Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

# Musculoskeletal Pain and Postural Abnormalities among Lebanese University Students: Prevalence and Correlates from a Cross-Sectional Study

**Moussa Nassar**
Lebanese American University
**Mohsen Yassine**
Lebanese American University
**Jimmy Bakhos**
Lebanese American University
**Zeinab Safieddine**
Lebanese American University
**Christina Haydar**
Lebanese American University
**Georges Dagher**
Lebanese American University
**Michele Cherfane**
Lebanese American University
**Joseph Stephan**
joseph.stephan@lau.edu.lb
Lebanese American University

**Research Article**

**Keywords:** Musculoskeletal pain, Posture, Ergonomics, University students, Screen exposure

**Posted Date:** November 12th, 2026

**DOI:** https://doi.org/10.21203/rs.3.rs-11118577/v1

**License:** This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License

**Additional Declarations:** No competing interests reported.

## Abstract

# Background

Musculoskeletal (MSK) pain is a major global health concern and is increasingly recognized among university students due to prolonged sedentary behavior, extensive digital device use, and academic demands. In Lebanon, data on MSK pain within this population remain limited. This study aims to determine the prevalence of MSK pain and postural abnormalities among Lebanese university students and to identify demographic, academic, lifestyle, and health-related factors associated with MSK pain.

# Methods

A cross-sectional study using the Extended Nordic Musculoskeletal Questionnaire (NMQ-E) and the Internet Addiction Test (IAT) was conducted among 396 university students from higher education institutions across Lebanon. Participants completed a structured questionnaire incorporating these validated instruments, along with questions on sociodemographic characteristics, academic behaviors, ergonomic practices, lifestyle factors, and medical conditions. Descriptive statistics, bivariate analyses, multivariable logistic regression, and multiple linear regression were performed.

# Results

The findings indicate a high lifetime prevalence of MSK pain, particularly in the neck (68.7%), lower back (69.2%), and shoulders (60.9%). In multivariable analysis, female sex is independently associated with higher odds of MSK pain across multiple regions (aOR = 1.9–2.8, 95% CI: 1.0–5.3, $p < 0.05$). Self-perceived poor posture shows a strong association with lower back pain (aOR = 2.0, 95% CI: 1.01–4.14, $p < 0.05$), upper back pain, wrist/hand pain, and overall pain burden. Sleep disorders (aOR = 2.3–3.0, 95% CI: 1.03–7.02, $p < 0.05$) and migraine (aOR = 2.3, 95% CI: 1.26–4.05, $p < 0.01$) are also independently associated with increased MSK pain. In linear regression, male sex is associated with a lower overall pain score ($\beta = -0.16$, $p < 0.01$), while poor posture and comorbid conditions remain significant predictors of higher pain scores.

# Conclusion

MSK pain is highly prevalent among Lebanese university students and is influenced by a combination of ergonomic, academic, lifestyle, and health-related factors. These findings highlight the importance of implementing university-based prevention strategies that promote ergonomic awareness, healthy study behaviors, and student well-being to reduce the burden of MSK pain.

## Background

Musculoskeletal (MSK) disorders represent one of the leading causes of disability and reduced quality of life globally. According to the 2019 Global Burden of Disease Study, MSK conditions collectively rank among the top contributors to years lived with disability, affecting populations across all age groups and socioeconomic strata [1]. While the epidemiological burden of MSK pain has been extensively documented in occupational and aging populations [2], growing evidence indicates that young adults are also at considerable risk [3]. Among this population, university students warrant particular attention due to their unique constellation of academic, behavioral, and lifestyle-related risk factors [4]. The transition into higher education is characterized by prolonged sedentary study behavior, heavy reliance on digital devices, irregular sleep patterns, and heightened academic stress—all of which have been independently associated with the onset and exacerbation of musculoskeletal pain [5].

Students enrolled in health sciences programs may be exposed to additional occupational and ergonomic stressors during clinical training. These include prolonged standing, awkward or sustained postures, repetitive movements and manual patient handling tasks, which may further increase their susceptibility to MSK disorders [6, 7].

Although the burden of MSK pain among university students is increasingly recognized, its underlying determinants are complex and multifactorial encompassing biomechanical, behavioral, and psychosocial determinants. From a biomechanical perspective, prolonged screen use is associated with forward head posture and other postural deviations that contribute to cervical and thoracic musculoskeletal pain [8, 9]. Internet addiction has emerged as an additional public health concern, representing a novel pathway through which excessive screen time, sustained non-ergonomic device use, and prolonged sedentary behavior may increase the risk and severity of MSK pain among university students [10–13]. Psychosocial factors also play a significant role, as anxiety, depression, and chronic academic stress have been shown to amplify pain perception through central sensitization mechanisms [6, 14]. Furthermore, early-life adversity and adverse childhood experiences have been associated with reduced pain thresholds and an increased susceptibility to chronic pain in young adulthood [15].

In Lebanon, the current evidence on MSK pain has been primarily derived from occupational cohorts. Studies among office workers and hospital personnel have reported alarmingly high rates of low back pain (LBP), ranging from 45% to 54%, with women consistently exhibiting higher rates than men [16, 17]. Across these occupational populations, poor workplace ergonomics, prolonged sitting, heavy lifting, and insufficient preventive training have emerged as the most consistently reported physical risk factors [16, 17]. In addition, psychological factors, particularly occupational stress and burnout, have been shown to contribute to the development and persistence of MSK pain.

Despite the growing body of international literature on MSK pain among university students—with studies from Saudi Arabia, Egypt, and Syria reporting prevalence rates ranging from 72% to 82% among medical and health science students [18–21]—data specific to Lebanese university students remain conspicuously lacking. This evidence gap is particularly concerning given Lebanon's unique socioeconomic and educational landscape, where the ongoing economic crisis may have further altered

students' health behaviors, learning environments, and access to ergonomic resources. To date, only one Lebanese study has explored musculoskeletal conditions among university students, focusing solely on the prevalence of fibromyalgia [22]. No published study has comprehensively characterized the prevalence and distribution of musculoskeletal pain and postural abnormalities across university students from different academic disciplines or identified the factors associated with these conditions.

Against this background, robust epidemiological data are needed to quantify the burden of MSK pain among Lebanese university students and identify modifiable risk factors amenable to prevention. Therefore, the present study aimed to determine the prevalence of MSK pain and postural abnormalities among Lebanese university students and to examine demographic, academic, lifestyle, and psychosocial correlates of musculoskeletal pain. By providing the first comprehensive epidemiological assessment of MSK health among university students in Lebanon, the findings are expected to inform the development of targeted prevention and intervention strategies at the university level.

# Methods

### Study Design and Population

A cross-sectional observational study was conducted among university students enrolled in higher education institutions across Lebanon. The manuscript is reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for cross-sectional studies [23]. A nationwide, web-based survey was administered between November 2025 and February 2026 using a structured, self-administered questionnaire. Eligible participants were undergraduate students from any academic discipline who were aged 18 years or older, able to complete the questionnaire in either English or Arabic, and willing to provide informed consent. Participants were recruited using a convenience sampling strategy through social media platforms commonly used by Lebanese university students, particularly WhatsApp. The survey link and a Quick Response (QR) code were disseminated through student networks, university group chats, faculty contacts, and printed flyers on campus to maximize participation across institutions and academic disciplines. Students who choose to participate did so voluntarily, without any incentive or coercion.

### Sample Size Calculation

Sample size was calculated using Epi Info™ (Centers for Disease Control and Prevention [CDC], Atlanta, GA, USA; available at cdc.gov/epiinfo/). Assuming a 95% confidence level, a 5% margin of error, an anticipated prevalence of musculoskeletal (MSK) pain of 50% (a conservative estimate that maximizes the required sample size in the absence of national data), and an estimated population of 222,064 university students in Lebanon during the 2019–2020 academic year [24], the minimum required sample size was calculated to be 383 participants. The use of a 50% expected prevalence was supported by previous international studies reporting a high burden of MSK pain among university students in comparable settings [25].

## Data Collection Instruments

### *Extended Nordic Musculoskeletal Questionnaire (NMQ-E)*

Musculoskeletal pain was assessed using the Extended Nordic Musculoskeletal Questionnaire (NMQ-E), a validated, self-administered instrument that evaluates the presence of musculoskeletal symptoms across nine anatomical regions: the neck, shoulders, upper back, elbows, wrists/hands, lower back, hips/thighs, knees, and ankles/feet [26]. Participants reported whether they had experienced pain or discomfort in each body region during the previous 12 months and the previous 7 days. The NMQ-E has demonstrated good reliability and validity across different populations and has been validated in Arabic for use among Arab-speaking populations [27]. Pain intensity in affected body regions was assessed using an 11-point Numeric Rating Scale (NRS), ranging from 0 (no pain) to 10 (worst imaginable pain). Participants were also asked about strategies used to relieve or manage their symptoms, including analgesic use, physiotherapy, and rest.

### *Internet Addiction Test (IAT)*

Internet addiction was assessed using the Internet Addiction Test (IAT), a validated 20-item self-administered questionnaire developed by Young [28] and subsequently validated in Arabic among Lebanese populations [29]. Each item is rated on a 5-point Likert scale ranging from 1 (rarely) to 5 (always), yielding a total score between 20 to 100. Total scores were categorized as normal internet use (20–39), moderate internet addiction (40–69), and as severe internet addiction (70–100) [28].

### *Demographic, Academic and Lifestyle Variables*

A structured questionnaire was used to collect information on demographic, academic, lifestyle, and ergonomic characteristics potentially associated with musculoskeletal pain. Demographic variables included age, sex, university, academic discipline, and year of study. Lifestyle characteristics comprised daily study duration, daily screen time, frequency of physical activity, average sleep duration, smoking status, and body mass index (BMI), calculated from self-reported height and weight. Academic and ergonomic factors included the primary study environment, chair type, desk height, monitor position, and other workstation characteristics at home and on campus. Participants were also asked about previous musculoskeletal conditions or injuries.

## Plan of Analysis

The internal consistency of the Extended Nordic Musculoskeletal Questionnaire (NMQ-E) and the Internet Addiction Test (IAT) was evaluated using Cronbach's alpha, with values ≥0.70 considered indicative of acceptable reliability [30]. Prior to analysis, continuous variables were assessed for normality using the Shapiro–Wilk test and visual inspection of histograms and Q–Q plots.

Descriptive statistics were used to summarize participant characteristics and study outcomes. Continuous variables, including age, BMI, pain severity, and IAT scores, were reported as means and

standard deviations (SD), or medians and interquartile ranges (IQR), as appropriate, while categorical variables, such as sex, academic major, and pain prevalence by body region, were presented as frequencies and percentages. The prevalence of musculoskeletal pain by anatomical region and the prevalence of postural abnormalities were estimated with corresponding 95% confidence intervals (CIs).

Bivariate analyses were conducted using two complementary approaches. First, anatomical region assessed by the NMQ-E (neck, shoulders, upper back, elbows, lower back, hands/wrists, hips/thighs, knees, and feet/ankles) was analyzed separately as a binary outcome (presence vs. absence of pain). Associations with demographic, academic, lifestyle, ergonomic, health-related, and internet addiction variables were examined using the Chi-square test or Fisher's exact test for categorical variables, and the independent samples t-test, one-way analysis of variance (ANOVA), Mann–Whitney U, or Kruskal–Wallis tests for continuous variables, as appropriate. Second, an overall musculoskeletal pain burden was calculated by summing the number of anatomical regions in which participants reported pain, with higher scores indicating greater musculoskeletal burden. Associations between the composite pain score and the same set of independent variables were subsequently examined using the appropriate parametric or non-parametric statistical tests according to data distribution.

Multivariable analyses mirrored the bivariate approach. Separate binary logistic regression models were constructed for each anatomical pain region to identify independent factors associated with the presence of pain, with results presented as adjusted odds ratios (aORs) and 95% confidence intervals. Multiple linear regression analysis was subsequently performed using the composite musculoskeletal pain score as the dependent variable to identify factors independently associated with overall pain burden. Variables with a $p < 0.20$ in the bivariate analyses, together with variables considered clinically relevant based on existing literature, were entered into the multivariable models. Model assumptions, including multicollinearity and goodness-of-fit, were assessed before final model interpretation. Statistical significance was established at a two-sided p-value $<0.05$. All statistical analyses were performed using IBM SPSS Statistics, Version 29.0 (IBM Corp., Armonk, NY, USA).

# Results

### Reliability of Study Instruments

Both study instruments demonstrated excellent internal consistency. The Extended Nordic Musculoskeletal Questionnaire (NMQ-E) yielded a Cronbach's alpha of 0.926 (99 items), while the Internet Addiction Test (IAT) demonstrated a Cronbach's alpha of 0.904 (20 items), confirming excellent reliability.

### Descriptive Statistics

A total of 396 university students from higher education institutions across Lebanon participated in this study. Participants had a mean age of 20.5 ± 1.9 years, and 60.9% were female. Nearly two-thirds (61.6%) had a normal BMI, while 41.9% were enrolled in health-related disciplines. Regarding health and

lifestyle characteristics, 22.5% of participants reported a mental health condition, 23.0% reported migraines, and 15.4% reported a sleep disorder. Most students (62.1%) reported sleeping 6–7 hours per night. The mean Internet Addiction Test score was 39.35 ± 14.58, with 44.7% of participants demonstrating moderate to severe internet addiction. Full sociodemographic, academic, and health-related characteristics are presented in Table 1. Full item-level responses to the Internet Addiction Test are presented in Supplementary Table S1.

**Table 1. Sociodemographic, academic, and health-related characteristics of the study participants (N = 396).**

| Variable | Category | n | % |
|---|---|---|---|
| Age | Mean ± SD | 20.52 ± 1.92 | — |
| Gender | Female | 241 | 60.9 |
| | Male | 155 | 39.1 |
| BMI | Underweight (<18.5) | 17 | 4.3 |
| | Normal weight (18.5–24.9) | 244 | 61.6 |
| | Overweight (25.0–29.9) | 106 | 26.8 |
| | Obesity class I | 21 | 5.3 |
| | Obesity class II | 5 | 1.3 |
| | Obesity class III | 3 | 0.8 |
| Area of residency | Bekaa-Baalbek-Hermel | 29 | 7.3 |
| | Beirut | 83 | 21.0 |
| | Mount Lebanon | 142 | 35.9 |
| | North Lebanon (Akkar and North) | 103 | 26.0 |
| | South Lebanon | 39 | 9.8 |
| University | American University of Beirut | 25 | 6.3 |
| | Antonine University | 21 | 5.3 |
| | Beirut Arab University | 4 | 1.0 |
| | Holy Spirit University of Kaslik | 13 | 3.3 |
| | Islamic University of Lebanon | 13 | 3.3 |
| | Lebanese American University | 119 | 30.1 |
| | Lebanese University | 50 | 12.6 |
| | Notre Dame University | 23 | 5.8 |
| | Université Saint-Joseph | 11 | 2.8 |
| | University of Balamand | 85 | 21.5 |
| | Other | 32 | 8.1 |
| Academic year | First year | 49 | 12.4 |
| | Second year | 85 | 21.5 |
| | Third year | 73 | 18.4 |

| Variable | Category | n | % |
|---|---|---|---|
| | Fourth year | 151 | 38.1 |
| | Fifth year | 38 | 9.6 |
| Working status | Not employed | 266 | 67.2 |
| | Part-time employed | 81 | 20.5 |
| | Self-employed | 22 | 5.6 |
| | Internship | 17 | 4.3 |
| | Other | 10 | 2.5 |
| Field of study | Health sciences | 166 | 41.9 |
| | Engineering | 73 | 18.4 |
| | Computer and natural sciences | 62 | 15.7 |
| | Business | 33 | 8.3 |
| | Humanities and Arts | 35 | 8.8 |
| | Other | 27 | 6.8 |
| Medical condition | Diabetes | 5 | 1.3 |
| | Hypertension | 10 | 2.5 |
| | Thyroid disorder | 11 | 2.8 |
| | Sleep disorder | 61 | 15.4 |
| | Mental health disorder | 89 | 22.5 |
| | Migraine | 91 | 23.0 |
| Sleep duration per night | <4 hours | 10 | 2.5 |
| | 4–5 hours | 69 | 17.4 |
| | 6–7 hours | 246 | 62.1 |
| | 8–9 hours | 71 | 17.9 |
| Internet Addiction Test score | Mean ± SD | 39.35 ± 14.58 | — |
| Internet addiction category | No addiction | 219 | 55.3 |
| | Moderate addiction | 161 | 40.7 |
| | Severe addiction | 16 | 4.0 |

Data are presented as n (%) unless otherwise indicated. Continuous variables are presented as mean ± standard deviation (SD). Percentages may not total 100% due to rounding; participants could report more than one medical condition, so percentages for medical conditions do not total 100%. Internet addiction categories were defined according to the Internet Addiction Test (IAT).

Musculoskeletal (MSK) pain was highly prevalent across all anatomical regions. The most frequently affected sites were the lower back (69.2%), neck (68.7%), and shoulders (60.9%), as illustrated in Figure 1 and detailed by anatomical region in Table 2. Full item-level results of the NMQ-E, including pain prevalence over the past 12 months, past 4 weeks, and today, as well as associated healthcare-seeking behavior, are presented in Supplementary Table S2.

**Table 2. Prevalence of musculoskeletal pain by anatomical region, based on the NMQ-E (N = 396).**

| Body region | Ever had pain, n (%) | Pain in last 12 months, n (%) | Pain today, n (%) |
|---|---|---|---|
| Neck | 272 (68.7) | 229 (57.8) | 129 (32.6) |
| Shoulder | 241 (60.9) | 201 (50.8) | 92 (23.2) |
| Upper back | 193 (48.7) | 169 (42.7) | 78 (19.7) |
| Lower back | 274 (69.2) | 227 (57.3) | 104 (26.3) |
| Hands/wrists | 145 (36.6) | 98 (24.7) | 33 (8.3) |
| Knee | 144 (36.4) | 112 (28.3) | 43 (10.9) |
| Feet/ankles | 121 (30.6) | 90 (22.7) | 43 (10.9) |
| Hip/thigh | 88 (22.2) | 57 (14.4) | 23 (5.8) |
| Elbows | 53 (13.4) | 35 (8.8) | 11 (2.8) |

Data are presented as n (%). “Ever had pain” refers to pain reported at any point in the participant’s lifetime. Full item-level NMQ-E results, including hospitalization, days of pain in the last 4 weeks, work prevention, healthcare-seeking behavior, medication use, sick leave, and duty changes by region, are presented in Supplementary Table S2.

Overall, 208 participants (52.5%) reported having poor posture, and 152 (38.4%) had been told by a healthcare professional or peer that they had poor posture. Postural and ergonomic habits were common: holding the cell phone predominantly on one side (85.1%), carrying a backpack or bag on one shoulder (82.6%), working or studying with the screen not at eye level (83.1%), tilting the head downward for prolonged periods during device use (81.8%), crossing the legs while sitting (80.6%), and slouching while sitting (78.3%). Most of these habits, along with self-perceived poor posture, were significantly more common among female than male students (Table 3).

**Table 3. Postural habits and ergonomic factors, by sex (N = 396).**

| Variable | Male, n (%) | Female, n (%) | P value |
|---|---|---|---|
| Self-perceived poor posture (yes) | 72 (34.6) | 136 (65.4) | <0.001 |
| Told by a healthcare professional or peer that posture is poor (yes) | 54 (35.5) | 98 (64.5) | 0.245 |
| Tilts head downward for prolonged periods during device use (yes) | 114 (35.2) | 210 (64.8) | 0.001 |
| Crosses legs while sitting | 94 (29.5) | 225 (70.5) | <0.001 |
| Carries a backpack or bag on one shoulder | 110 (33.6) | 217 (66.4) | <0.001 |
| Holds cell phone predominantly on one side | 127 (37.7) | 210 (62.3) | 0.156 |
| Slouches while sitting (e.g., rounded shoulders, forward head posture) | 109 (35.2) | 201 (64.8) | 0.002 |
| Screen not positioned at eye level while working/studying | 116 (35.3) | 213 (64.7) | <0.001 |
| Aware of ergonomic guidelines for posture during device use | 75 (41.0) | 108 (59.0) | 0.486 |
| Applies ergonomic techniques to correct posture | 52 (46.0) | 61 (54.0) | 0.076 |

Data are presented as n (%), reflecting the sex composition of participants reporting each habit (e.g., of the 208 participants who self-reported poor posture, 34.6% were male and 65.4% were female); these are not percentages within each sex group. P-values were obtained using the Chi-square test. A shortened version of Supplementary Table S3 is presented here; full item-level detail, including break-frequency habits, is retained in Supplementary Table S3.

**Bivariate Analysis**

*Region Specific Analysis*

Bivariate analyses identified several demographic, health-related, ergonomic, and lifestyle factors associated with musculoskeletal pain across individual anatomical regions. Female sex was consistently associated with a higher prevalence of pain in most body regions with the exception of the elbows, knees and hips/thighs (Figure 2). Neck pain was significantly associated with longer daily study duration with prevalence increasing to 79.7% among students studying ≥4 hours per day ($p < 0.001$). In addition, neck pain was also significantly more common among students reporting mental health conditions (82.0% vs. 64.8%, $p = 0.002$), migraine (81.3% vs. 64.9%, $p = 0.003$), self-perceived poor posture ($p < 0.001$), and poor postural habits (Table S4).

Shoulder pain was significantly more prevalent among students with sleep disorders (77.0% vs. 57.9%, $p = 0.005$) and migraine (72.5% vs. 57.4%, $p = 0.009$). Upper back pain was significantly associated with

internship training and self-perceived poor posture ($p < 0.05$). Lower back pain was significantly associated with being informed by others or a healthcare professional of having poor posture ($p = 0.028$). Academic discipline was not significantly associated with overall MSK pain burden (mean pain score 3.21–4.51 across disciplines, $p = 0.290$) or with pain in most individual regions (all $p > 0.05$), with the exception of neck pain, which varied significantly by field of study ($p = 0.017$): prevalence was highest among students in the humanities and arts (80.0%) and lowest among business students (48.5%). Associations between health-related factors, ergonomic characteristics, and region-specific musculoskeletal pain are illustrated in Supplementary Figures S1 and S2, respectively. Detailed bivariate analyses for all anatomical regions are presented in Supplementary Table S4-S12.

*Pain Scores*

The overall MSK pain burden, measured as the total number of painful anatomical regions, differed significantly across several participant characteristics. Female students reported a significantly higher mean pain score than males (4.36 ± 2.23 vs. 3.10 ± 2.45, $p < 0.001$). Similarly, students with sleep disorders (4.90 ± 2.47 vs. 3.68 ± 2.34, $p < 0.001$), mental health conditions (4.75 ± 2.36 vs. 3.61 ± 2.35, $p < 0.001$), migraine (4.93 ± 2.34 vs. 3.55 ± 2.32, $p < 0.001$), and gastrointestinal disorders (4.92 ± 2.61 vs. 3.62 ± 2.28, $p < 0.001$) demonstrated significantly greater musculoskeletal pain burden than their counterparts. Poor postural characteristics were also consistently associated with higher pain scores (Figure 3). Detailed bivariate analyses are presented in supplementary Table S13.

**Multivariable Analysis**

*Region-specific binary logistic regression*

Multivariable logistic regression identified several independent predictors of region-specific musculoskeletal pain (Table 4). Male sex was consistently associated with lower odds of neck, shoulder, and upper back pain compared with female sex (aOR = 0.384, 95% CI: 0.202–0.732, $p = 0.004$; aOR = 0.484, 95% CI: 0.265–0.885, $p = 0.018$; and aOR = 0.575, 95% CI: 0.331–0.998, $p = 0.049$, respectively).

For shoulder pain, regular use of printed books was associated with increased odds of pain (aOR = 1.721, 95% CI: 1.010–2.934, $p = 0.046$), whereas regular iPad or tablet use was associated with approximately 50% lower odds (aOR = 0.497, 95% CI: 0.303–0.815, $p = 0.006$). Students with sleep disorders had more than twofold higher odds of shoulder pain than those without sleep disorders (aOR = 2.317, 95% CI: 1.030–5.214, $p = 0.042$).

For upper back pain, internship training was independently associated with more than threefold increased odds of pain compared with non-working students (aOR = 3.631, 95% CI: 1.039–12.694, $p = 0.043$). In addition, students reporting poor posture had more than twice the odds of upper back pain compared with those perceiving their posture as normal (aOR = 2.383, 95% CI: 1.167–4.868, $p = 0.017$). Employment status was independently associated with upper back pain, with internship students having significantly higher odds than non-working students.

For lower back pain, prolonged daily screen time of 4–6 hours was associated with nearly ninefold higher odds of pain compared with less than one hour of screen time (aOR = 8.812, 95% CI: 1.501–51.721, p = 0.016). Self-perceived poor posture (aOR = 2.040, 95% CI: 1.006–4.137, p = 0.048) and carrying a backpack or bag on one shoulder (aOR = 2.053, 95% CI: 1.120–3.765, p = 0.020) were also independently associated with increased odds of lower back pain.

Additional independent predictors were identified for elbow, wrist/hand, and knee pain, including obesity, sleep disorders, gastrointestinal disorders, internship training, and migraine (Table 4).

**Table 4. Multivariable logistic regression analysis of factors independently associated with musculoskeletal pain by anatomical region.**

| Anatomical region | Variable | Category | aOR | 95% CI | P value |
|---|---|---|---|---|---|
| **Neck pain** | Gender | Female | Reference | | |
| | | Male | 0.384 | 0.202–0.732 | 0.004 |
| | University | American University of Beirut | Reference | | |
| | | Notre Dame University | 0.166 | 0.030–0.911 | 0.039 |
| **Shoulder pain** | Gender | Female | Reference | | |
| | | Male | 0.484 | 0.265–0.885 | 0.018 |
| | Hours of studying per day | Less than 1 hr | Reference | | |
| | | 3 hr | 0.191 | 0.068–0.535 | 0.002 |
| | Regular use of printed books | No | Reference | | |
| | | Yes | 1.721 | 1.010–2.934 | 0.046 |
| | Regular use of iPad or tablet | No | Reference | | |
| | | Yes | 0.497 | 0.303–0.815 | 0.006 |
| | Sleep disorder | No | Reference | | |
| | | Yes | 2.317 | 1.030–5.214 | 0.042 |
| **Upper back pain** | Gender | Female | Reference | | |
| | | Male | 0.575 | 0.331–0.998 | 0.049 |
| | Employment status | Not employed | Reference | | |
| | | Self-employed | 0.211 | 0.058–0.763 | 0.018 |
| | | Internship | 3.631 | 1.039–12.694 | 0.043 |

| Anatomical region | Variable | Category | aOR | 95% CI | P value |
|---|---|---|---|---|---|
| | Self-perceived poor posture | No | Reference | | |
| | | Not sure | 2.573 | 1.279–5.177 | 0.008 |
| | | Yes | 2.383 | 1.167–4.868 | 0.017 |
| **Elbow pain** | BMI | <18.5 (underweight) | Reference | | |
| | | Obesity class II (35.0–39.9)† | 54.904 | 1.773–1699.996 | 0.022 |
| | Employment status | Not employed | Reference | | |
| | | Self-employed | 0.028 | 0.001–0.632 | 0.025 |
| | Sleep disorder | No | Reference | | |
| | | Yes | 3.010 | 1.292–7.016 | 0.011 |
| | Muscular exercises | No | Reference | | |
| | | Yes | 2.288 | 1.153–4.539 | 0.018 |
| **Wrist/hand pain** | Age, years | — | 0.743 | 0.638–0.886 | <0.001 |
| | Gastrointestinal disorders | No | Reference | | |
| | | Yes | 2.001 | 1.068–3.748 | 0.030 |
| | Hours of sleep per night | Less than 4 hrs | Reference | | |
| | | 8–9 hrs | 0.135 | 0.021–0.860 | 0.034 |
| | Self-perceived poor posture | No | Reference | | |
| | | Yes | 2.151 | 1.024–4.520 | 0.043 |
| | Employment status | Not working | Reference | | |
| | | Internship | 4.125 | 1.226–13.885 | 0.022 |

| Anatomical region | Variable | Category | aOR | 95% CI | P value |
|---|---|---|---|---|---|
| **Lower back pain** | Total screen time | Less than 1 hour | Reference | | |
| | | 4–6 hrs | 8.812 | 1.501–51.721 | 0.016 |
| | Self-perceived poor posture | No | Reference | | |
| | | Yes | 2.040 | 1.006–4.137 | 0.048 |
| | Carrying a backpack or bag on one shoulder | No | Reference | | |
| | | Yes | 2.053 | 1.120–3.765 | 0.020 |
| **Knee pain** | Migraine | No | Reference | | |
| | | Yes | 2.256 | 1.258–4.046 | 0.006 |
| | Holding cell phone predominantly on one side | No | Reference | | |
| | | Yes | 2.169 | 1.030–4.565 | 0.042 |

**Abbreviations:** aOR, adjusted odds ratio; CI, confidence interval; BMI, body mass index. Separate multivariable logistic regression models were constructed for each anatomical pain region. Variables with $p < 0.20$ in the corresponding bivariate analyses were entered into each model. Only variables retained in the final models are presented; non-significant categories of each retained variable are omitted from this table for readability; the complete results for every variable and category are presented in Supplementary Table S14. Reference categories are indicated as “Reference.” Statistical significance was set at $p < 0.05$. †This estimate should be interpreted with caution: the very wide confidence interval reflects a small cell size (obesity class II) and indicates an unstable, imprecise estimate.

*Linear Regression*

Male sex was independently associated with a lower overall musculoskeletal pain burden, whereas migraine, gastrointestinal disorders, and self-perceived poor posture were independently associated with a higher pain burden (Table 5). Self-perceived poor posture demonstrated the strongest standardized association with pain burden ($\beta = 0.185$; $B = 0.542$, 95% CI: 0.202–0.882, $p = 0.002$).

**Table 5: Multiple linear regression analysis of factors associated with overall musculoskeletal pain burden.**

| Variable | B | β | P value | 95% CI Lower Bound | 95% CI Upper Bound |
|---|---|---|---|---|---|
| Male sex (vs. female*) | −0.785 | −0.160 | 0.006 | −1.339 | −0.230 |
| Migraine (vs. no*) | 0.728 | 0.128 | 0.013 | 0.156 | 1.299 |
| Gastrointestinal disorder (vs. no*) | 0.660 | 0.108 | 0.029 | 0.068 | 1.251 |
| Self-perceived poor posture (vs. no*) | 0.542 | 0.185 | 0.002 | 0.202 | 0.882 |

**Abbreviations:** B, unstandardized regression coefficient; β, standardized regression coefficient; CI, confidence interval. Variables with $p < 0.20$ in the bivariate analyses were entered into the multiple linear regression model. Statistical significance was set at $p < 0.05$.

# Discussion

This study provides the first comprehensive assessment of musculoskeletal (MSK) pain and postural abnormalities among Lebanese university students. The findings reveal a substantial burden of MSK pain, with the neck and lower back emerging as the most commonly affected anatomical regions. These findings indicate that MSK pain is not merely an occasional complaint but a common and clinically relevant health concern among university students in Lebanon. The observed distribution of pain is consistent with previous studies identifying neck, shoulder, and back pain as the most frequently affected regions among university students and young adults exposed to prolonged sitting, academic workload, and intensive digital device use [4,20,25,31]

Beyond the high prevalence of MSK pain, sex emerged as one of the most consistent determinants across multiple anatomical regions. Female students experienced significantly higher odds of neck, shoulder, and upper back pain, in addition to a greater overall musculoskeletal pain burden. These findings are consistent with previous evidence demonstrating that musculoskeletal disorders are more commonly reported among women than men, both in the general population and among university students [4,32]. Several mechanisms may contribute to these differences, including biological variations in pain perception, hormonal influences, psychosocial factors, and differences in exposure or response to physical and academic stressors. Further research is warranted to better understand the mechanisms underlying these sex-related differences.

Postural factors also emerged as key contributors to musculoskeletal (MSK) pain. Self-perceived poor posture was independently associated with upper back pain, hand/wrist pain, lower back pain, as well as with a greater overall musculoskeletal pain burden. These findings reinforce the importance of sustained non-neutral posture during studying and digital device use as a major mechanical stressor among university students. They are in agreement with previous studies linking forward head posture, slouched sitting, and poor ergonomic practices to musculoskeletal symptoms in young adults and student

populations [20,25]. Given that posture is a modifiable risk factor, these findings highlight an important opportunity for preventive interventions aimed at improving ergonomic awareness and study habits within university settings.

The influence of academic behaviors further supports the role of the university environment in the development of MSK symptoms. Although the associations varied by anatomical region, prolonged screen time was independently associated with lower back pain, longer daily study duration was associated with neck and feet/ankle pain, and the type of study material was associated with shoulder pain. Interestingly, regular use of printed books increased the odds of shoulder pain, whereas tablet or iPad use was associated with lower odds. While this finding should be interpreted cautiously, it may reflect differences in posture, device positioning, and movement during study activities rather than intrinsic effects of the study tools themselves. These findings are consistent with previous studies demonstrating that prolonged screen exposure, sustained sitting, repetitive study-related activities, and poor ergonomic practices increase the risk of musculoskeletal symptoms among university students [8,9,20,31]. Collectively, these observations reinforce the concept that prolonged academic engagement, combined with specific study behaviors and suboptimal ergonomic conditions, contributes substantially to the development of MSK pain among university students.

The present findings also support a broader biopsychosocial model of musculoskeletal pain. Students with migraines and gastrointestinal disorders experienced a greater overall musculoskeletal pain burden, while sleep disorders were independently associated with both shoulder pain and elbow pain in region-specific analyses. Mental health conditions were also associated with several pain regions in the bivariate analyses, although these associations did not persist after multivariable adjustment. Together, these findings suggest that MSK pain among university students extends beyond biomechanical factors and reflects the complex interplay between physical strain, psychological vulnerability, sleep quality, and underlying comorbid conditions. This interpretation is consistent with previous evidence demonstrating interactions between sleep disturbances, psychological distress, central pain sensitization, and multisite pain in young adults [15,22,33,34]. Consequently, MSK symptoms should be viewed not as isolated musculoskeletal complaints but as part of a broader health burden affecting university students.

The findings of this study have important implications for university health promotion and prevention strategies. Universities should prioritize the implementation of ergonomic education programs that promote appropriate posture, optimal screen positioning, and regular study breaks, as these represent modifiable risk factors consistently associated with MSK pain [35]. In parallel, student wellness initiatives should encourage regular physical activity, stretching routines, and healthier screen-use behaviors to minimize prolonged mechanical strain. Given the observed associations between MSK pain and conditions such as sleep disorders, migraines, and mental health issues, prevention efforts should adopt a multidisciplinary approach integrating ergonomic interventions with physical therapy, mental health support, stress management and sleep hygiene. Clinically, early identification of students experiencing recurrent or multisite pain may help prevent progression to chronic conditions and improve overall well-being. Future longitudinal studies are needed to establish temporal relationships, evaluate

the effectiveness of targeted preventive interventions, and confirm these findings in larger and more representative samples of Lebanese university students.

This study has several strengths that enhance the validity and relevance of its findings. To our knowledge, it is the first study in Lebanon to provide a comprehensive assessment of musculoskeletal (MSK) pain among university students, addressing an important gap in the local literature. The relatively large sample size (n = 396) and inclusion of students from several universities across Lebanon improve the precision of the prevalence estimates and increase the diversity of the study population. Additionally, the use of the validated Extended Nordic Musculoskeletal Questionnaire (NMQ-E), and the Internet Addiction Test (IAT), both of which demonstrated excellent internal consistency in the present study, further strengthens the reliability of the findings. Another important strength is the multidimensional assessment of MSK pain, simultaneously evaluating demographic, academic, ergonomic, lifestyle, and health-related factors using both region-specific and overall pain burden analyses. Finally, the use of multivariable regression analyses enabled the identification of independent predictors while accounting for potential confounding variables.

Despite these strengths, several limitations should be considered when interpreting the findings. First, the cross-sectional design precludes the ability to establish temporal or causal relationships between the identified risk factors and MSK pain. Second, all data were self-reported, which may introduce the potential for recall bias and reporting bias, particularly for posture, ergonomic practices, and medical conditions. Moreover, postural abnormalities were assessed using self-perception rather than objective clinical or photographic evaluation, which may have resulted in some degree of misclassification. The use of convenience sampling and online recruitment may also have introduced selection bias and may limit the generalizability of the findings to all Lebanese university students. In addition, female students constituted approximately 61% of the study sample, which may have influenced the overall prevalence estimates despite adjustment for sex in the multivariable analyses. Finally, although a broad range of variables was examined, residual confounding cannot be excluded, and other potentially relevant factors including objective ergonomic assessments, psychosocial stress measures, and physical examination findings, were not evaluated. Some subgroup estimates in the multivariable models (e.g., the obesity class II category for elbow pain) were based on small cell sizes and yielded wide confidence intervals; these should be interpreted with caution and treated as hypothesis-generating rather than conclusive.

# Conclusion

This study provides the first comprehensive assessment of musculoskeletal pain and postural abnormalities among Lebanese university students. The findings demonstrate a substantial burden of MSK pain, with the neck and lower back emerging as the most commonly affected anatomical regions. Female sex, poor posture, prolonged screen- and study-related behaviors, and selected health conditions, including migraine, sleep disorders, and gastrointestinal disorders, were identified as important factors associated with MSK pain and overall pain burden. Collectively, these findings highlight that MSK pain among university students is a multifactorial condition influenced by modifiable ergonomic, academic,

lifestyle, and health-related factors. Universities should therefore prioritize preventive strategies that promote ergonomic education, healthy study habits, physical activity, and student well-being to reduce the burden of MSK pain. Future longitudinal studies are warranted to clarify causal relationships and evaluate the effectiveness of targeted preventive interventions.

# Abbreviations

ANOVA: analysis of variance

aOR: adjusted odds ratio

BMI: body mass index

CI: confidence interval

IAT: Internet Addiction Test

IQR: interquartile range

IRB: Institutional Review Board

LBP: low back pain

MSK: musculoskeletal

NMQ-E: Extended Nordic Musculoskeletal Questionnaire

NRS: Numeric Rating Scale

QR: Quick Response

SD: standard deviation

STROBE: Strengthening the Reporting of Observational Studies in Epidemiology

# Declarations

### Ethics Approval and Consent to Participate

This study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki and relevant national guidelines for research involving human subjects. Ethical approval was obtained from the Institutional Review Board (IRB) of the Lebanese American University (FWA Registration under reference FWA00014723, IRB Registration under reference IRB00006954 Lebanese American U IRB #1) prior to data collection (Approval No. LAU.SOM.JS3.30/Jul/2025). Participation was

voluntary and anonymous. Before accessing the questionnaire, participants were presented with an electronic informed consent form outlining the study objectives, procedures, and measures taken to ensure confidentiality. Only students who provided electronic informed consent were granted access to the survey. Participants were free to discontinue the questionnaire at any time, and no personally identifiable information was collected. Completion and submission of the questionnaire were considered to constitute informed consent.

**Availability of Data and Materials**

The dataset supporting the conclusions of this article is included within the article (and its additional file(s)).

**Competing interests**

The authors declare that they have no competing interests.

**Funding**

All authors declare no funding.

**Author Contributions**

Conception and design of the study: MN, MY, JB, ZS, CH, GD, MC, JS.

Data acquisition: MN, MY, JB, ZS, CH, GD, MC, JS.

Data curation: MN, MY, JB, ZS, MC.

Data analysis and interpretation: MN,MY, JB.

Writing of the original draft: MN, MY, JB, ZS.

Critical revision and editing of the manuscript: MN, MY, MC, JS.

Supervision: MC, JS.

All authors read and approved the final manuscript.

**Acknowledgements**

The authors would like to acknowledge Jean Karam, Sophie Haidar, Dhaen Yassine and Zahra Mazloum for their valuable assistance in data collection.

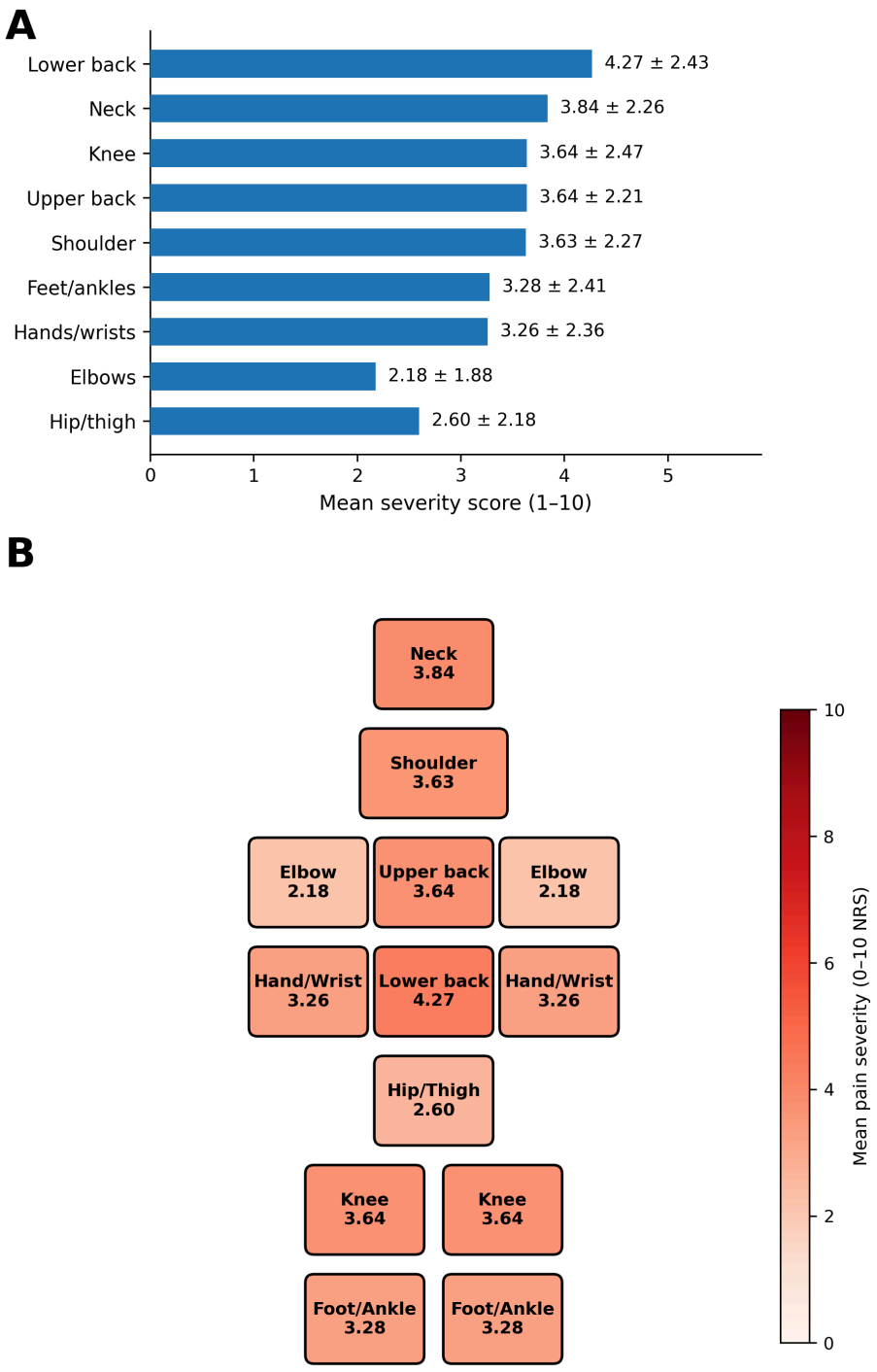
# References

1. Vos T, Lim SS, Abbafati C, Abbas KM, Abbasi M, Abbasifard M, et al. Global burden of 369 diseases and injuries in 204 countries and territories, 1990–2019: A systematic analysis for the Global Burden of Disease Study 2019. Lancet. 2020;396(10258):1204–22. doi:10.1016/S0140-6736(20)30925-9
2. Smith DR, Wei N, Kang L, Wang RS. Musculoskeletal disorders among professional nurses in mainland China. J Prof Nurs. 2004;20(6):390–5. doi:10.1016/j.profnurs.2004.08.002
3. Owoeye OBA, Neme JR, Buchanan P, Esposito F, Breitbach AP. Absence of injury is not absence of pain: Prevalence of preseason musculoskeletal pain and associated factors in collegiate soccer and basketball student athletes. Int J Environ Res Public Health. 2022;19(15):9128. doi:10.3390/ijerph19159128
4. Parto DN, Wong AY, Macedo L. Prevalence of musculoskeletal disorders and associated risk factors in Canadian university students. BMC Musculoskelet Disord. 2023;24(1):501. doi:10.1186/s12891-023-06630-4
5. Alanazi SA, Kashoo FZ. Musculoskeletal pain among university students and its correlations with risk factors: A cross-sectional study. J Clin Med. 2025;14(17):6076. doi:10.3390/jcm14176076
6. Tinitali S, Bowles KA, Keating JL, Haines T. Are musculoskeletal disorders associated with stress in healthcare workers? A systematic review. BMC Musculoskelet Disord. 2019;20:153. doi:10.1186/s12891-019-2535-0
7. Shaikh S, Siddiqui AA, Alshammary F, Amin J, Agwan MAS. Musculoskeletal disorders among healthcare workers: Prevalence and risk factors in the Arab World. In: Laher I, editor. Handbook of Healthcare in the Arab World. Cham: Springer International Publishing; 2021. p. 1–39. doi:10.1007/978-3-319-74365-3_129-1
8. Namwongsa S, Puntumetakul R, Neubert MS, Boucaut R. Factors associated with neck disorders among university student smartphone users. Work. 2018;61(3):367–78. doi:10.3233/WOR-182819
9. Almutairi H, Alhammad L, Aldossari B, Alonazi A. Prevalence and interrelationships of screen time, visual disorders, and neck pain among university students: A cross-sectional study at Majmaah University. Healthcare. 2024;12(20):2067. doi:10.3390/healthcare12202067
10. Nochian MA, Mousavi S, Khosravi H, Basirinezhad MH, Mirhosseini S. Association between internet addiction and musculoskeletal disorders in Iranian medical sciences students. BMC Musculoskelet Disord. 2024;25(1):662. doi:10.1186/s12891-024-07780-9
11. Upadhayay N, Guragain S. Internet use and its addiction level in medical students. Adv Med Educ Pract. 2017;8:641–7. doi:10.2147/AMEP.S142199
12. Mustafaoglu R, Yasaci Z, Zirek E, Griffiths MD, Ozdincler AR. The relationship between smartphone addiction and musculoskeletal pain prevalence among young population: a cross-sectional study. Korean J Pain. 2021;34(1):72–81. doi:10.3344/kjp.2021.34.1.72
13. Alsalameh AM, Harisi MJ, Alduayji MA, Almutham AA, Mahmood FM. Evaluating the relationship between smartphone addiction/overuse and musculoskeletal pain among medical students at Qassim University. J Fam Med Prim Care. 2019;8(9):2953–9. doi:10.4103/jfmpc.jfmpc_665_19

14. Tandon T, Rouhana Y, Rahme E, Zalaket N, Martin-Soelch C. Youth mental health in crisis: Understanding the relationship between mental health and physical pain in Lebanon's youth – A scoping review. Int J Public Health. 2025;70:1608156. doi:10.3389/ijph.2025.1608156
15. Waller R, Smith AJ, O'Sullivan PB, Slater H, Sterling M, Straker LM. The association of early life stressors with pain sensitivity and pain experience at 22 years. Pain. 2020;161(1):220–9. doi:10.1097/j.pain.0000000000001704
16. Bawab W, Ismail K, Awada S, Rachidi S, Al Hajje A, Salameh P. Prevalence and risk factors of low back pain among office workers in Lebanon. Int J Occup Hyg. 2015;7(1):45–52.
17. Ghoussoub K, El Asmar A, Kreichati G, Wakim S, Bakhache M, Baz M, et al. Prevalence and risk factors associated with low back pain among hospital staff in a university hospital in Lebanon. Ann Phys Rehabil Med. 2016;59:e146. doi:10.1016/j.rehab.2016.07.325
18. Alhumaidan MI, Alhazmi B, Aljabr S, Alhazmi A, Alhujayri AK. Prevalence of musculoskeletal pain among medical students at King Saud University in Riyadh, Saudi Arabia. Cureus. 2025;17(4):e82703. doi:10.7759/cureus.82703
19. Hendi OM, Alturkistani LH, Bajaber AS, Alhamoud MA, Mahmoud Mahfouz ME. Prevalence of musculoskeletal disorder and its relation to stress among medical students at Taif University, Saudi Arabia. Int J Prev Med. 2021;12:98. doi:10.4103/ijpvm.IJPVM_335_20
20. Torbey A, Kadri SA, Asaad SA, Zahrawi H, Alhouri A, Harba G. Studying the prevalence of musculoskeletal pain among a sample of medical students in Damascus, Syria: A cross-sectional study. Health Sci Rep. 2023;6(3):e1149. doi:10.1002/hsr2.1149
21. Aly AT, Hasan M, Abouelmagd ME, Abouhussain SM, Mohamed MS, Mohamed MH, et al. The prevalence of musculoskeletal pain and assessment of potential risk factors among a sample of medical students in Giza, Egypt. Cureus. 2024;16(10):e70644. doi:10.7759/cureus.70644
22. Hasbani GE, Ibrahem M, Haidous M, Chaaya M, Uthman IW. Fibromyalgia among university students: A vulnerable population. Mediterr J Rheumatol. 2022;33(4):407. doi:10.31138/mjr.33.4.407
23. Vandenbroucke JP, von Elm E, Altman DG, Gøtzsche PC, Mulrow CD, Pocock SJ, et al. Strengthening the Reporting of Observational Studies in Epidemiology (STROBE): Explanation and elaboration. PLOS Med. 2007;4(10):e297. doi:10.1371/journal.pmed.0040297
24. Akar B. Surviving the crises: Lebanon's higher education in the balance [Internet]. Lebanese Center for Policy Studies; 2022. Report Policy Brief No. 72. Available from: https://www.lcps-lebanon.org/en/articles/details/4751
25. Pacheco MP, Carvalho PJ, Cavalheiro L, Sousa FM. Prevalence of postural changes and musculoskeletal disorders in young adults. Int J Environ Res Public Health. 2023;20(24):7191. doi:10.3390/ijerph20247191
26. Dawson AP, Steele EJ, Hodges PW, Stewart S. Development and test-retest reliability of an Extended Version of the Nordic Musculoskeletal Questionnaire (NMQ-E): A screening instrument for musculoskeletal pain. J Pain. 2009;10(5):517–26. doi:10.1016/j.jpain.2008.11.008

27. Al Amer HS, Alharbi AA. Arabic version of the Extended Nordic Musculoskeletal Questionnaire, cross-cultural adaptation and psychometric testing. J Orthop Surg Res. 2023;18(1):672. doi:10.1186/s13018-023-04161-1
28. Young KS. Internet addiction: The emergence of a new clinical disorder. Cyberpsychol Behav. 1998;1(3):237–44. doi:10.1089/cpb.1998.1.237
29. Hawi N. Arabic validation of the Internet Addiction Test. Cyberpsychol Behav Soc Netw. 2013;16(3):200-4. doi:10.1089/cyber.2012.0426
30. Tavakol M, Dennick R. Making sense of Cronbach's alpha. Int J Med Educ. 2011;2:53–5. doi:10.5116/ijme.4dfb.8dfd
31. Alshagga MA, Nimer AR, Yan LP, Ibrahim IAA, Al-Ghamdi SS, Radman Al-Dubai SA. Prevalence and factors associated with neck, shoulder and low back pains among medical students in a Malaysian Medical College. BMC Res Notes. 2013;6(1):244. doi:10.1186/1756-0500-6-244
32. Wijnhoven HAH, De Vet HCW, Picavet HSJ. Prevalence of musculoskeletal disorders is systematically higher in women than in men. Clin J Pain. 2006;22(8):717–24. doi:10.1097/01.ajp.0000210912.95664.53
33. Alsaadi SM. Musculoskeletal pain in undergraduate students is significantly associated with psychological distress and poor sleep quality. Int J Environ Res Public Health. 2022;19(21):13929. doi:10.3390/ijerph192113929
34. Alghamdi MS, Alghamdi AF, Almalawi AM, Alsulami RA, Hazazi HA, Al Ghashmari AA, et al. The association between neck pain and psychological distress experienced by King Abdulaziz University students: A cross-sectional study. Cureus. 2023;15(3):e35685. doi:10.7759/cureus.35685
35. Putsa B, Jalayondeja W, Mekhora K, Bhuanantanondh P, Jalayondeja C. Factors associated with reduced risk of musculoskeletal disorders among office workers: a cross-sectional study 2017 to 2020. BMC Public Health. 2022;22:1503. doi:10.1186/s12889-022-13940-0

# Figures




## Figure 1

**Mean musculoskeletal pain severity by anatomical region.**

Mean pain severity scores (0–10 Numeric Rating Scale) for each anatomical region, assessed using the Extended Nordic Musculoskeletal Questionnaire (NMQ-E). (A) Bar chart of mean severity by region. (B) Posterior body schematic with the same data, colored by mean severity; regions are shown at equal

visual scale so that color, not shape size, conveys severity, with a numeric 0–10 severity scale on the color bar. Values are presented as mean ± standard deviation.

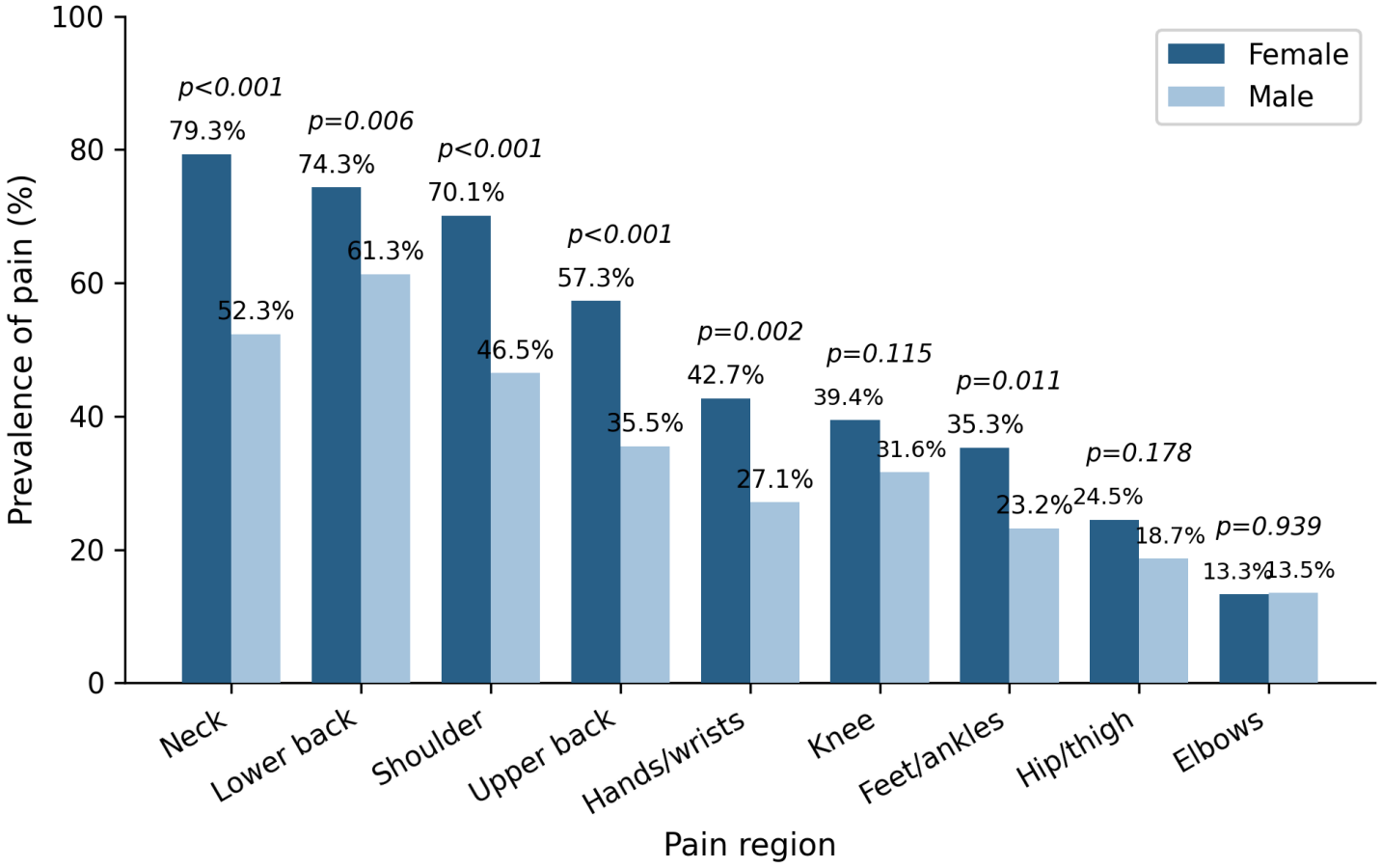



**Figure 2**

**Sex differences in the prevalence of musculoskeletal pain across anatomical regions.**

Bars represent the percentage of female and male students reporting pain in each anatomical region (i.e., prevalence within each sex, not raw counts). P-values were obtained using the Chi-square test.

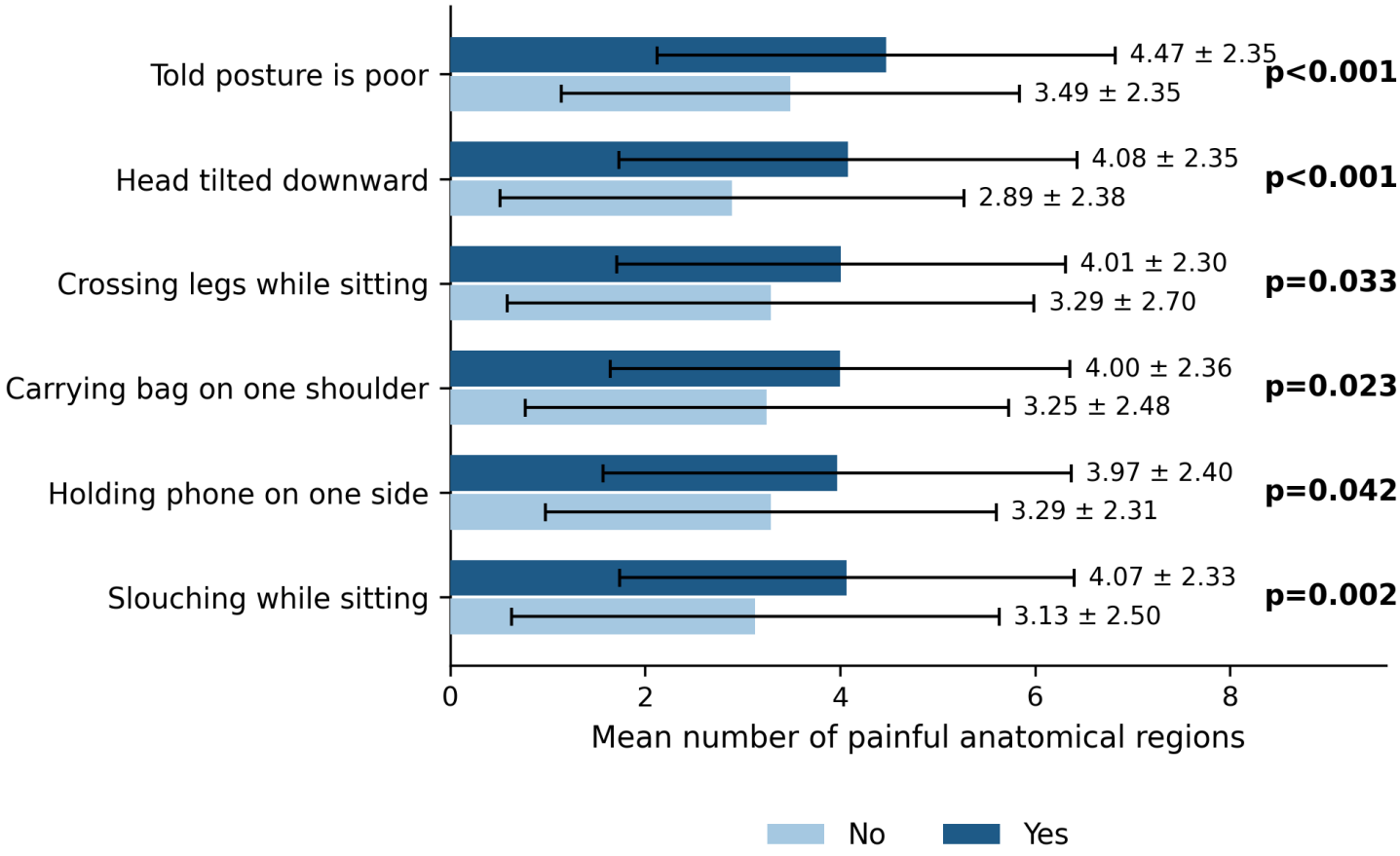



**Figure 3**

**Overall musculoskeletal pain burden according to postural characteristics.**

Error bars represent standard deviations (SD). Only postural characteristics demonstrating statistically significant associations with pain burden are shown.

## Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- SupplementaryTables.docx