


Evaluation of Depression and Its Correlates in Terms of Demographics, Eating Habits, and Exercises Among University Students: A Multicenter Cross-Sectional Analysis

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Background: University students are a vulnerable population prone to mental health challenges. This study aimed to investigate depression and its associated factors among university students in terms of demographics, eating habits, and exercises.

Methods: A total of 2891 university students from three universities participated in this study between January 2024 and February 2024. An online survey questionnaire was distributed using a snow-ball strategy. The survey collected demographic, lifestyle, and psychological data, including depression and anxiety scores using the PHQ-9 and GAD-7 screening tools. Subgroup analysis was conducted according to sport frequency and sport type using Chi-square test for qualitative data and *t*-test for quantitative data. Multiple linear regression analysis was performed to identify risk factors for depression.

Results: A total of 44.2% and 39.5% of the participants reported symptoms of depression and anxiety, respectively. Significant differences were observed in various characteristics across different sport frequency groups, with participants with higher sport frequency tending to have less depression ($P<0.001$) and anxiety ($P<0.001$) symptoms. As the frequency of weekly exercise increased, anxiety and depression scores gradually decreased. The mean PHQ-9 and GAD-7 scores were highest in the group with no sports and lowest in the group with a sport frequency of 3–4 times per week ($P<0.001$). Additionally, once exercise frequency reached 5 times per week or more, anxiety and depression scores no longer decreased. Subgroup analysis based on sport type revealed that participants engaging in specific sports, such as basketball, tennis, dance, and running, had lower depression ($P<0.001$) and anxiety ($P<0.001$) scores compared to the overall average. Based on multiple linear regression analysis, married status ($P=0.036$), enjoying barbecue food ($P<0.001$), prolonged sedentary time ($P=0.001$), experiencing stress events ($P<0.001$), and electronic device usage time ($P<0.001$) were positively associated with depression scores, while loving eating vegetables ($P=0.007$), a relatively longer sport time ($P=0.005$), a higher exercise frequency ($P=0.064$), and no chronic disease ($P<0.001$) were negatively associated with depression scores.

Conclusion: This study highlights the importance of a healthy lifestyle, including regular exercise, limited exposure to electronic screens, and a balanced diet, in preventing and mitigating depression among university students. This study also suggests that exercising 3–4 times a week is associated with the lowest levels of anxiety and depression. Activities such as basketball, tennis, dance, and running are effective in alleviating these mental health issues through regular exercise.

Keywords: depression, eating habits, sports, university students, cross-sectional study

Introduction

University students are a vulnerable population prone to mental health challenges, with depression being one of the most prevalent issues.^{1,2} Studies have consistently shown that depression is a prevalent issue among university students. Epidemiological research has demonstrated that depression is common among university students, with a reported prevalence rate ranging from 18.0% to 68.5%.²⁻⁴ Notably, depression is one of the predisposing factors of suicide in university students.⁵ Depression not only impacts the individual but also has significant consequences for their families and society at large, leading to reduced academic performance,⁶ social dysfunction, and increased risk of suicide.⁵

Identifying the risk factors for depression is of great importance, as it allows for the development of targeted prevention strategies. In general, risk factors for depression can be categorized into three main groups: individual factors, interpersonal factors, and environmental factors. Individual factors include personal characteristics such as age, gender, personality traits, and cognitive functioning,⁷ while interpersonal factors encompass social relationships and communication patterns.⁸ Environmental factors, on the other hand, include broader contextual factors such as stressors, life events,⁷ and exposure to some diseases, including cancer, trauma, or chronic diseases. Previous research has consistently shown that exercise can play a significant role in reducing depression.¹ However, the specific types of exercise and the frequency of exercise that were most effective in reducing depression among university students have not been extensively studied. This lack of knowledge could hamper the development of effective intervention strategies that target exercise as a means of prevention and treatment of depression among university students.

Therefore, the purpose of this study is to evaluate depression and its correlates in terms of demographics, eating habits, and exercises among university students. By identifying the risk factors associated with depression and the specific types and frequencies of exercise that are most effective in reducing depression, we can contribute to the development of targeted prevention and intervention strategies that can effectively address this important public health issue.

Patients and Methods

Participants

A total of 2891 university students were enrolled for analysis in the study from three universities between January 2024 and February 2024. An online survey questionnaire was designed and distributed, and snow-ball strategy was involved.⁹ This technique operates on the idea of participants referring or recommending the survey to others within their network. It's like a rolling snowball gathering momentum as it moves, collecting more and more participants along the way. The brilliance of the snowball strategy lies in its organic and expansive reach. Participants not only respond to the survey but also act as catalysts, bringing in additional participants from their social circles. This creates a self-perpetuating cycle, making the survey sample grow in a way that would not be possible with a static distribution method. When participants enter the online survey, they will be asked if they are willing to participate in this study. If the answer is yes, they will be directed to the questionnaire survey to provide their responses. If the answer is no, the survey will conclude immediately. It is essential to emphasize that participation in this study is entirely voluntary and based on the participant's own willingness. Participants who were voluntary to take part in the survey were included for analysis in the study, and those who were reluctant to fill the survey were excluded. Ethical approval for this study was secured from the Academic Committee and Ethics Board of Xiamen University of Technology. Participants provided informed consent online before actively engaging in the survey, ensuring that their personally identifiable information was not collected. The study adhered to the principles outlined in the Declaration of Helsinki, and its reporting followed the guidelines outlined in the TRIPOD Checklist.¹⁰

Sample Size Determination

According to previous studies, the prevalence rate for depression among university students ranged from 18.0% to 68.5%.²⁻⁴ Based on this information, we assumed a prevalence rate of 43.25% (95% confidence interval: 43.25% ± 5.0%) for depression among university students. A significance level of 0.05 and a power of 0.95 were also considered in the sample size calculation. Using PASS software (Version 11.0.10), a total of 1546 participants were determined to be

necessary for the study to achieve meaningful results. It is also noteworthy that a total of 2891 university students were recruited for the study, exceeding the estimated sample size of 1546 required for statistical significance.

Target Variables

The study investigated the relationship between sport frequency, sport type, and duration of sports activities on mental health outcomes. Specifically, the study measured the weekly frequency of engagement in different sports, the type of sport engaged in, and the total time spent participating in physical activities during each session. These variables were operationalized as follows: sport frequency was defined as the number of times an individual participated in organized or unstructured sport activities in a given week; sport type referred to the specific type of sport engaged in, such as basketball or yoga; and duration of sports activities was measured as the average time spent engaging in sport-related activities during each session.

Covariates

In our study, a comprehensive array of covariates was collected and categorized to provide a holistic understanding of the factors under investigation. The demographic profile encompassed gender distribution, age distribution with mean and standard deviation, and educational attainment across different grades. Marital status was delineated into categories including single, dating, and married individuals. Delving into dietary habits, participants' inclinations towards consuming low salt, oily, barbecue, meat, vegetable, and fruit-based foods were recorded. Lifestyle choices were scrutinized through variables such as smoking and drinking status, sedentary and electronic time usage, and monthly expenditure. Psychological and comorbid factors were assessed through the presence of stress events and the prevalence of chronic diseases. The above categorization facilitates a nuanced analysis of the interplay between various factors and their potential implications on the outcomes of interest in our study.

Evaluation of Mental Health

Psychological assessment scores for depression (PHQ-9) and anxiety (GAD-7) were documented. The PHQ-9 and GAD-7 are both widely used screening tools in the field of mental health assessment. The PHQ-9 comprises nine questions that assess the severity of depressive symptoms over the past two weeks, covering aspects such as mood, sleep, energy levels, and concentration. Each item is scored from 0 to 3, with higher scores indicating more severe symptoms. The total score ranges from 0 to 27, with thresholds commonly used to categorize symptom severity (eg, 0–4 minimal, 5–9 mild, 10–14 moderate, 15–19 moderately severe, and 20–27 severe depression). On the other hand, the GAD-7 consists of seven items designed to evaluate the presence and severity of generalized anxiety disorder symptoms over the past two weeks, including aspects such as nervousness, worry, and physical symptoms of anxiety. Each item is also scored from 0 to 3, with a total score ranging from 0 to 21. Similar to the PHQ-9, higher scores on the GAD-7 indicate more severe anxiety symptoms, with thresholds for severity classification commonly used (eg, 0–4 minimal anxiety, 5–9 mild anxiety, 10–14 moderate anxiety, and 15–21 severe anxiety). These assessment tools were particularly relevant for surveys targeting college students due to their potential susceptibility to mental health challenges during this transitional phase of life.^{11,12} By incorporating PHQ-9 and GAD-7 scores into research endeavors, we could gain insights into the prevalence and severity of depressive and anxiety symptoms among college students, thereby informing interventions and support services tailored to this demographic group's needs.

Statistical Analysis

For the statistical analysis, data were presented in both qualitative and quantitative forms. The qualitative data were presented as proportions, while the quantitative data were presented as means \pm standard deviations. For the comparison between groups, Chi-square test was used for qualitative data, and *t*-test was used for quantitative data. To identify the variables associated with depression, multiple linear regression was performed. All statistical analyses were conducted using R program language (version 4.1.2).

Results

Baseline Characteristics of All Participants

Table 1 of this study presents the baseline characteristics of all participants, with a total of 2891 participants included in the analysis. The majority of the participants were male (55.4%) and aged 19.54 years on average. The participants were distributed across different grades, with the majority being first-year students (42.9%). The majority of the participants were single (77.1%) and reported a love for eating low salt food (71.1%), oily food (69.0%), barbecue (63.7%), and meat (67.9%). In contrast, they showed a relatively lower preference for fruits (39.8%) and vegetables (51.1%). Smoking and drinking habits were mostly none (90.0% and 74.2%, respectively), while 6.8% of the participants reported current smoking and 22.4% current drinking.

Table 1 Baseline Characteristics of All Participants and a Comparison of Characteristics Based on the Presence of Depression Among University Students

Characteristics	Overall	Depression Based on PHQ-9 Score		P
		No	Yes	
n	2891	1613	1278	
Gender (%)				<0.001
Male	1603 (55.4)	948 (58.8)	655 (51.3)	
Female	1288 (44.6)	665 (41.2)	623 (48.7)	
Age (years, mean [SD])	19.54 (1.76)	19.46 (1.63)	19.64 (1.90)	0.008
Grade (%)				0.031
First	1241 (42.9)	713 (44.2)	528 (41.3)	
Second	1224 (42.3)	672 (41.7)	552 (43.2)	
Third	233 (8.1)	122 (7.6)	111 (8.7)	
Fourth	171 (5.9)	100 (6.2)	71 (5.6)	
Delayed	22 (0.8)	6 (0.4)	16 (1.3)	
Marital status (%)				0.034
Single	2230 (77.1)	1250 (77.5)	980 (76.7)	
Dating	642 (22.2)	358 (22.2)	284 (22.2)	
Married	19 (0.7)	5 (0.3)	14 (1.1)	
Love eating low salt food (%)				0.018
No	2056 (71.1)	1118 (69.3)	938 (73.4)	
Yes	835 (28.9)	495 (30.7)	340 (26.6)	
Love eating oily food (%)				<0.001
No	1996 (69.0)	1166 (72.3)	830 (64.9)	
Yes	895 (31.0)	447 (27.7)	448 (35.1)	
Love eating barbecue (%)				<0.001
No	1841 (63.7)	1099 (68.1)	742 (58.1)	
Yes	1050 (36.3)	514 (31.9)	536 (41.9)	

(Continued)

Table I (Continued).

Characteristics	Overall	Depression Based on PHQ-9 Score		P
		No	Yes	
Love eating meat (%)				0.039
No	928 (32.1)	544 (33.7)	384 (30.0)	
Yes	1963 (67.9)	1069 (66.3)	894 (70.0)	
Love eating vegetable (%)				0.494
No	1478 (51.1)	815 (50.5)	663 (51.9)	
Yes	1413 (48.9)	798 (49.5)	615 (48.1)	
Love eating fruit (%)				0.371
No	1151 (39.8)	630 (39.1)	521 (40.8)	
Yes	1740 (60.2)	983 (60.9)	757 (59.2)	
Smoking (%)				0.485
None	2603 (90.0)	1461 (90.6)	1142 (89.4)	
Previous	91 (3.1)	46 (2.9)	45 (3.5)	
Current	197 (6.8)	106 (6.6)	91 (7.1)	
Drinking (%)				0.142
None	2145 (74.2)	1218 (75.5)	927 (72.5)	
Previous	99 (3.4)	56 (3.5)	43 (3.4)	
Current	647 (22.4)	339 (21.0)	308 (24.1)	
Sedentary time (hours, %)				<0.001
< 1 hour	218 (7.5)	152 (9.4)	66 (5.2)	
≥ 1 and <3 hours	716 (24.8)	419 (26.0)	297 (23.2)	
≥ 3 and <6 hours	979 (33.9)	567 (35.2)	412 (32.2)	
≥ 6 hours	978 (33.8)	475 (29.4)	503 (39.4)	
Electronic time (hours, mean [SD])	6.46 (2.67)	6.09 (2.62)	6.92 (2.66)	<0.001
Monthly expense (RBM, %)				0.239
< 2000	2343 (81.0)	1319 (81.8)	1024 (80.1)	
≥ 2000 and <5000	485 (16.8)	258 (16.0)	227 (17.8)	
≥ 5000 and <10,000	42 (1.5)	27 (1.7)	15 (1.2)	
≥ 10,000	21 (0.7)	9 (0.6)	12 (0.9)	
Stress event (%)				<0.001
Yes	980 (33.9)	349 (21.6)	631 (49.4)	
No	1911 (66.1)	1264 (78.4)	647 (50.6)	

(Continued)

Table 1 (Continued).

Characteristics	Overall	Depression Based on PHQ-9 Score		P
		No	Yes	
Sport frequency (per week, %)				<0.001
None	616 (21.3)	285 (17.7)	331 (25.9)	
1–2	1461 (50.5)	814 (50.5)	647 (50.6)	
3–4	528 (18.3)	332 (20.6)	196 (15.3)	
≥5	286 (9.9)	182 (11.3)	104 (8.1)	
Sport type (%)				<0.001
None	616 (21.3)	285 (17.7)	331 (25.9)	
Basketball	203 (7.0)	127 (7.9)	76 (5.9)	
Badminton	289 (10.0)	173 (10.7)	116 (9.1)	
Volleyball	304 (10.5)	158 (9.8)	146 (11.4)	
Dance	68 (2.4)	37 (2.3)	31 (2.4)	
Running	601 (20.8)	371 (23.0)	230 (18.0)	
Yoga	18 (0.6)	8 (0.5)	10 (0.8)	
Tai Chi	38 (1.3)	19 (1.2)	19 (1.5)	
Tennis	53 (1.8)	37 (2.3)	16 (1.3)	
Table tennis	138 (4.8)	89 (5.5)	49 (3.8)	
Instrument	106 (3.7)	56 (3.5)	50 (3.9)	
Others	457 (15.8)	253 (15.7)	204 (16.0)	
Sport time (hours/each exercise, %)				<0.001
None	616 (21.3)	285 (17.7)	331 (25.9)	
<1	1123 (38.8)	615 (38.1)	508 (39.7)	
≥1 and <3	961 (33.2)	594 (36.8)	367 (28.7)	
≥3	191 (6.6)	119 (7.4)	72 (5.6)	
Chronic disease (%)				<0.001
Yes	108 (3.7)	32 (2.0)	76 (5.9)	
No	2783 (96.3)	1581 (98.0)	1202 (94.1)	
PHQ-9 (%)				<0.001
None	1613 (55.8)	1613 (100.0)	0 (0.0)	
Mild	933 (32.3)	0 (0.0)	933 (73.0)	
Moderate	208 (7.2)	0 (0.0)	208 (16.3)	
Moderate-to-severe	89 (3.1)	0 (0.0)	89 (7.0)	
Severe	48 (1.7)	0 (0.0)	48 (3.8)	

(Continued)

Table 1 (Continued).

Characteristics	Overall	Depression Based on PHQ-9 Score		P
		No	Yes	
GAD-7 (%)				<0.001
None	1748 (60.5)	1456 (90.3)	292 (22.8)	
Mild	875 (30.3)	143 (8.9)	732 (57.3)	
Moderate	190 (6.6)	14 (0.9)	176 (13.8)	
Severe	78 (2.7)	0 (0.0)	78 (6.1)	

Abbreviations: SD, standardized deviation; PHQ-9, patient health questionnaire-9; GAD-7, generalized anxiety disorder-7.

The participants spent an average of 6.46 hours per day on electronic devices, and 81.0% of them had a monthly expense of less than 2000 RBM. Regarding stress events, 33.9% of the participants reported experiencing a stress event, while 21.3% of them reported no sport frequency. The most popular sports among the participants were basketball (7.0%), badminton (10.0%), volleyball (10.5%), and running (20.8%). A total of 3.7% of the participants reported no chronic disease, and the mean PHQ-9 score was 4.74, with 44.2% of the participants scoring depression symptom. Similarly, the mean GAD-7 score was 3.97, with 39.5% of the participants scoring anxiety symptom. Furthermore, 12.0% of participants had moderate or above depression, and 9.3% of participants had moderate and severe anxiety. Regarding reliability of the study, the Cronbach's alpha coefficient for the GAD-7 score was 0.94, and 0.93 for the PHQ-9 score. In addition, a comparison of characteristics between participants with and without the presence of depression was conducted, and the results are summarized in [Table 1](#).

Subgroup Analysis of Depression Score Based on Sport Frequency

This study presented the subgroup analysis of clinical characteristics based on sport frequency ([Table 2](#)). The specific characteristics for each sport frequency group (none, 1–2, 3–4, ≥ 5) were shown. Significant differences were observed in various characteristics across the sport frequency groups. To elaborate, participants with a higher frequency of sports tended to be male ($P<0.001$), older ($P=0.001$), in a higher grade ($P<0.001$), married or in a relationship ($P<0.001$), inclined to love eating low-salt food ($P<0.001$), consume relatively less oily food ($P<0.001$) and barbecue ($P<0.001$), engage in more current smoking ($P<0.001$) or drinking ($P<0.001$), spend less time being sedentary ($P<0.001$), use electronic devices less frequently ($P<0.001$), have a higher monthly expense ($P<0.001$), experience fewer stress events ($P<0.001$), and spend a higher duration of time per exercise session ($P<0.001$). In terms of sport types, individuals with a higher frequency of participation tended to be inclined towards volleyball and instrumental activities, but their involvement in badminton, running, and table tennis was less ($P<0.001$). In addition, the chronic disease prevalence was highest in the group with no sports (5.8%) and lowest in the group with a sport frequency of 5 or above times per week (2.4%) ($P=0.014$). As the frequency of weekly exercise increased, anxiety and depression scores gradually decreased. The mean PHQ-9 ([Figure 1A](#)) and GAD-7 ([Figure 1B](#)) scores were highest in the group with no sports and lowest in the group with a sport frequency of 3–4 times per week ($P<0.001$). Additionally, once exercise frequency reached 5 times per week or more, anxiety and depression scores no longer decreased. Overall, participants with a relatively higher frequency of sports engagement tended to have lower anxiety and depression scores.

Subgroup Analysis of Depression Score Based on Sport Type

The subgroup analysis of sport type for depression and anxiety scores was provided according to the sport type ([Table 3](#)). The mean PHQ-9 and GAD-7 scores for the overall group were 4.74 and 3.97, respectively. The results indicated that individuals engaging in sports, regardless of the specific sport type, tend to have lower depression and anxiety scores compared to those who do not participate in any sports ($P<0.001$). Among the different sport types, participants who played basketball, tennis,

Table 2 Subgroup Analysis of Clinical Characteristics Based on Sport Frequency

Characteristics	Overall	Sport Frequency (Per Week)				p
		None	1–2	3–4	≥5	
n	2891	616	1461	528	286	
Gender (%)						<0.001
Male	1603 (55.4)	257 (41.7)	750 (51.3)	371 (70.3)	225 (78.7)	
Female	1288 (44.6)	359 (58.3)	711 (48.7)	157 (29.7)	61 (21.3)	
Age (years, mean [SD])	19.54 (1.76)	19.67 (1.88)	19.42 (1.71)	19.60 (1.64)	19.76 (1.87)	0.001
Grade (%)						<0.001
First	1241 (42.9)	191 (31.0)	674 (46.1)	255 (48.3)	121 (42.3)	
Second	1224 (42.3)	349 (56.7)	610 (41.8)	169 (32.0)	96 (33.6)	
Third	233 (8.1)	39 (6.3)	102 (7.0)	53 (10.0)	39 (13.6)	
Fourth	171 (5.9)	32 (5.2)	65 (4.4)	46 (8.7)	28 (9.8)	
Delayed	22 (0.8)	5 (0.8)	10 (0.7)	5 (0.9)	2 (0.7)	
Marital status (%)						<0.001
Single	2230 (77.1)	476 (77.3)	1173 (80.3)	399 (75.6)	182 (63.6)	
Dating	642 (22.2)	134 (21.8)	281 (19.2)	126 (23.9)	101 (35.3)	
Married	19 (0.7)	6 (1.0)	7 (0.5)	3 (0.6)	3 (1.0)	
Love eating low salt food (no/yes, %)						<0.001
No	2056 (71.1)	451 (73.2)	1106 (75.7)	335 (63.4)	164 (57.3)	
Yes	835 (28.9)	165 (26.8)	355 (24.3)	193 (36.6)	122 (42.7)	
Love eating oily food (%)						<0.001
No	1996 (69.0)	371 (60.2)	1013 (69.3)	407 (77.1)	205 (71.7)	
Yes	895 (31.0)	245 (39.8)	448 (30.7)	121 (22.9)	81 (28.3)	
Love eating barbecue (%)						<0.001
No	1841 (63.7)	347 (56.3)	906 (62.0)	392 (74.2)	196 (68.5)	
Yes	1050 (36.3)	269 (43.7)	555 (38.0)	136 (25.8)	90 (31.5)	
Love eating meat (%)						0.366
No	928 (32.1)	210 (34.1)	447 (30.6)	176 (33.3)	95 (33.2)	
Yes	1963 (67.9)	406 (65.9)	1014 (69.4)	352 (66.7)	191 (66.8)	
Love eating vegetable (%)						0.965
No	1478 (51.1)	318 (51.6)	740 (50.7)	273 (51.7)	147 (51.4)	
Yes	1413 (48.9)	298 (48.4)	721 (49.3)	255 (48.3)	139 (48.6)	
Love eating fruit (no/yes, %)						0.051
No	1151 (39.8)	270 (43.8)	549 (37.6)	212 (40.2)	120 (42.0)	

(Continued)

Table 2 (Continued).

Characteristics	Overall	Sport Frequency (Per Week)				p
		None	1–2	3–4	≥5	
Yes	1740 (60.2)	346 (56.2)	912 (62.4)	316 (59.8)	166 (58.0)	
Smoking (%)						<0.001
None	2603 (90.0)	579 (94.0)	1336 (91.4)	457 (86.6)	231 (80.8)	
Previous	91 (3.1)	13 (2.1)	44 (3.0)	23 (4.4)	11 (3.8)	
Current	197 (6.8)	24 (3.9)	81 (5.5)	48 (9.1)	44 (15.4)	
Drinking (%)						<0.001
None	2145 (74.2)	474 (76.9)	1122 (76.8)	370 (70.1)	179 (62.6)	
Previous	99 (3.4)	19 (3.1)	39 (2.7)	25 (4.7)	16 (5.6)	
Current	647 (22.4)	123 (20.0)	300 (20.5)	133 (25.2)	91 (31.8)	
Sedentary time (hours, %)						<0.001
< 1 hour	218 (7.5)	42 (6.8)	93 (6.4)	41 (7.8)	42 (14.7)	
≥1 and <3 hours	716 (24.8)	94 (15.3)	379 (25.9)	161 (30.5)	82 (28.7)	
≥3 and <6 hours	979 (33.9)	170 (27.6)	518 (35.5)	196 (37.1)	95 (33.2)	
≥6 hours	978 (33.8)	310 (50.3)	471 (32.2)	130 (24.6)	67 (23.4)	
Electronic time (hours, mean [SD])	6.46 (2.67)	7.65 (2.65)	6.38 (2.54)	5.61 (2.45)	5.84 (2.86)	<0.001
Monthly expense (RBM, %)						<0.001
< 2000	2343 (81.0)	509 (82.6)	1214 (83.1)	420 (79.5)	200 (69.9)	
≥2000 and <5000	485 (16.8)	90 (14.6)	227 (15.5)	95 (18.0)	73 (25.5)	
≥5000 and <10,000	42 (1.5)	8 (1.3)	17 (1.2)	10 (1.9)	7 (2.4)	
≥10,000	21 (0.7)	9 (1.5)	3 (0.2)	3 (0.6)	6 (2.1)	
Stress event (%)						<0.001
Yes	980 (33.9)	236 (38.3)	506 (34.6)	138 (26.1)	100 (35.0)	
No	1911 (66.1)	380 (61.7)	955 (65.4)	390 (73.9)	186 (65.0)	
Sport type (%)						<0.001
None	616 (21.3)	616 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)	
Basketball	203 (7.0)	0 (0.0)	126 (8.6)	51 (9.7)	26 (9.1)	
Badminton	289 (10.0)	0 (0.0)	204 (14.0)	65 (12.3)	20 (7.0)	
Volleyball	304 (10.5)	0 (0.0)	135 (9.2)	85 (16.1)	84 (29.4)	
Dance	68 (2.4)	0 (0.0)	46 (3.1)	17 (3.2)	5 (1.7)	
Running	601 (20.8)	0 (0.0)	406 (27.8)	153 (29.0)	42 (14.7)	
Yoga	18 (0.6)	0 (0.0)	14 (1.0)	2 (0.4)	2 (0.7)	
Tai Chi	38 (1.3)	0 (0.0)	28 (1.9)	8 (1.5)	2 (0.7)	

(Continued)

Table 2 (Continued).

Characteristics	Overall	Sport Frequency (Per Week)				p
		None	1–2	3–4	≥5	
Tennis	53 (1.8)	0 (0.0)	36 (2.5)	11 (2.1)	6 (2.1)	
Table tennis	138 (4.8)	0 (0.0)	92 (6.3)	37 (7.0)	9 (3.1)	
Instrument	106 (3.7)	0 (0.0)	37 (2.5)	31 (5.9)	38 (13.3)	
Others	457 (15.8)	0 (0.0)	337 (23.1)	68 (12.9)	52 (18.2)	
Sport time (hours/each exercise, %)						<0.001
<1	1123 (38.8)	0 (0.0)	887 (60.7)	176 (33.3)	60 (21.0)	
≥1 and <3	961 (33.2)	0 (0.0)	523 (35.8)	301 (57.0)	137 (47.9)	
≥3	191 (6.6)	0 (0.0)	51 (3.5)	51 (9.7)	89 (31.1)	
Chronic disease (%)						0.014
Yes	108 (3.7)	36 (5.8)	45 (3.1)	20 (3.8)	7 (2.4)	
No	2783 (96.3)	580 (94.2)	1416 (96.9)	508 (96.2)	279 (97.6)	
PHQ-9 (mean [SD])	4.74 (5.07)	6.00 (5.89)	4.67 (4.72)	3.92 (4.67)	3.95 (5.13)	<0.001
GAD-7 (mean [SD])	3.97 (4.33)	4.98 (5.01)	3.96 (4.05)	3.20 (3.91)	3.27 (4.48)	<0.001

Abbreviations: SD, standardized deviation; RMB, renminbi; PHQ-9, patient health questionnaire-9; GAD-7, generalized anxiety disorder-7.

dance, and running had relatively lower depression and anxiety scores compared to the overall average. Among all the sports, three have been identified as having the lowest PHQ-9 scores for depression symptoms. These sports were tennis, basketball, and running. The mean PHQ-9 scores for participants engaging in these activities were 3.19, 3.76, and 4.06, respectively. Similarly, three sports have been identified as having the lowest GAD-7 scores for anxiety symptoms. These sports were tennis, dance, basketball, and the mean GAD-7 scores for participants engaging in these activities were 2.74, 3.10, and 3.29, respectively. The above results suggested that participating in these sports may have a calming effect on depression and anxiety symptoms and help reduce depression and anxiety levels to some degree.

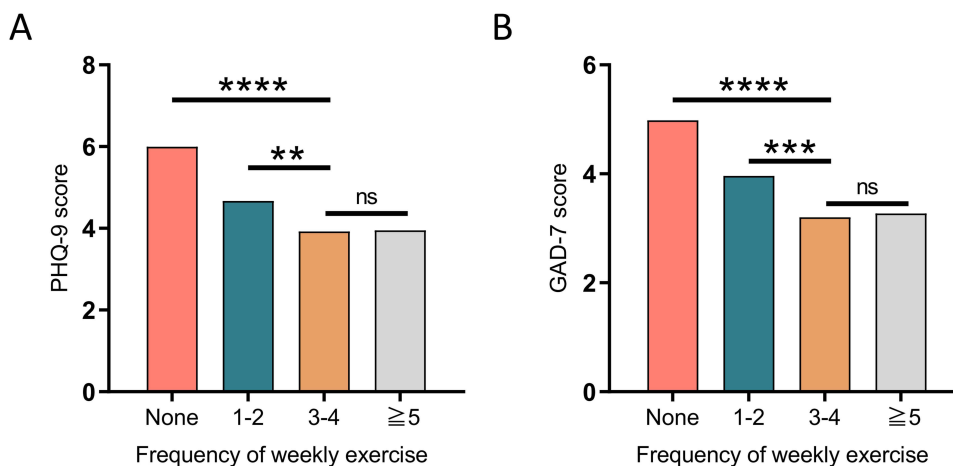


Figure 1 The distribution of PHQ-9 and GAD-7 scores based on the frequency of weekly exercise. **(A)** PHQ-9; **(B)** GAD-7. **Indicates P < 0.01, ****Indicates P < 0.001, and ****Indicates P < 0.0001.

Abbreviations: PHQ-9, patient health questionnaire-9; GAD-7, generalized anxiety disorder-7.

Table 3 Subgroup Analysis of Sport Type for Depression and Anxiety Scores

Sport Type	n	PHQ-9 (Mean [SD])	GAD-7 (Mean [SD])
Overall	2891	4.74 (5.07)	3.97 (4.33)
None	616	6.00 (5.89)	4.98 (5.01)
Basketball	203	3.76 (4.27)	3.29 (3.79)
Badminton	289	4.24 (4.61)	3.34 (3.68)
Volleyball	304	5.18 (5.50)	4.36 (4.81)
Dance	68	4.38 (3.91)	3.10 (3.39)
Running	601	4.06 (4.33)	3.41 (3.68)
Yoga	18	6.00 (4.64)	5.33 (3.76)
Tai Chi	38	5.87 (5.67)	5.29 (5.10)
Tennis	53	3.19 (4.47)	2.74 (3.85)
Table tennis	138	4.10 (5.03)	3.62 (4.25)
Instrument	106	4.76 (4.68)	3.89 (4.26)
Others	457	4.69 (5.03)	4.00 (4.30)
P values		<0.001	<0.001

Abbreviations: PHQ-9, patient health questionnaire-9; GAD-7, generalized anxiety disorder-7.

Risk Factors for Depression Identified Using Multiple Linear Regression Analysis

The results of the multiple linear regression analysis indicated that several factors were associated with depression symptoms (Table 4). Notably, being married were positively correlated with depression scores ($P=0.036$). Additionally,

Table 4 Multiple Linear Analysis for Clinical Characteristics in Predicting Depression

Characteristics	Estimate	Standardized Error	T value	P value
(Intercept)	4.845	1.724	2.810	0.005
Gender				
Male	Ref.			
Female	0.370	0.217	1.700	0.089
Age	0.067	0.081	0.825	0.409
Grade (%)				
First	Ref.			
Second	-0.049	0.223	-0.222	0.824
Third	0.079	0.400	0.197	0.844
Fourth	-0.706	0.526	-1.344	0.179
Delayed	0.637	1.330	0.479	0.632
Marital status (%)				
Single	Ref.			

(Continued)

Table 4 (Continued).

Characteristics	Estimate	Standardized Error	T value	P value
Dating	0.029	0.228	0.129	0.897
Married	2.773	1.321	2.099	0.036
Love eating low salt food				
No	Ref.			
Yes	-0.021	0.215	-0.096	0.924
Love eating oily food				
No	Ref.			
Yes	0.185	0.214	0.867	0.386
Love eating barbecue				
No	Ref.			
Yes	0.747	0.209	3.572	0.000
Love eating meat				
No	Ref.			
Yes	0.035	0.208	0.166	0.868
Love eating vegetable				
No	Ref.			
Yes	-0.533	0.199	-2.681	0.007
Love eating fruit				
No	Ref.			
Yes	-0.098	0.210	-0.465	0.642
Smoking (%)				
None	Ref.			
Previous	-0.596	0.532	-1.119	0.263
Current	0.516	0.381	1.355	0.176
Drinking (%)				
None	Ref.			
Previous	-0.230	0.528	-0.436	0.663
Current	0.073	0.245	0.299	0.765
Sedentary time (hours, %)				
< 1 hour	Ref.			
≥ 1 and <3 hours	1.267	0.376	3.368	0.001
≥ 3 and <6 hours	0.996	0.371	2.682	0.007
≥ 6 hours	1.323	0.385	3.432	0.001

(Continued)

Table 4 (Continued).

Characteristics	Estimate	Standardized Error	T value	P value
Electronic time	0.218	0.039	5.598	0.000
Monthly expense (RBM, %)				
< 2000	Ref.			
≥ 2000 and <5000	-0.154	0.252	-0.611	0.541
≥ 5000 and <10,000	-1.704	0.793	-2.149	0.032
≥ 10,000	0.690	1.292	0.534	0.593
Stress event				
Yes	Ref.			
No	-3.175	0.199	-15.929	0.000
Sport frequency (per week, %)				
1-2	Ref.			
3-4	-0.047	0.235	-0.199	0.842
≥ 5	-0.598	0.323	-1.850	0.064
Sport type				
Basketball	Ref.			
Badminton	0.788	0.408	1.933	0.053
Volleyball	1.327	0.408	3.253	0.001
Dance	0.735	0.630	1.166	0.244
Running	0.269	0.378	0.713	0.476
Yoga	1.614	1.087	1.485	0.138
Tai Chi	1.501	0.791	1.898	0.058
Tennis	-0.346	0.680	-0.509	0.611
Table tennis	0.587	0.489	1.200	0.230
Instrument	0.840	0.533	1.576	0.115
Others	0.808	0.387	2.087	0.037
Sport time (hours/each exercise, %)				
<1	Ref.			
≥ 1 and <3	-0.596	0.213	-2.797	0.005
≥ 3	-0.042	0.381	-0.111	0.912
Chronic disease				
Yes	Ref.			
No	-2.642	0.532	-4.969	0.000

Abbreviation: Ref., reference.

enjoying barbecue food ($P < 0.001$) was significantly associated with higher depression scores, while loving eating vegetable ($P = 0.007$) was significantly associated with lower depression scores. Prolonged sedentary time ($P = 0.001$) and electronic device usage time ($P < 0.001$) were both positively correlated with depression symptoms. Participants without stress event ($P < 0.001$) had significantly less depression symptoms. Furthermore, specific exercise types, such as volleyball ($P = 0.001$), were significantly related to depression symptoms. A relatively longer sport time ($P = 0.005$) and no chronic disease ($P < 0.001$) were significantly associated with less depression symptoms. Notably, a higher exercise frequency ($P = 0.064$) was associated with less depression score, although it did not reach significance. The above results indicated that a relatively healthy eating habit, less exposure to electronic screen, and exercise were beneficial to prevent or mitigate depression.

Discussion

Main Findings

The main findings of this study indicated that there was a significant association between various lifestyle factors and depression among university students. The results suggested that higher sport frequency, longer sport time, and participation in specific sports, such as basketball, tennis, dance, and running, were associated with lower levels of depression and anxiety. In contrast, factors such as married status, enjoying barbecue food, prolonged sedentary time, experiencing stress events, and increased electronic device usage time were positively associated with depression scores. The findings also revealed that a preference for eating vegetables, engaging in longer sports activities, exercising more frequently, and the absence of chronic disease were negatively associated with depression scores. Furthermore, these results underscored the importance of adopting a healthy lifestyle, which includes regular exercise, limited screen time, and a balanced diet, in preventing and mitigating depression among university students. The findings of this study are able to provide valuable insights for the development of targeted interventions and support services to address the mental health needs of this vulnerable population.

To begin with, the prevalences of depression and anxiety symptoms were 44.2% and 39.5%, respectively, both of which were consistent with previous studies. It was reported that 18.0% to 68.5%^{3,4} university students suffered from depression, and 30.0% to 54.4%^{3,4} university students had anxiety. The above numbers suggested that mental health problems are common among university students. At this juncture of their academic journey, university students face a multitude of challenges, including adaptation to role changes, balancing study and personal life, managing emotional upheavals, coping with financial constraints, anticipating future employment prospects, and navigating interpersonal relationships. These stressors have a profound impact on their physical and mental well-being.

Previous studies have demonstrated that exercise was negatively associated with symptoms of depression.^{3,13} In addition, it was also associated with other measures of mental health problems, including stress, anxiety, and suicidality.¹⁴ A meta-analysis concluded that significant mental health benefits from being physically active, even at levels below the public health recommendations.¹⁵ Our findings further suggested that higher sport frequency, longer sport time, and participation in specific sports, such as basketball, tennis, dance, and running, were associated with lower levels of depression and anxiety. To elaborate, as the frequency of physical activity increased, participants' scores for anxiety and depression gradually decreased, with the lowest ratings observed among those engaging in 3–4 sessions per week. Although participants who exercised 5 or more times weekly also had lower anxiety and depression scores, the difference was not as pronounced compared to those who exercised 3–4 times weekly. In light of the potential benefits and uncertainties at higher levels of physical activity,¹⁵ this study recommends that college students engage in physical activity 3–4 times weekly. Previously, a study also showed that the detection rate of cognitive symptoms was significantly lower among college students who exercised >3 times per week for 30–59 minutes.¹ In addition, among various types of exercise, basketball, tennis, dance, and running were found to be particularly beneficial in our study, as they were associated with lower scores for anxiety and depression. Previous dance was served as a protective factor for depression among university students.¹⁶ In addition, the depression symptoms of college students could also be effectively improved by aerobic exercise, traditional Chinese exercises, and meditation.¹⁷

Furthermore, this study also identified a series of factors associated with depression. In detail, factors such as married status, enjoying barbecue food, prolonged sedentary time, experiencing stress events, and increased electronic device usage time were positively associated with depression scores, while loving eating vegetables, engaging in longer sports activities, exercising more frequently, and no chronic disease were negatively associated with depression scores. The above findings underscored the significance of adopting a healthy lifestyle, encompassing regular physical activity, limited screen time, and a balanced diet, in preventing and mitigating depression among university students. More recently, a study also pointed out that problematic mobile phone use was an important risk factors for depression.¹⁸ Significantly, a previous investigation also highlighted that as sitting hours accumulate, university students experience a significant rise in depression and anxiety. In line with the social withdrawal hypothesis, this phenomenon could be attributed to the increased viewing of television or use of computers and the internet, which in turn fosters a sedentary lifestyle and reduces social interactions. This ultimately increases the risk of developing mental health issues.¹⁹ The aforementioned findings offer valuable insights for designing tailored interventions and treatments to combat depression, while taking into account the various factors that could influence mental health.

Measures to Management Depression Among University Students

Effective methods for relieving depression among college students, as suggested by our study and previous researches,²⁰ encompass various approaches. First and foremost, educational interventions²¹ play a pivotal role in raising students' awareness of mental health issues, particularly depression, and equipping them with effective coping strategies. School counseling centers should also provide accessible mental health services, making it easier for students struggling with severe depression, anxiety, and stress to seek help. Additionally, behavioral interventions that encourage students to engage in physical activities, such as exercise research program,²² can help reduce sedentary behavior, increase physical activity, and improve students' mental health. Creating a healthy learning environment by implementing adjustable sit-stand desks and enhancing campus walkability is equally important. Moreover, adjusting students' lifestyle habits,²³ such as scheduling study and rest time reasonably, avoiding long periods of sedentary behavior, and minimizing electronic product use, can contribute to their well-being. Lastly, psychiatric medical providers can employ psychological therapy intervention models and practical interventions including online guided self-help interventions²⁴ to assist students in expressing their psychological challenges and modifying their behavior and lifestyle. By implementing these multi-faceted strategies, a deeper understanding of the psychological and social barriers and motivations behind modifying their behavior and lifestyle among college students can be achieved, ultimately enabling the development of targeted intervention measures to effectively alleviate depression in this population. In addition, electroconvulsive therapy was a highly effective and efficient intervention for treating treatment-resistant depression, as it has enjoyed over 80 years of clinical practice.²⁵ Its well-established efficacy and documented superiority have solidified its position as the first-line treatment for treatment-resistant depression. Transcranial magnetic stimulation, another non-surgical brain stimulation technique, has also emerged as a promising treatment option for major depressive disorder.^{26,27}

Limitations

This study has several limitations that should be considered in the interpretation of the findings. Firstly, the cross-sectional design of the study does not allow for the establishment of causal relationships between the variables. Secondly, the study is based on self-reported data, which may be subject to recall bias and social desirability effects. Thirdly, the sample size, while large, is limited to three universities, which may not be representative of all university students in the country. Fourthly, the study did not consider other potential factors that might influence depression, such as family history of mental health issues, personality traits, sleep patterns, and body dissatisfaction.¹³ Fifthly, the use of screening tools for depression and anxiety may not be as accurate as diagnostic tools, and the results should be interpreted with caution. Finally, the study did not account for the potential effect of clustering in the data, which may have led to an underestimation of the true associations between variables. Despite these limitations, the study provides valuable insights into the factors associated with depression among university students and highlights the need for targeted interventions to address this important public health issue.

Conclusions

This study highlights the importance of a healthy lifestyle, including regular exercise, limited exposure to electronic screens, and a balanced diet, in preventing and mitigating depression among university students. This study also suggests that exercising 3–4 times a week is associated with the lowest levels of anxiety and depression. Activities such as basketball, tennis, dance, and running are effective in alleviating these mental health issues through regular exercise.

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