



## Research article

# Association among physical activity, anxiety and oral health status in Chinese university students: A cross-sectional study

Beibei Chen<sup>a,1</sup>, Rongkai Cao<sup>a,1</sup>, Lei Yu Pan<sup>b</sup>, Danni Song<sup>a</sup>, Chongshan Liao<sup>a,\*\*</sup>, Yongming Li<sup>a,\*</sup>

<sup>a</sup> Stomatological Hospital and School of Tongji University, Shanghai Engineering Research Center of Tooth Restoration and Regeneration, Shanghai, China

<sup>b</sup> Sports and Health Research Center, Department of Physical Education, Tongji University, Shanghai, China

## ARTICLE INFO

Handling Editor: Madhav Jatin Chandarana

## Keywords:

Physical activity  
Anxiety  
Tooth brushing  
Gingival bleeding  
China

## ABSTRACT

**Background:** Evidence is limited regarding the relationship among physical activity, anxiety, and oral health in Chinese university students. This cross-sectional investigation aimed to assess the potential relationship between physical activity, anxiety, and oral health conditions among university students in China.

**Methods:** An online questionnaire measuring physical activity, anxiety status, and oral health condition was completed by 1604 university students. The International Physical Activity Questionnaire Short Form (IPAQ-SF) and Generalized Anxiety Disorder-7 (GAD-7) were selected to evaluate physical activity and anxiety, respectively. Oral health condition was assessed through several self-reported variables, including self-reported toothache, gingival bleeding, frequency of tooth brushing, and use of dental floss. Multivariate logistic regression was performed to analyze the underlying relationship between outcome variables. The control variables included age, height, weight, gender, whether only one-child, education level, parental education level, smoking status, drinking habits, and length of sleep. Path analysis was conducted to disentangle the association between physical activity, anxiety, and oral health conditions.

**Results:** Among 1604 university students, 666 (41.5 %) were males and 938 (58.5 %) were females, with an average of  $21.9 \pm 2.8$  years. Only 833 (51.9 %) reported sufficient physical activity, while 684 (42.6 %) of the subjects displayed varying degrees of anxiety. Self-reported gingival bleeding was associated with insufficient physical activity (OR = 1.25; 95%CI: 1.02–1.55), anxiety (OR = 0.45; 95%CI: 0.27–0.74), frequency of tooth brushing (OR = 0.75; 95%CI: 0.60–0.95) and use of dental floss (OR = 0.75; 95%CI: 0.59–0.96), while toothache was not directly influenced by the physical activity and anxiety among university students. Anxiety markedly mediated the relationship between physical activity and oral health conditions.

**Conclusions:** Anxiety was considered a factor associated with the level of physical activity, tooth brushing habits, and self-reported gingival bleeding among university students. Further investigations are required to elucidate whether oral health conditions could be enhanced through the improvement of anxiety and physical activity.

**Abbreviations:** COVID-19, Corona Virus Disease 2019; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2.

\* Corresponding author.

\*\* Corresponding author.

**E-mail addresses:** [liao-chongshan@tongji.edu.cn](mailto:liao-chongshan@tongji.edu.cn) (C. Liao), [liyongming@tongji.edu.cn](mailto:liyongming@tongji.edu.cn) (Y. Li).

<sup>1</sup> These authors contributed equally to this work.

<https://doi.org/10.1016/j.heliyon.2024.e24529>

Received 16 October 2023; Received in revised form 29 December 2023; Accepted 10 January 2024

Available online 16 January 2024

2405-8440/© 2024 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

## 1. Background

Based on the definition approved by the World Dental Federation, oral health includes the ability to smile, taste, speak, smell, chew, swallow, touch, and convey various emotions through facial expressions with confidence and without pain, discomfort, and disease of the craniofacial complex [1]. As a critical component of general health, attention has been focused on the necessity of oral health in achieving better life quality. The oral health condition is strongly linked with the physical health condition. For example, periodontal diseases are associated with hypertension [2]. Moreover, oral problems lead to hours lost from work and adversely influence the productivity of people [3]. A recent article summarized the oral health condition of Chinese university students and concluded that the prevalence of dental caries and periodontal disease among university students was 30.96%–80.25 % and 20.14%–57.26 %, respectively [4]. Improvements in oral health in society could increase people's well-being [5]. Accordingly, it is critical to determine potential influencing factors that affect oral health to inform the implementation of oral health management strategies.

Physical activity is defined as any bodily movement produced by the contraction of skeletal muscle that leads to energy expenditure [6]. It can be categorized into sports, occupational, household, conditioning, or other activities in everyday life. Various investigations have assessed the influence of physical activity on various oral complications. For instance, a previous study of 2,521 adults indicated that increased physical activity can reduce the prevalence of periodontitis [7]. Physically active adolescents have been demonstrated to present better oral health behavior than less active ones [8]. Another recent study reported a linear and inverse association between physical activity and the occurrence and severity of periodontal diseases among females in Japan [9]. This may be attributed to the positive influence of physical activity on the reduction of inflammatory cytokines such as tumor necrosis factor-alpha, interleukin 6, and C-reactive protein [10]. Accordingly, physical activity may present potential advantages in the management of oral health conditions. The World Health Organization recommends a physical activity of 150 min of brisk walking or 75 min of running every week to keep physical fitness [11]. However, because of the COVID-19 pandemic, unprecedented changes have taken place in the lifestyle of university students. A meta-analysis containing 57 articles with 119,094 subjects reported that during the COVID-19 pandemic, physical activity decreased in all age groups, independent of gender [12].

Anxiety refers to the anticipation of future threats [13]. As a normal emotion, anxiety is distinguished from fear which means the emotional response to a real or perceived imminent threat. Influenced by oral hygiene condition, oral health-related quality of life was markedly related to emotional distress [14]. Due to the changes in lifestyles caused by the pandemic, university students were more likely to feel anxious [15]. A longitudinal study of 1892 subjects concluded that anxiety turned out to be the most prevalent problem for university students in China, especially for those female subjects [16]. Another study of 7,143 subjects in China concluded that the occurrence of severe, moderate and mild anxiety among university students during the COVID-19 epidemic was 0.9 %, 2.7 % and 21.3 %, respectively [17]. The increase in anxiety may influence the academic performance of university students and increase the risk of multiple health-related problems. For example, researchers have demonstrated that anxiety portends adverse prognoses in people with cardiovascular disease [18]. Results from another research emphasized the association between anxiety and lower oral health-related quality of life in the average representative of society [19]. In addition, studies have demonstrated that a high occurrence of anxiety is linked with temporomandibular joint disorder (TMD), a broad pain disorder [20]. Accordingly, the occurrence of anxiety in Chinese university students and its potential effect on oral health conditions need to be clarified.

On the basis of the evidence above, the objective of this study was to perform a survey to determine the relationship between physical activity, anxiety and oral health conditions among Chinese university students during the COVID-19 pandemic, when anxiety was prevalent extensively.

## 2. Methods

### 2.1. Study design

The present cross-sectional survey was performed from March 20th to April 20th, 2023, targeting current Chinese university students. This survey was conducted under the Declaration of Helsinki and approved by the Ethics Committee of the Stomatological Hospital and Dental School of Tongji University (approval number [2023]-R-29). Data were collected online through a commonly used Chinese online questionnaire platform, Questionnaire Star. Participants were informed about the objectives, anonymity of data collection, inclusion criteria, and the right to withdraw from this study. Only those subjects who agree with written consent to participate in the survey could complete the questionnaire.

### 2.2. Participants

An online survey was used to recruit current Chinese university students at the time when they completed the questionnaire. Participants were considered eligible if they met the following criteria: (1) at least 18 years old and (2) current student at the university.

### 2.3. Measurements

#### 2.3.1. Demographic characteristics

Questions regarding the demographic characteristics collected the following data of the subjects: age, height, weight, gender,

whether only one-child, education level, parental education level.

### 2.3.2. Clinical characteristics

Several clinical characteristics were included in this study. Body mass index (BMI) was calculated according to the weight and height of the subjects. Smoking status and drinking habits of the subjects were classified as current, never, or previous, and the length of sleep was categorized as <6 h, 6–8 h, or >8 h.

### 2.3.3. International physical activity questionnaire short form (IPAQ-SF)

The level of physical activity of university students was measured using the IPAQ-SF, a 7-question questionnaire used to record the total minutes of physical activity per week and sitting time per day [21]. The IPAQ-SF measures the physical activity of three intensity levels: vigorous-intensity activity (8.0 metabolic equivalents, METs), moderate-intensity activity (4.0 METs), and low-intensity activity (3.3 METs). Total physical activity per week was determined using this formula: Total MET-minutes/week = Low physical activity (METs × min × days) + Moderate physical activity (METs × min × days) + Vigorous physical activity (METs × min × days). Subjects were classified as sufficiently active (≥600 MET-minutes/week) and insufficiently active (<600 MET-minutes/week) under the guidelines of the IPAQ-SF [11]. The Chinese version of IPAQ-SF has been proven in current studies [22–24].

### 2.3.4. Generalized Anxiety Disorder 7 (GAD-7)

The anxiety of university students was evaluated by GAD-7, a 7-question scale that determines the anxiety status of subjects during the past two weeks [25]. Each question contains 4 options (nearly every day, more than half the days, several days, not at all) with a four-point Likert scale of 0, 1, 2 and 3, respectively. The gradation of GAD-7 based upon the scores was classified as 4 levels: no anxiety (0–4), mild anxiety (5–9); moderate anxiety (10–14) and severe anxiety (15–21). The Chinese version of GAD-7 showed good validity, reliability, and measurement invariance [26–28].

### 2.3.5. Oral health condition

The oral health condition was evaluated through several self-reported variables. Self-reported toothache and gingival bleeding were used as the two main parameters of oral health conditions. In addition, oral health behaviors including frequency of tooth brushing and use of dental floss were evaluated.

### 2.3.6. Study size

Because of the instability of the COVID-19 pandemic, it is hard to calculate the sample size. Nevertheless, our sample size (1604) is sufficient since it significantly exceeds other similar researches assessing the physical activity or anxiety of university students, which is approximately 1000 [29–32].

### 2.3.7. Statistical methods

The statistical analysis was conducted in the SPSS software (version 27.0, IBM Corp., Armonk, NY, USA). Qualitative data were expressed as percentage values and quantitative data were described using the mean and standard deviation. A Kolmogorov–Smirnov test was performed to evaluate the normality of distribution in our data. Differences in oral health condition were compared among university students using the Chi-squared tests for qualitative variables and the independent-sample *t*-test for quantitative variables. Spearman's Rank Correlation Analysis was performed to evaluate the association between physical activity, anxiety, and oral health behaviors. In addition, the underlying association between physical activity, anxiety, oral health behaviors and oral health condition was assessed through Multivariable logistic regression analysis. The models were adjusted demographic characteristics including age, BMI, gender, whether only one-child, parental education level, education level, smoking, drinking and sleep. Age was considered a continuous variable, while other variables were regarded as categorical variables. Results of logistic regression analyses are presented as odds ratio (OR) with a 95 % confidence interval (95%CI). Path analysis was conducted in Mplus 8.3 to disentangle the underlying association between physical activity, anxiety and oral health conditions. A saturated model was used since the variables in this study were all explicit variables. All the parameters to be estimated were exactly equal to the elements in the covariance matrix. Accordingly, only the path coefficient was concerned while the fitting index was no longer estimated in this study. The *p*-value <0.05 was considered significant.

## 3. Results

### 3.1. Sample characteristics

A total of 1844 subjects completed the survey, and 1604 fulfilled the criteria for data integrity and inclusion. The age of the subjects ranged from 18 to 32, with an average of  $21.9 \pm 2.8$  years. Based on the height and weight collected, 270 (16.8 %) students were considered people with overweight based on the recommended criteria for Chinese people in previous literature since they reported a BMI larger than 24 [33]. Among the university students included, 666 (41.5 %) were males and 938 (58.5 %) were females. 758 (47.3 %) were the only child in their family. The number of undergraduate, master and doctoral students was 1081, 430 and 93, respectively. The parental education level of the included subjects is mainly a high school degree or below (66.7 %). Most subjects were not smokers (88.5 %), and the number of current or previous drinkers was 130 (8.1 %) and 54 (3.4 %), respectively. The number of current, never and previous drinkers was 663 (41.3 %), 892(55.6 %) and 49 (3.1 %), respectively. Most of the subjects reported a length of sleep

**Table 1**  
Sample characteristics.

Characteristics	Category	Total	Self-reported toothache			Self-reported gingival bleeding			Tooth brushing ( $\geq 2$ times a day)			Dental floss ( $\geq$ once a day)		
			Yes	No	<i>p</i>	Yes	No	<i>p</i>	Yes	No	<i>p</i>	Yes	No	<i>p</i>
Age	Mean (SD)	21.9(2.8)	22.0(2.8)	21.8(2.8)	0.37	22.0(2.9)	21.8(2.6)	0.31	22.0(2.7)	21.8(2.8)	0.24	22.2(2.8)	21.8(2.7)	<0.01**
Gender	Male	666(41.5 %)	318 (37.2 %)	348 (46.5 %)	<0.01**	360 (42.2 %)	306 (40.7 %)	0.55	417 (36.3 %)	249 (54.6 %)	<0.01**	146 (41.5 %)	520 (41.5 %)	0.99
	Female	938(58.5 %)	537 (62.8 %)	401 (53.5 %)		493 (57.8 %)	225 (59.3 %)	0.731 (63.7 %)	207 (45.4 %)	731 (63.7 %)	207 (45.4 %)	<0.01**	206 (58.5 %)	732 (58.5 %)
Only one-child	Yes	758(47.3 %)	390 (45.6 %)	368 (49.1 %)	0.16	384 (45.0 %)	374 (49.8 %)	0.06	570 (49.7 %)	188 (41.2 %)	<0.01**	175 (49.7 %)	583 (46.6 %)	0.30
	No	846(52.7 %)	465 (54.4 %)	381 (50.9 %)	0.42	469 (55.0 %)	377 (50.2 %)	0.74	578 (50.3 %)	268 (58.8 %)	0.12	177 (50.3 %)	669 (53.4 %)	0.02*
Education	Undergraduate	1081(67.4 %)	565 (66.1 %)	516 (68.9 %)	0.42	571 (66.9 %)	510 (67.9 %)	0.74	759 (66.1 %)	322 (70.6 %)	0.12	216 (61.4 %)	865 (69.1 %)	0.02*
	Master	430(26.8 %)	236 (27.6 %)	194 (25.9 %)	0.29	229 (26.8 %)	201 (26.8 %)	0.31	324 (28.2 %)	106 (23.2 %)	0.65	115 (32.7 %)	315 (25.2 %)	0.21
	Doctor	93(5.8 %)	54 (6.3 %)	39 (5.2 %)	<0.01**	52 (6.2 %)	40 (5.3 %)	0.03*	65 (5.7 %)	28 (6.1 %)	0.65	21 (6.0 %)	72 (5.8 %)	0.21
Parental education level	>High school	534(33.3 %)	253 (29.6 %)	281 (37.5 %)	<0.01**	263 (30.8 %)	271 (36.1 %)	0.03*	386 (33.6 %)	148 (32.5 %)	0.65	127 (36.1 %)	407 (32.5 %)	0.21
	$\leq$ High school	1070(66.7 %)	602 (70.4 %)	468 (62.5 %)	0.67	590 (69.2 %)	480 (63.9 %)	0.35	762 (66.4 %)	308 (67.5 %)	<0.01**	225 (63.9 %)	845 (67.5 %)	<0.01**
Smoking	Current	130(8.1 %)	69 (8.1 %)	61 (8.1 %)	0.67	77 (9.0 %)	53 (7.1 %)	0.35	73 (6.4 %)	57 (12.5 %)	<0.01**	41 (11.6 %)	89 (7.1 %)	<0.01**
	Never	1420(88.5 %)	754 (88.2 %)	666 (88.9 %)	0.29	747 (87.6 %)	673 (89.6 %)	0.03*	1043 (90.9 %)	377 (82.7 %)	<0.01**	294 (83.5 %)	1126 (89.9 %)	<0.01**
Drinking	Previous	54(3.4 %)	32 (3.7 %)	22 (2.93 %)	0.29	29 (3.4 %)	25 (3.3 %)	0.29	32 (2.8 %)	22 (4.8 %)	<0.01**	17 (4.8 %)	37 (3.0 %)	0.03*
	Current	663(41.3 %)	367 (42.9 %)	296 (39.5 %)	0.29	388 (45.5 %)	275 (36.6 %)	<0.01**	444 (38.7 %)	219 (48.0 %)	<0.01**	148 (42.0 %)	515 (41.1 %)	0.03*
	Never	892(55.6 %)	460 (53.8 %)	432 (57.7 %)	0.23	438 (51.3 %)	454 (60.5 %)	0.23	673 (58.6 %)	219 (48.0 %)	0.01**	186 (52.8 %)	706 (56.4 %)	0.39
Sleeping	Previous	49(3.1 %)	28 (3.3 %)	21 (2.8 %)	0.23	27 (3.2 %)	22 (2.9 %)	0.23	31 (2.7 %)	18 (3.9 %)	0.01**	18 (5.1 %)	31 (2.5 %)	0.39
	<6 h	156(9.7 %)	93 (10.9 %)	63 (8.4 %)	0.23	105 (12.3 %)	51 (6.8 %)	<0.01**	99 (8.6 %)	57 (12.5 %)	0.01**	41 (11.6 %)	115 (9.2 %)	0.39
Overweight	6–8 h	1239(77.2 %)	649 (75.9 %)	590 (78.8 %)	0.70	649 (76.1 %)	590 (78.6 %)	0.85	887 (77.3 %)	352 (77.2 %)	<0.01**	266 (75.6 %)	973 (77.7 %)	0.84
	>8 h	209(13.0 %)	113 (13.2 %)	96 (12.8 %)	0.70	99 (11.6 %)	110 (14.6 %)	0.85	162 (14.1 %)	47 (10.3 %)	<0.01**	45 (12.8 %)	164 (13.1 %)	0.84
Physical activity	Yes	1334(83.2 %)	141 (16.5 %)	129 (17.2 %)	0.70	145 (17.0 %)	125 (16.6 %)	0.85	166 (14.5 %)	104 (22.8 %)	<0.01**	58 (16.5 %)	212 (16.9 %)	0.84
	No	270(16.8 %)	714 (83.5 %)	620 (82.8 %)	0.42	708 (83.0 %)	626 (83.4 %)	0.42	982 (85.5 %)	352 (77.2 %)	<0.01**	294 (83.5 %)	1040 (83.1 %)	0.48
Anxiety	Insufficient	771(48.1 %)	419 (49.0 %)	352 (47.0 %)	0.42	440 (51.6 %)	331 (44.1 %)	<0.01**	518 (45.1 %)	253 (55.5 %)	<0.01**	175 (49.7 %)	596 (47.6 %)	0.48
	Sufficient	833(51.9 %)	436 (51.0 %)	397 (53.0 %)	0.52	413 (48.4 %)	420 (55.9 %)	0.52	630 (54.9 %)	203 (44.5 %)	<0.01**	177 (50.3 %)	656 (52.4 %)	0.61
Anxiety	No	920(57.4 %)	478 (55.9 %)	442 (59.0 %)	0.52	446 (52.3 %)	474 (63.1 %)	<0.01**	708 (61.7 %)	212 (46.5 %)	<0.01**	205 (58.2 %)	715 (57.1 %)	0.61
	Mild	434(27.1 %)	234 (27.4 %)	200 (26.7 %)	0.52	232 (27.2 %)	202 (26.9 %)	0.52	300 (26.1 %)	134 (29.4 %)	<0.01**	100 (28.4 %)	334 (26.7 %)	0.61
	Moderate	166(10.3 %)	94 (11.0 %)	72 (9.6 %)	0.52	115 (13.5 %)	51 (6.8 %)	0.52	89 (7.8 %)	77 (16.9 %)	<0.01**	31 (8.8 %)	135 (10.8 %)	0.61
	Severe	84(5.2 %)	49 (5.7 %)	35 (4.7 %)	0.52	60 (7.0 %)	24 (3.2 %)	0.52	51 (4.4 %)	33 (7.2 %)	<0.01**	16 (4.5 %)	68 (5.4 %)	0.61

Chi-squared tests for obesity, gender, only one-child, education, parental education level, smoking, drinking, sleeping, physical activity, anxiety, toothbrushing and dental floss; independent-sample *t*-test for age.

\**p* < 0.05; \*\**p* < 0.01.

between 6 and 8 h per day (77.2 %). However, 156 (9.7 %) subjects sleep less than 6 h a day. According to the guidelines of IPAQ-SF, only 833 (51.9 %) university students in this study were considered sufficiently active. while the number of students who reported mild, moderate and severe anxiety were 434 (27.1 %), 166 (10.3 %) and 84 (5.2 %), respectively (Table 1).

Regarding oral health behaviors, 1148 (71.6 %) students reported good tooth brushing habits ( $\geq 2$  times a day). However, only 352 (21.9 %) used dental floss ( $\geq$  once a day) in their daily life. The number of subjects who reported toothache and gingival bleeding were 855 (53.3 %) and 853 (53.2 %), respectively. Results of Chi-squared tests showed that female students and those subjects with lower parental education levels were also more likely to report toothache. In addition, parental education level, drinking, length of sleep, physical activity and anxiety were considered significant influencing factors for self-reported gingival bleeding. Regarding the frequency of tooth brushing, most variables were considered to have an impact except age, education and parental education level. For the use of dental floss, age, education, smoking and drinking habits were considered influencing factors (Table 1).

### 3.2. Association between physical activity, anxiety and oral health condition

Correlation analysis showed a significant relationship between physical activity, anxiety and tooth brushing ( $p < 0.05$ ) (Table 2). However, the use of dental floss did not present a correlation with physical activity and anxiety. After controlling various variables (that is, age, BMI, gender, education level, whether only one-child, parental education level, smoking status, drinking habits and sleep length), the multivariate logistic regression analysis showed a significant association between oral health behaviors, anxiety and gingival bleeding. Those students with less anxiety (OR = 0.45; 95%CI: 0.27–0.74), better tooth brushing habits (OR = 0.75; 95%CI: 0.60–0.95) and who use dental floss (OR = 0.75; 95%CI: 0.59–0.96) were less likely to report gingival bleeding. Conversely, those students with insufficient physical activity were more likely to report gingival bleeding (OR = 1.25; 95%CI: 1.02–1.55). However, physical activity, anxiety, frequency of tooth brushing and use of dental floss did not directly influence the toothache based on the logistic regression model (Table 3).

The results of path analysis showed that physical activity significantly affected anxiety status. The increase in the intensity of exercise led to a lower level of anxiety. In addition, the anxiety status significantly affected the oral health condition and oral health behavior. Those students with higher anxiety are more likely to report gingival bleeding and lower toothbrushing frequency. Moreover, tooth brushing also mediated the association between anxiety and self-reported gingival bleeding. Although physical activity had no direct effect on gingival bleeding or tooth brushing, anxiety may play a mediating factor, affecting the oral health condition and oral behavior through anxiety (Fig. 1).

## 4. Discussion

The present study tried to investigate physical activity, anxiety and oral health conditions and their underlying relationship among university students in China. The questionnaire was posted online and was accessible to all students to eliminate the potential risk of bias. In our study, we found a lower level of sufficient physical activity (51.9 %) and a higher level of anxiety (42.6 %) among university students compared to previous studies conducted before the pandemic [34–36]. Self-reported gingival bleeding was associated with insufficient physical activity, anxiety, tooth brushing and dental floss, while toothache was not directly influenced by the physical activity and anxiety among university students. To the best of our knowledge, this is the first survey to draw attention to the underlying association between physical activity, anxiety and oral health conditions among university students in China.

As an essential public approach to the prevention of many psychiatric and physical diseases, physical activity has been recommended to the public by multiple medical entities [37]. As a health-promoting behavior physical activity has also been recommended to individuals with or without disease for the purpose of improving life quality. Moreover, for university students, a positive association between physical activity habits and high academic achievement has been reported [38]. Accordingly, maintaining the recommended level of physical activity is essential for the development of university students. However, the results of our study showed that only 51.9 % of students reported sufficient physical activity, which is significantly lower than those studies conducted before COVID-19 [34,36]. A previous study evaluated the level of physical activity from 2001 to 2016 among more than 1.9 million participants and concluded that only 17.3 % of East and Southeast Asia people reported insufficient physical activity [39]. A previous cross-sectional survey performed on 517 university students indicated that only 11 % of respondents reported insufficient physical activity [34]. Another study assessing the association between physical activity and inflammatory biomarkers in periodontitis also demonstrated more than 60 % of subjects reported sufficient physical activity [36].

This may be due to the unprecedented changes in lifestyle of the COVID-19 pandemic. Due to various strict strategies during the past three years, enormous changes have taken place in the everyday life of university students [40]. Although the pandemic coming to

**Table 2**

Correlation analysis between physical activity, anxiety and oral health behaviors among university students in China.

Category	Physical activity	Anxiety	Toothbrushing	Dental floss
Physical activity	\			
Anxiety	<0.01**	\		
Toothbrushing	<0.01**	<0.01**	\	
Dental floss	0.48	0.35	<0.01**	\

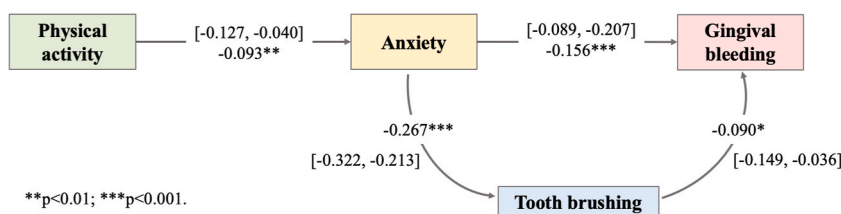
\* $p < 0.05$ ; \*\* $p < 0.01$ .

**Table 3**  
Multivariate logistic regression of factors associated with oral health condition.

Characteristics	Category	Toothache			Gingival bleeding		
		WaldX <sup>2</sup>	p	OR (95%CI)	WaldX <sup>2</sup>	p	OR (95%CI)
Age	Mean (SD)	0.02	0.88	1.00 (0.95–1.06)	0.79	0.38	1.02 (0.97–1.08)
Overweight	No	0.26	0.61	0.93 (0.70–1.23)	0.27	0.61	1.08 (0.81–1.43)
	Yes						
Gender	Male	14.91	<0.01**	0.64 (0.51–0.80)	<0.01	0.97	1.01 (0.80–1.27)
	Female						
Only one-child	Yes	0.04	0.83	0.98 (0.79–1.22)	1.00	0.32	0.89 (0.72–1.12)
	No						
Education	Undergraduate	1.53	0.22	0.72 (0.42–1.22)	0.01	0.92	0.97 (0.57–1.66)
	Master	0.78	0.38	0.81 (0.50–1.30)	0.01	0.93	0.98 (0.60–1.59)
	Doctor						
Parental education level	>High school	8.72	<0.01**	0.71 (0.57–0.89)	2.81	0.09	0.82 (0.66–1.03)
	≤High school						
Smoking	Current	0.94	0.33	0.72 (0.37–1.40)	0.05	0.83	1.08 (0.55–2.11)
	Never	1.44	0.23	0.70 (0.39–1.26)	0.16	0.69	1.13 (0.63–2.03)
	Previous						
Drinking	Current	0.01	0.94	1.03 (0.56–1.88)	0.12	0.73	1.12 (0.60–2.06)
	Never	0.40	0.53	0.82 (0.45–1.51)	0.53	0.47	0.80 (0.43–1.47)
	Previous						
Sleeping	<6 h	0.44	0.51	1.16 (0.75–1.79)	6.11	0.01*	1.76 (1.12–2.75)
	6–8 h	0.75	0.39	0.88 (0.65–1.18)	0.55	0.46	1.12 (0.83–1.52)
	>8 h						
Physical activity	Insufficient	0.01	0.95	1.01 (0.82–1.24)	4.42	0.04*	1.25 (1.02–1.54)
	Sufficient						
Anxiety	No	0.72	0.40	0.82 (0.51–1.31)	9.59	<0.01**	0.45 (0.27–0.75)
	Mild	0.30	0.59	0.87 (0.54–1.42)	5.78	0.02*	0.53 (0.31–0.89)
	Moderate	<0.01	0.98	1.01 (0.59–1.73)	0.04	0.85	0.94 (0.52–1.70)
	Severe						
Toothbrushing	≥2 times a day	2.31	0.13	1.20 (0.95–1.51)	5.74	0.02*	0.75 (0.59–0.95)
	<2 times a day						
Dental floss	≥once a day	<0.01	0.97	1.01 (0.79–1.28)	5.12	0.02*	0.75 (0.59–0.96)
	<once a day						

The following covariates were controlled for: age, obesity, gender, only one-child, education, parental education level, smoking, drinking, sleeping, physical activity, anxiety, toothbrushing and dental floss.

\*p < 0.05; \*\*p < 0.01.



**Fig. 1.** Path analysis testing the mediation effect of anxiety on the relationship between physical activity, tooth brushing and self-reported gingival bleeding.

an end, the influence of COVID-19 on the lifestyle of university students is unlikely to be eliminated quickly. Issues worth considering remain, including the level of physical activity and anxiety status. Accordingly, we emphasized the influence of COVID-19 on university students' lifestyles in our study. The correlation analysis indicated an association between physical activity and oral health behaviors, the multivariate logistic regression analysis also showed the relationship between physical activity and gingival bleeding, which is consistent with the conclusions of previous studies [36,37]. For example, Sanders et al. evaluated the relationship of physical activity with both periodontitis and their inflammatory mediators [36]. Studies have revealed that physical exercise can modulate C-reactive protein (CRP), a by-product of vitamin K metabolism, which is significantly correlated with periodontitis [41]. The underlying mechanism may be due to the anti-inflammatory activity exerted by the physical activity and the favorable effects of physical activity on endothelial function, thus promoting periodontal health [42]. Accordingly, strategies should be taken to increase physical activity levels among university students in China to improve oral and mental health conditions. Social support was a significant predictor of physical activity in university students, which has been demonstrated in the previous study [43]. Establishing clubs or groups focused on specific physical activities, such as running or cycling, can provide a supportive and motivating environment for students. Furthermore, the use of technology-based interventions, such as mobile apps or wearable devices, has shown promise in promoting physical activity. A previous research by Direito et al. [44] demonstrated the effectiveness of mobile apps in increasing

physical activity levels among young adults. These interventions can provide personalized feedback, goal setting, and tracking features, which can enhance motivation and engagement. By implementing a combination of these strategies, it is possible to create an environment that supports and encourages physical activity levels among university students in China.

Anxiety refers to the ambiguous feelings that arise from unresolved stress, which is usually considered to negatively influence the student's academic performance [45]. Previous studies have concluded that the occurrence of anxiety in university students during the epidemic was higher than the general population because of the disruption of academic planning caused by the unpredictability of the epidemic [46]. Moreover, our study showed that 42.6 % of students reported various levels of anxiety, which is significantly higher than the previous study performed at the beginning of the COVID-19 pandemic which found that 75.1 % of university students presented no anxiety. In addition, in our study, the level of anxiety was not only higher than that before the pandemic but also during the peak of the pandemic [17,47]. This high level of anxiety may be due to the higher stress levels caused by academic achievement, impaired concentration and decreased motivation. Another influencing factor is the potential risk of "revenge eating" after the campus lockdown ends, which may affect the anxiety status of university students and should be further tracked and related to prevention [48]. Furthermore, the underlying relationship between physical activity and anxiety among university students has also been found in this study. Accordingly, attention should be drawn to relieving anxiety symptoms by focusing on the improvement in physical activity among university students in China. Psychological adversities like generalized anxiety may negatively influence oral health conditions. Researchers concluded that anxiety was linked to bleeding gums [49]. Our results were in accordance with the literature. Moreover, those students with no anxiety presented better tooth-brushing habits. Therefore, self-reported gingival bleeding may be prevented by improving oral health behaviors among those students with anxiety.

It has been widely accepted that oral health plays a crucial role in general health. Tooth brushing and flossing are two main oral health behaviors in improving the oral health condition. A previous study evaluated the effectiveness of flossing combined with toothbrushing in reducing gingival and plaque indices [50]. The results indicated that flossing can significantly reduce inter-dental plaque build-up and improve gingival health. In this study, almost all variables were considered to have an impact on flossing except age, education and parental education level. Another cross-section study indicated that toothbrushing frequency of less than once a day presented with a higher number of gingival units having bleeding [51]. The path analysis of our study also showed the relationship between tooth brushing and gingival bleeding. In addition, we found that the habits of tooth brushing can be improved through enhancing the level of physical activity and reducing anxiety. However, only 21.9 % of university students in our study used dental floss every day, which needed to be improved. The result of this study also showed the association between self-reported gingival bleeding and anxiety, which is consistent with the previous research [52]. Moreover, the role of physical activity has also been proven according to the path analysis of our study. Accordingly, strategies for the prevention of periodontal diseases should focus on the enhancement of physical activity and reduction in anxiety. However, another self-reported oral health symptom, toothache, was concluded to present no relationship with oral health behaviors, physical activity and anxiety.

This study has several limitations. Firstly, the online survey may result in potentially biased results since some eligible subjects may be excluded, and the use of objective self-reported data may have led to different findings, which may limit the generalizability of our findings. A major weakness of this study was that self-reported students were not competent to detect their oral health status accurately. In addition, dental pathologies are not necessarily associated with pain, and the frequency of toothbrushing per day is not necessarily associated with the quality. Another issue that needed to be considered is that the samples in this study have certain limitations, and the results may not be extrapolated to all university students in China. Finally, we did not rule out stress, depression, dietary habits and other potential problems that have an impact on oral health conditions and behaviors. Further longitudinal investigations are required to better elucidate the underlying association of these influencing factors.

## 5. Conclusions

This is the first survey to draw attention to the underlying relationship between physical activity, anxiety and oral health conditions among university students in China. Despite the limitations, the present study indicated that self-reported gingival bleeding presented a significant relationship with physical activity, anxiety and oral health behaviors. Anxiety may be a risk indicator and significantly mediated the level of physical activity, tooth brushing habits and self-reported gingival bleeding among university students in China during the pandemic. Accordingly, strategies for the improvement of oral health conditions should draw attention to emphasize the physical activity and anxiety status among university students. Further longitudinal investigations are required to better elucidate the underlying association of these influencing factors.

## Declarations

### *Data availability statement*

The data presented in this study are available on request from the corresponding authors.

### *Ethics approval and consent to participate*

The study was conducted in accordance with the Declaration of Helsinki, and approved by the Institutional Review Board of School & Hospital of Stomatology, Tongji University (protocol code [2023]-R-29). Informed consent was obtained from all subjects involved in the study.

## Funding

This study was supported by the National Natural Science Foundation of China (82001008), Shanghai Municipal Health Commission (JKKPZX-2023-A07), Shanghai Sailing Program (21YF1450600) and China Oral Health Foundation (A2023-029).

## CRedit authorship contribution statement

**Beibei Chen:** Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Rongkai Cao:** Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Leiyu Pan:** Validation, Software. **Danni Song:** Visualization. **Chongshan Liao:** Writing – review & editing, Supervision, Resources, Project administration, Funding acquisition. **Yongming Li:** Writing – review & editing, Supervision, Resources, Project administration, Funding acquisition.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Acknowledgements

The authors thank all subjects who participated in the study.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.heliyon.2024.e24529>.

## References

- [1] M. Glick, D.M. Williams, D.V. Kleinman, M. Vujcic, R.G. Watt, R.J. Weyant, A new definition for oral health developed by the FDI World Dental Federation opens the door to a universal definition of oral health, *J. Publ. Health Dent.* 77 (1) (2017) 3–5, <https://doi.org/10.1016/j.ajodo.2016.11.010>.
- [2] R. Martin-Cabezas, N. Seelam, C. Petit, K. Agossa, S. Gaertner, H. Tenenbaum, J.L. Davideau, O. Huck, Association between periodontitis and arterial hypertension: a systematic review and meta-analysis, *Am. Heart J.* 180 (2016) 98–112, <https://doi.org/10.1016/j.ahj.2016.07.018>.
- [3] U. Kelekar, S. Naavaal, Hours lost to planned and Unplanned dental visits among US adults, *Prev. Chronic Dis.* (15) (2018) E04, <https://doi.org/10.5888/pcd15.170225>.
- [4] L. Gao, D. Wang, A study on oral health status and behavior of Chinese college students, *Chi. J. Sch. Health* 44 (8) (2023) 1261–1265.
- [5] A.J. Righolt, M. Jevdjevic, W. Marcenec, S. Listl, Global-, regional-, and country-level economic impacts of dental diseases in 2015, *J. Dent. Res.* 97 (5) (2018) 501–507, <https://doi.org/10.1177/0022034517750572>.
- [6] C.J. Caspersen, K.E. Powell, G.M. Christenson, Physical activity, exercise, and physical fitness: definitions and distinctions for health-related research, *Publ. Health Rep.* 100 (2) (1985) 126–131.
- [7] M.S. Al-Zahrani, E.A. Borawski, N.F. Bissada, Increased physical activity reduces prevalence of periodontitis, *J. Dent.* 33 (9) (2005) 703–710, <https://doi.org/10.1016/j.jdent.2005.01.004>.
- [8] J.I. Virtanen, T. Muikku, T. Similä, A.B. Cinar, V. Pohjola, Physical activity, BMI and oral health behaviour among adolescents: Finnish School Health Promotion Study, *Eur. J. Publ. Health* 29 (2) (2019) 296–302, <https://doi.org/10.1093/eurpub/cky193>.
- [9] M. Iwasaki, A. Yoshihara, K. Suwama, T. Zaitso, S. Suzuki, H. Ihira, N. Sawada, J. Aida, A cross-sectional study of the association between periodontitis and physical activity in the Japanese population, *J. Periodontol. Res.* 58 (2) (2023) 350–359, <https://doi.org/10.1111/jre.13095>.
- [10] G. Zheng, P. Qiu, R. Xia, H. Lin, B. Ye, J. Tao, L. Chen, Effect of aerobic exercise on inflammatory markers in healthy middle-aged and older adults: a systematic review and meta-analysis of randomized controlled trials, *Front. Aging Neurosci.* 11 (2019) 98, <https://doi.org/10.3389/fnagi.2019.00098>.
- [11] G.F.L. Sanchez, L. Smith, A. Koyanagi, I. Grabovac, L. Yang, N. Veronese, J.I. Shin, M. Loosemore, L. Jacob, Associations between self-reported physical activity and oral health: a cross-sectional analysis in 17,777 Spanish adults, *Br. Dent. J.* 228 (5) (2020) 361–365, <https://doi.org/10.1038/s41415-020-1306-3>.
- [12] K. Wunsch, K. Kienberger, C. Niessner, Changes in physical activity patterns due to the covid-19 pandemic: a systematic review and meta-analysis, *Int. J. Environ. Res. Publ. Health* 19 (4) (2022) 2250, <https://doi.org/10.3390/ijerph19042250>.
- [13] M.A. Crocq, A history of anxiety: from Hippocrates to DSM, *Dialogues Clin. Neurosci.* 17 (3) (2015) 319–325, <https://doi.org/10.31887/DCNS.2015.17.3/macroq>.
- [14] K. Hayashi, M. Izumi, Y. Mastuda, A. Isobe, S. Akifusa, Relationship between anxiety/depression and oral health-related quality of life in inpatients of convalescent hospitals, *Odontology* 107 (2) (2019) 254–260, <https://doi.org/10.1007/s10266-018-0394-x>.
- [15] J.J. Chang, Y. Ji, Y.H. Li, H.F. Pan, P.Y. Su, Prevalence of anxiety symptom and depressive symptom among college students during COVID-19 pandemic: a meta-analysis, *J. Affect. Disord.* 292 (2021) 242–254, <https://doi.org/10.1016/j.jad.2021.05.109>.
- [16] W. Gao, S. Ping, X. Liu, Gender differences in depression, anxiety, and stress among college students: a longitudinal study from China, *J. Affect. Disord.* 263 (2020) 292–300, <https://doi.org/10.1016/j.jad.2019.11.121>.
- [17] W. Cao, Z. Fang, G. Hou, M. Han, X. Xu, J. Dong, J. Zheng, The psychological impact of the COVID-19 epidemic on college students in China, *Psychiatr. Res.* 287 (2020) 112934, <https://doi.org/10.1016/j.psychres.2020.112934>.
- [18] P.J. Tully, N.J. Harrison, P. Cheung, S. Cosh, Anxiety and cardiovascular disease risk: a review, *Curr. Cardiol. Rep.* 18 (12) (2016) 120, <https://doi.org/10.1007/s11886-016-0800-3>.
- [19] A. Hajek, H.H. König, Oral health-related quality of life, probable depression and probable anxiety: evidence from a representative survey in Germany, *BMC Oral Health* 22 (1) (2022) 9, <https://doi.org/10.1186/s12903-022-02047-y>.
- [20] R. Rajan, Y.M. Sun, Reevaluating antidepressant selection in patients with bruxism and temporomandibular joint disorder, *J. Psychiatr. Pract.* 23 (3) (2017) 173–179, <https://doi.org/10.1097/PRA.000000000000227>.
- [21] S. Rodríguez-Muñoz, C. Corella, A. Abarca-Sos, J. Zaragoza, Validation of three short physical activity questionnaires with accelerometers among university students in Spain, *J. Sports Med. Phys. Fit.* 57 (12) (2017) 1660–1668, <https://doi.org/10.23736/S0022-4707.17.06665-8>.



- [22] D.J. Macfarlane, C.C. Lee, E.Y. Ho, K.L. Chan, D.T. Chan, Reliability and validity of the Chinese version of IPAQ (short, last 7 days), *J. Sci. Med. Sport* 10 (1) (2007) 45–51, <https://doi.org/10.1016/j.jsams.2006.05.003>.
- [23] R. Kamolthip, Y.N. Yang, J.D. Latner, K.S. O'Brien, Y.L. Chang, C.C. Lin, A.H. Pakpour, C.Y. Lin, The effect of time spent sitting and excessive gaming on the weight status, and perceived weight stigma among Taiwanese young adults, *Heliyon* 9 (3) (2023) e14298, <https://doi.org/10.1016/j.heliyon.2023.e14298>.
- [24] L. Zhu, J. Hou, B. Zhou, X. Xiao, J. Wang, W. Jia, Physical activity, problematic smartphone use, and burnout among Chinese college students, *PeerJ* 11 (2023) e16270, <https://doi.org/10.7717/peerj.16270>.
- [25] R.L. Spitzer, K. Kroenke, J.B. Williams, B. Löwe, A brief measure for assessing generalized anxiety disorder: the GAD-7, *Arch. Intern. Med.* 166 (10) (2006) 1092–1097, <https://doi.org/10.1001/archinte.166.10.1092>.
- [26] C. Zhang, T. Wang, P. Zeng, M. Zhao, G. Zhang, S. Zhai, L. Meng, Y. Wang, D. Liu, Reliability, validity, and measurement invariance of the general anxiety disorder scale among Chinese medical university students, *Front. Psychiatr.* 12 (2021) 648755, <https://doi.org/10.3389/fpsy.2021.648755>.
- [27] T.A. Dhira, M.A. Rahman, A.R. arker, J. Mehareen, Validity and reliability of the Generalized Anxiety Disorder-7 (GAD-7) among university students of Bangladesh, *PLoS One* 16 (12) (2021) e0261590, <https://doi.org/10.1371/journal.pone.0261590>.
- [28] A. Bártolo, S. Monteiro, A. Pereira, Factor structure and construct validity of the Generalized Anxiety Disorder 7-item (GAD-7) among Portuguese college students, *Cad. Saúde Pública* 33 (9) (2017) e00212716, <https://doi.org/10.1590/0102-311X00212716>.
- [29] O.W.A. Wilson, K.E. Holland, L.D. Elliott, M. Duffey, M. Bopp, The impact of the COVID-19 pandemic on US college students' physical activity and mental health, *J. Phys. Activ. Health* 18 (3) (2021) 272–278, <https://doi.org/10.1123/jpah.2020-0325>.
- [30] S. Yuan, M. You, Effects of physical activity on college students' subjective well-being during COVID-19, *J. Epidemiol. Glob Health* 12 (4) (2022) 441–448, <https://doi.org/10.1007/s44197-022-00062-4>.
- [31] E. Ramón-Arbués, V. Gea-Caballero, J.M. Granada-López, R. Juárez-Vela, B. Pellicer-García, I. Antón-Solanas, The prevalence of depression, anxiety and stress and their associated factors in college students, *Int. J. Environ. Res. Publ. Health* 17 (19) (2020) 7001, <https://doi.org/10.3390/ijerph17197001>.
- [32] Y. Zhao Y, Investigation on anxiety and coping style of college students during COVID-19 epidemic, *Psychiatr. Danub.* 33 (4) (2021) 651–655, <https://doi.org/10.24869/psyd.2021.651>.
- [33] B. Zhou, Predictive values of body mass index and waist circumference to risk factors of related diseases in Chinese adult population, *Zhonghua Liuxingbingxue Zazhi* 23 (1) (2002) 5–10.
- [34] I. Sklempe Kokic, M. Znika, V. Brumnic, Physical activity, health-related quality of life and musculoskeletal pain among students of physiotherapy and social sciences in Eastern Croatia - cross-sectional survey, *Ann. Agric. Environ. Med.* 26 (1) (2019) 182–190, <https://doi.org/10.26444/aaem/102723>.
- [35] M. Hajduk, A.J. Heretik, B. Vaseckova, L. Forgacova, J. Pecenek, Prevalence and correlations of depression and anxiety among Slovak college students, *Bratisl. Lek. Listy* 120 (9) (2019) 695–698, <https://doi.org/10.4149/BLL.2019.117>.
- [36] A.E. Sanders, G.D. Slade, T.R. Fitzsimmons, P.M. Bartold, Physical activity, inflammatory biomarkers in gingival crevicular fluid and periodontitis, *J. Clin. Periodontol.* 36 (5) (2009) 388–395, <https://doi.org/10.1111/j.1600-051X.2009.01394.x>.
- [37] R.R. Pate, M. Pratt, S.N. Blair, W.L. Haskell, C.A. Macera, C. Bouchard, D. Buchner, W. Ettinger, G.W. Heath, A.C. King, et al., Physical activity and public health. A recommendation from the centers for disease control and prevention and the American college of sports medicine, *JAMA* 273 (5) (1995) 402–407, <https://doi.org/10.1001/jama.273.5.402>.
- [38] A. Al-Drees, H. Abdulghani, M. Irshad, A.A. Baqays, A.A. Al-Zhrani, S.A. Alshammari, N.I. Alturki, Physical activity and academic achievement among the medical students: a cross-sectional study, *Med. Teach.* 38 (2016) S66–S72, <https://doi.org/10.3109/0142159X.2016.1142516>.
- [39] R. Guthold, G.A. Stevens, L.M. Riley, F.C. Bull, Worldwide trends in insufficient physical activity from 2001 to 2016: a pooled analysis of 358 population-based surveys with 1.9 million participants, *Lancet Global Health* 6 (10) (2018) e1077–e1086, [https://doi.org/10.1016/S2214-109X\(18\)30357-7](https://doi.org/10.1016/S2214-109X(18)30357-7).
- [40] H. Onyeaka, C.K. Anumudu, Z.T. Al-Sharif, E. Egele-Godswill, P. Mbaegbu, COVID-19 pandemic: a review of the global lockdown and its far-reaching effects, *Sci. Prog.* 104 (2) (2021) 368504211019854, <https://doi.org/10.1177/00368504211019854>.
- [41] B. Lieske, N. Moszka, K. Borof, E.L. Petersen, B. Jagemann, M. Ebinghaus, T. Beikler, G. Heydecke, G. Aarabi, B.C. Zyriax, Association between an anti-inflammatory dietary score and periodontitis-evidence from the population-based Hamburg city health study, *Nutrients* 15 (14) (2023) 3235, <https://doi.org/10.3390/nu15143235>.
- [42] Y. Shimazaki, Y. Egami, T. Matsubara, G. Koike, S. Akifusa, S. Jingu, Y. Yamashita, Relationship between obesity and physical fitness and periodontitis, *J. Periodontol.* 81 (8) (2010) 1124–1131, <https://doi.org/10.1902/jop.2010.100017>.
- [43] L.R. Buis, T.A. Poulton, R.G. Holleman, A. Sen, P.J. Resnick, D.E. Goodrich, L. Palma-Davis, C.R. Richardson, Evaluating Active U: an Internet-mediated physical activity program, *BMC Publ. Health* 9 (2009) 331, <https://doi.org/10.1186/1471-2458-9-331>.
- [44] A. Direito, D. Walsh, M. Hinbarji, R. Albatat, M. Tooley, R. Whittaker, R. Maddison, Using the intervention mapping and behavioral intervention technology frameworks: development of an mHealth intervention for physical activity and sedentary behavior change, *Health Educ. Behav.* 45 (3) (2018) 331–348, <https://doi.org/10.1177/1090198117742438>.
- [45] J.L. Hsu, G.R. Goldsmith, Instructor strategies to alleviate stress and anxiety among college and university STEM students, *CBE-Life Sci. Educ.* 20 (1) (2021) es1, <https://doi.org/10.1187/cbe.20-08-0189>.
- [46] Y. Ren, Y. Zhou, W. Qian, Z. Li, Z. Liu, R. Wang, L. Qi, J. Yang, X. Song, L. Zeng, X. Zhang, Letter to the Editor "A longitudinal study on the mental health of general population during the COVID-19 epidemic in China", *Brain Behav. Immun.* 87 (2020) 132–133, <https://doi.org/10.1016/j.bbi.2020.05.004>.
- [47] M.Q. Xiang, X.M. Tan, J. Sun, H.Y. Yang, X.P. Zhao, L. Liu, X.H. Hou, M. Hu, Relationship of physical activity with anxiety and depression symptoms in Chinese college students during the COVID-19 outbreak, *Front. Psychol.* 11 (2020) 582436, <https://doi.org/10.3389/fpsyg.2020.582436>.
- [48] W. Duan, Q. Ding, S. Peng, Q. Kang, L. Guo, L. Zhang, Y. Wei, Z. Xiao, J. Fan, J. Chen, Chinese university students showed less disordered eating during the COVID-19 campus lockdown, *Eat. Weight Disord.* 28 (1) (2023) 47, <https://doi.org/10.1007/s40519-023-01569-w>.
- [49] P. Marques-Vidal, V. Milagre, Are oral health status and care associated with anxiety and depression? A study of Portuguese health science students, *J. Publ. Health Dent.* 66 (1) (2006) 64–66, <https://doi.org/10.1111/j.1752-7325.2006.tb02553.x>.
- [50] E. Shamsoddin, Dental floss as an adjuvant of the toothbrush helps gingival health, *Evid. Base Dent.* 23 (3) (2022) 94–96, <https://doi.org/10.1038/s41432-022-0818-x>.
- [51] R. Nagpal, A. Gupta, C.M. Marya, I. Mushtaq, S. Tandon, Association of sense of coherence with oral health behaviors and gingival bleeding among adolescents, *J. Indian Soc. Periodontol.* 25 (2) (2021) 150–155, [https://doi.org/10.4103/jisp.jisp.165\\_20](https://doi.org/10.4103/jisp.jisp.165_20).
- [52] R. Cao, J. Lai, X. Fu, P. Qiu, J. Chen, W. Liu, Association between psychological stress, anxiety and oral health status among college students during the Omicron wave: a cross-sectional study, *BMC Oral Health* 23 (1) (2023) 470, <https://doi.org/10.1186/s12903-023-03151-3>.