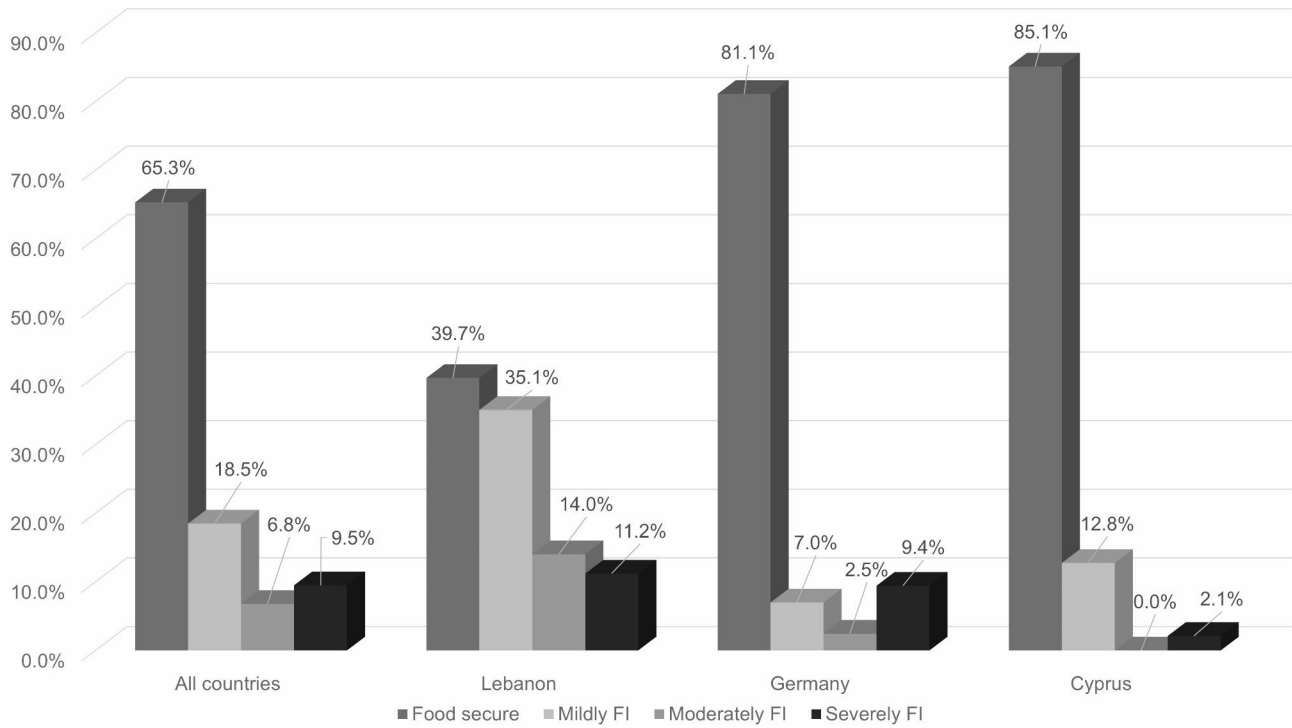
**Fig. 1** Food insecurity in university students of 3 countries according to the household. Food insecurity (FI) levels differed significantly according to the countries ($p < 0.05$). Legend: Food Insecurity Access Scale Score: Food Secure 0–1 points, Mild FI: 2–8 points, Moderate FI: 9–16 points, Severe FI: 17–27 points
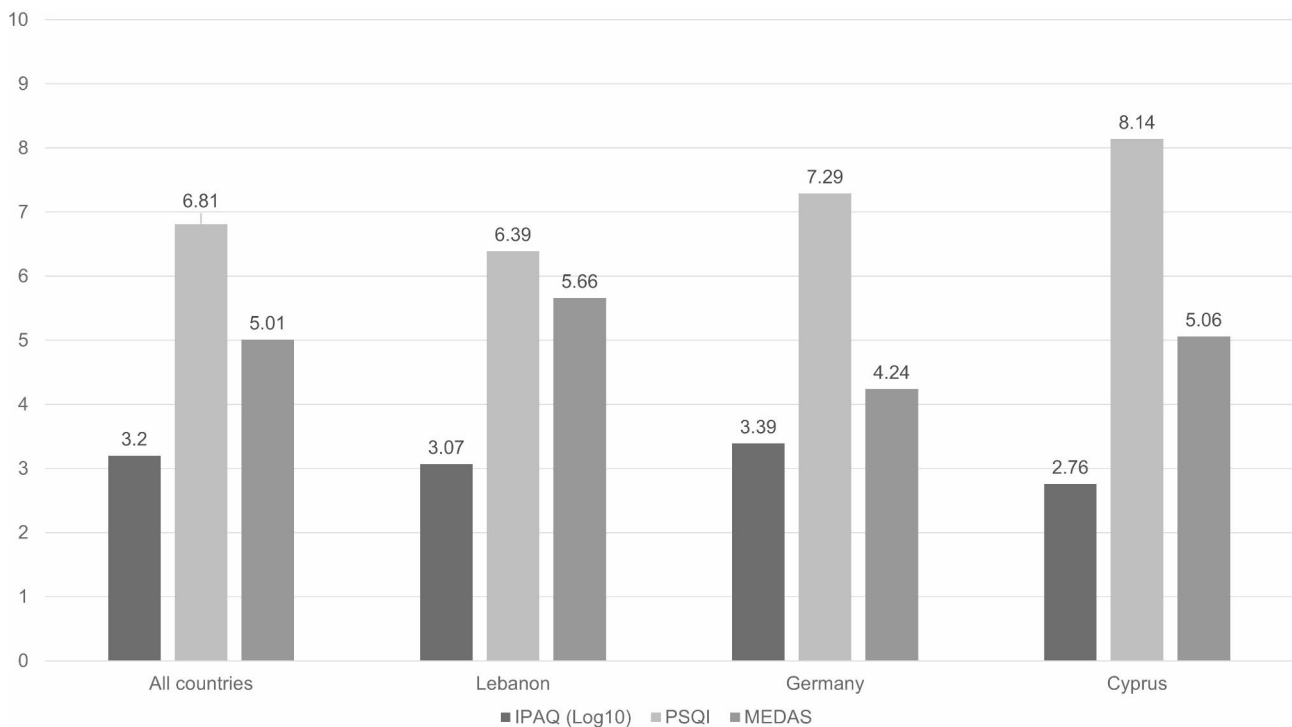


**Fig. 2** Lifestyle behaviours of university students according to country. Behaviors (physical activity, sleep and Mediterranean diet adherence) differed significantly between Germany, Cyprus, and Lebanon ($p < 0.05$). Legend: Mean scores for International Physical Activity Questionnaires (IPAQ), Pittsburgh Sleep Quality Index (PSQI), and Mediterranean Diet Adherence Screener (MEDAS)

**Table 2** Multivariate analysis of covariance (MANCOVA) testing for association between food insecurity and lifestyle behaviours

|  | Beta | 95% Confidence interval | | *P*-value |
|---|---|---|---|---|
| **Physical Activity (IPAQ total score)** | | | | |
| Age | -0.002 | -0.016 | 0.011 | 0.731 |
| Gender (Female vs. male*) | -0.125 | -0.255 | 0.004 | 0.058 |
| Marital status (Married vs. single*) | -0.028 | -0.152 | 0.095 | 0.652 |
| Employment (employed vs. unemployed*) | **0.191** | **0.065** | **0.318** | **0.003** |
| Income (low vs. no income*) | -0.088 | -0.219 | 0.042 | 0.185 |
| Income (Intermediate vs. no income*) | -0.165 | -0.334 | 0.004 | 0.056 |
| Income (high vs. no income*) | -0.061 | -0.271 | 0.15 | 0.571 |
| Sterss (PSS scale) | 0.001 | -0.007 | 0.009 | 0.811 |
| Financial well-being (IFDFW scale) | 0.0009 | -0.004 | 0.005 | 0.967 |
| Food insecure vs. food secure* (HFIAS scale) | **-0.171** | **-0.313** | **-0.029** | **0.018** |
| Country (Germany vs. Lebanon*) | **0.235** | **0.069** | **0.401** | **0.006** |
| Country (Cyprus vs. Lebanon*) | **-0.297** | **-0.512** | **-0.082** | **0.007** |
| **Sleep Quality (PSQI total score)** | | | | |
| Age | 0.077 | -0.008 | 0.162 | 0.076 |
| Gender (Female vs. male*) | 0.423 | -0.396 | 1.242 | 0.31 |
| Marital status (Married vs. single*) | 0.284 | -0.497 | 1.065 | 0.475 |
| Employment (employed vs. unemployed*) | 0.101 | -0.695 | 0.897 | 0.803 |
| Income (low vs. no income*) | -0.098 | -0.924 | 0.729 | 0.817 |
| Income (Intermediate vs. no income*) | -0.125 | -1.195 | 0.945 | 0.818 |
| Income (high vs. no income*) | 0.454 | -0.875 | 1.783 | 0.502 |
| Stress (PSS scale) | **0.172** | **0.12** | **0.224** | **< 0.001** |
| Financial well-being (IFDFW scale) | -0.012 | -0.04 | 0.016 | 0.41 |
| Food insecure vs. food secure* (HFIAS scale) | 0.859 | -0.039 | 1.757 | 0.061 |
| Country (Germany vs. Lebanon*) | **1.421** | **0.373** | **2.47** | **0.008** |
| Country (Cyprus vs. Lebanon*) | 1.297 | -0.061 | 2.655 | 0.061 |
| **Adherence to Mediterranean Diet (MEDAS total score)** | | | | |
| Age | -0.013 | -0.071 | 0.045 | 0.665 |
| Gender (Female vs. male*) | 0.378 | -0.18 | 0.936 | 0.184 |
| Marital status (Married vs. single*) | 0.288 | -0.244 | 0.82 | 0.288 |
| Employment (employed vs. unemployed*) | -0.096 | -0.638 | 0.446 | 0.728 |
| Income (low vs. no income*) | 0.22 | -0.343 | 0.783 | 0.442 |
| Income (Intermediate vs. no income*) | 0.073 | -0.655 | 0.802 | 0.843 |
| Income (high vs. no income*) | -0.121 | -1.027 | 0.784 | 0.792 |
| Stress (PSS scale) | -0.023 | -0.059 | 0.012 | 0.196 |
| Financial well-being (IFDFW scale) | 0.002 | -0.017 | 0.021 | 0.837 |
| Food insecure vs. food secure* (HFIAS scale) | 0.064 | -0.547 | 0.676 | 0.836 |
| Country (Germany vs. Lebanon*) | **-1.137** | **-1.851** | **-0.422** | **0.002** |
| Country (Cyprus vs. Lebanon*) | 0.206 | -0.719 | 1.131 | 0.661 |

Note: In the global model, the major independent variables were country and food security and the covariates were age, gender, marital status, income, employment status, PSS, IFDFW.

IPAQ: International Physical Activity Questionnaires; PSQI: Pittsburgh Sleep Quality Index; MEDAS: Mediterranean Diet Adherence Screener; PSS: Perceived Stress Scale; HFIAS: Household Food Insecurity Access Scale; IFDFW: InCharge Financial Distress/Financial Well-Being Scale

*Reference group

resources for students to have enough safe and nutritious food. Part-time employment, common but often insufficient, may not cover all needs. The high cost of living, especially in urban university areas, further strains budgets [8, 49]. On-campus housing's limited cooking facilities and time constraints lead to reliance on expensive, less nutritious food. Social pressures and a lack of awareness about support services may lead students to prioritize non-essential expenses over food [48]. In addition,

the initial period of the COVID-19 pandemic may have exacerbated FI, as shown in other countries [9, 49]. Indeed, with quarantine mandates affecting the operation of institutions and companies globally, youth have been hit hard by temporarily or permanently lost jobs or reduced working hours [50]. Our findings related to the lowest FI in Cyprus are likely due to the composition of the sample in this country, which included a substantial proportion of international students from high-income

families and/or countries (55%) [51]. Nevertheless, selection bias cannot be excluded because of the small sample size from Cyprus.

Our study indicated a notable inverse association between FI and physical activity, supported by findings from European populations [52] showing that household FI is associated with less physical activity among children and adults. This relationship could be explained by the assumption that malnourished populations have decreased physical performance compared with well-nourished populations [53]. Additionally, students facing FI due to restricted family income may be more likely to work during their studies, implying time constraints for physical activity compared with their food-secure peers, as suggested by our analysis showing that unemployed students had higher physical activity than employed ones. These findings emphasize the complex interplay between FI, physical activity, and external factors, shedding light on the multifaceted [54] nature of well-being among different populations. Our results also revealed that students from Germany had significantly higher physical activity, followed by Lebanese students, while students from Cyprus had the lowest level of physical activity. Physical activity levels among university students vary with cultural norms, infrastructure accessibility, academic pressures, economic factors, climate, transportation habits, health awareness, and social influences. Wealthier nations may offer more resources related to government initiatives, green space availability, healthcare integration, and the educational system that increase youth engagement in physical activity [55], while extreme climates (heat waves that are more common in Southern countries) can limit physical activity [56]. Moreover, cultural attitudes related to family and community norms, gender expectations and religious norms, workload and academic demands, and environmental conditions shape how students engage in exercise [57].

Differences in the quality of sleep among students stem from diverse environmental, lifestyle, and cultural practices. Our study revealed poorer sleep quality in Germany compared with Lebanon, possibly due to the busier lifestyle in the former. Shorter sleep durations in European and Mediterranean students are documented and often caused by irregular sleep schedules and part-time jobs [21]. Our analysis also showed an inverse, although non-significant, association between FI and sleep quality, consistent with the findings of a meta-analysis of nine studies showing that the risk of poor sleep quality was associated with FI in adults 18 years and older inside and outside of the United States [58]. Although the underlying mechanism of this relationship is not well studied, mental health conditions resulting from FI, such as anxiety and depression, may contribute to diminished sleep

quality [58], also supported by the association between perceived stress and sleep quality found in this study.

While previous literature suggested a correlation between FI and low adherence to the Mediterranean diet [20, 59, 60], our study does not report on a similar association. The country was the only factor associated with adherence to the Mediterranean diet in multivariate analysis. Lebanon showed the highest adherence, followed closely by Cyprus, while Germany ranked lowest. Traditional dietary patterns and regional food availability may be the key factors, with Lebanese and Cypriot populations adhering more closely to the Mediterranean diet [59], as might be anticipated, given the geographical perspective. Although research suggests that people of higher socioeconomic status are more likely to afford and adhere to a healthier diet [61], this was not seen at a country level. Our study shows how notable differences in MEDAS values between Germany, Lebanon, and Cyprus are influenced by cultural background eating behaviours and the country's wealth, also shown in previous research [62]. The lack of correlation between FI and MEDAS scores was influenced by the fact that two out of the three participating countries in this study are in the Mediterranean region, potentially restricting the number of students not adherent to the Mediterranean diet, with a subsequent insufficient power to independently assess this association. Further studies are necessary to depict the discrepancy presented by our results.

## Implications of this study

Our study highlights the burden of FI on university students during the COVID-19 pandemic, especially in countries with a pre-existing financial crisis. This study also suggests that FI may adversely impact physical activity in this population and that the country of residence plays a role in lifestyle behaviours, with significantly higher physical activity in Germany but lower adherence to the Mediterranean diet compared to Cyprus and Lebanon. These findings hold significant implications for targeted public health policy and programs to address specific challenges contributing to FI among university students and to alleviate FI's physical and mental health consequences. Studying how different countries handle similar problems helps policymakers learn valuable lessons, allowing them to apply successful strategies while considering the importance of understanding social and cultural differences for tangible improvements in the health and well-being of young populations. Supplemental Nutrition Assistance Program and campus food/banks pantries providing free groceries have been shown to reduce FI and improve mental health. Meal voucher programs, ensure access to nutritious meals, reducing stress and enhancing well-being. Financial aid and emergency grants specifically for food-related expenses help

students manage their finances better, decreasing the likelihood of meal-skipping [63, 64]. Furthermore, nutrition education, cooking classes, and community gardens may empower students to make healthier food choices and prepare cost-effective meals, thereby improving dietary habits [65]. Finally, health and educational authorities should prioritize promoting a healthy lifestyle among university students through lifestyle interventions tailored to each country to prevent future chronic diseases and decrease the burden on the health system and society. Tailoring these interventions to the social and cultural context of each country can enhance their effectiveness and sustainability. For example, in Germany, the Physical Activity Programme provides access to sports activities close to people's homes, while the Federal Ministry of Health coordinates national efforts to promote health-enhancing physical activity, focusing on reducing socially determined and gender inequalities in physical activity access [55].

**Strengths and limitations of the study**
The present analysis has many strengths, including the use of validated instruments that reduce the risk of information bias, although some scales, such as MEDAS in Lebanon and IFDFW in Germany and Cyprus, lacked validation. However, their reliability was confirmed. Another strength is the duration of data collection, which spanned a full academic year. This extended time frame allowed for the inclusion of students who may have experienced interruptions in their studies in the fall semester of 2021 due to the pandemic. It also contributed to increasing the survey's response rate and an adequate sample size for conducting most of the multivariable analyses, minimising residual confounding. However, the smaller sample size in Cyprus compared with the two other countries may obscure some associations after adjusting for confounders, suggesting a cautious interpretation of some Cyprus-related results, particularly the non-significant ones, such as the physical activity and dietary differences between Cyprus and Lebanon. Nonetheless, the variation in university student respondents across the three countries reflects the student population size for the 2021–2022 academic year, according to national statistics (~ 1,725,461 students in Germany, ~ 222,064 in Lebanon, ~ 60,000 in Cyprus).

Many other limitations deserve to be highlighted. Potential selection bias is inherent in survey-based data collection. Moreover, this study utilised convenience sampling, which is widely used in studies on FI, as shown in two reviews [66, 67], due to practical constraints and the need for timely data collection from diverse groups of university students across different countries. While this method enabled the collection of a substantial amount of data, it may introduce selection bias, as participants who chose to respond might differ in significant ways from those who did not. This selection bias is expected to overestimate some concepts, as students who responded may be more interested in the study's topic or more affected by the context or the behaviours being researched. Efforts were made to reach a broad and diverse sample by distributing the survey through multiple channels, including university in-class announcements and social media platforms, to mitigate this potential bias. Given the majority of females in all three samples, the uneven gender distribution resulting from voluntary response bias may impact the generalisability of the analysis outcomes.

This uneven distribution, resulting from voluntary response bias may underestimate overall physical activity levels and overestimate healthy eating behaviours due to cultural norms, body image considerations, and safety concerns that often differ between genders [68]. However, the comparative approach adopted and the use of multivariable analysis likely decreased the effect of this bias on the results.

Additionally, the lack of specific exclusion criteria may have led to the inclusion of participants with unique circumstances that could skew results, obscure key relationships, or identify outliers that could significantly affect statistical interpretations. Nevertheless, no significant outliers were detected in the analysis, which is likely due to the healthy-student effect.

Also, the self-reported information and the inclusion of retrospective questions in the questionnaire introduce challenges with recall. It should be noted that the presence of some missing values related to HFIAS did not affect the outcomes, as described in the results section. Moreover, the HFIAS scale was positioned in the middle of the questionnaire, so participants' fatigue could not be incriminated, but rather the sensitive nature of the questions related to FI. In summary, a more extensive investigation with a larger and more diverse sample across multiple countries is imperative to support and confirm the observed associations and to provide generalisability of findings; handling missing values with a multiple imputation method is also suggested.

**Conclusions**
Our study suggests that during the COVID-19 pandemic, FI affected university students in countries of varying income levels, while the country of residence independently influenced lifestyle behaviours. FI was more prevalent in less affluent countries, such as Lebanon, and less frequent in Germany and Cyprus. Despite some limitations related to selection and information biases, this study highlighted the significant impact of FI on physical activity, but larger-size multi-country, culturally diverse, and multidisciplinary academic prospective studies are warranted to confirm these findings, further explore the

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influence of FI on university students outside the context of the pandemic, investigate the long-term effects of FI on students' health and academic performance, and suggest cost-effective interventions to mitigate the impact of FI in this vulnerable population. Furthermore, concerned authorities and policymakers at national, regional, and global levels could use the results of the current study to make evidence-based decisions to promote healthy behaviours of university students.

## Abbreviations

| | |
|---|---|
| ANOVA | Analysis of Variance |
| COVID-19 | Coronavirus Disease |
| FI | Food Insecurity |
| GNI | Gross National Income |
| HFIAS | Household Food Insecurity Access Scale |
| IFDFW | InCharge Financial Distress/Financial Well-Being Scale |
| IPAQ | International Physical Activity Questionnaire |
| MEDAS | Mediterranean Diet Adherence Screener |
| MANCOVA | Multivariate Analysis of Covariance |
| PSQI | Sleep Quality Index |
| PSS-10 | Perceived Stress Scale |

## Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12889-024-21033-3.

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Supplementary Material 1

Supplementary Material 2

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## Author contributions
Conceptualization, P.S. & Y.S.; Methodology, P.S., H.S. & J.S.; Validation, P.S., C.H. & J.S.; Formal Analysis, C.H.; Investigation, R.R., D.M., H.S., & Y.S.; Data Curation, C.H.; Writing – Original Draft Preparation, M.M.W., A.I., A.S.; Review & Editing, M.M.W., A.I., A.S., H.S., R.R., D.M., J.S., P.S., D.I., Supervision, P.S. & D.I. All authors have read and approved the submission of the manuscript for publication.

## Data availability
The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

## Declarations

### Ethics approval and consent to participate
This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving research study participants were approved a priori by the INSPECT-LB Research Ethics Committee (2021REC-002-INSPECT-09-17). In every country, participation was entirely voluntary and confidential, and participants had the option to withdraw at any stage. Before completing the questionnaire, participants were briefed on the study objectives, and inclusion was contingent upon their consent, which was obtained on the initial page of the online survey. No form of compensation, whether financial or otherwise, was offered to participants for their involvement. The convenience sampling being observational with no traceability of patients offers a further guarantee of participants' information confidentiality. All study participants provided informed consent before data collection.

### Consent for publication
Not Applicable.

### Competing interests
The authors declare no competing interests.

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