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Impact of campus closure during COVID-19 on lifestyle, educational performance, and anxiety levels of college students in China

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Abstract

Background Higher education students exhibit heightened sensitivity to environmental changes as they navigate the critical transition from adolescence to adulthood. The coronavirus disease 2019 (COVID-19) pandemic has posed unprecedented challenges to universities worldwide, exemplifying a crisis that profoundly affects the learning outcomes and psychological status of college students. Although it is known that campus lockdown has triggered dramatic changes in lifestyles, learning outcomes, and psychological statuses, in-depth knowledge of the causal relationships among these changes remains largely unclear.

Methods Here, we conducted a cross-sectional survey designed to assess the impact of campus closure during COVID-19 on lifestyle, educational performance, and anxiety levels among college students. We surveyed over 3,500 junior college, undergraduate and graduate participants from 94 colleges/universities across 30 provinces, municipalities, and autonomous regions in China.We employed structural equation modeling (SEM) to explore the relationships between changes in lifestyle, educational performance, and levels of anxiety associated with campus open or closure regulations during the COVID-19 pandemic.

Results Our results discovered that sleep duration, physical activity involvement, and social connections were crucial for sustaining students' learning outcomes and mental health. The shift to online learning and campus lockdown exacerbated stressors, contributing to heightened anxiety ($\beta = 0.066$), disrupted sleep patterns, and enhanced physical activity ($\beta = 0.070$) and reduced learning effect ($\beta = -0.059$). Sleep patterns were disrupted by the campus lockdown, an effect mediated by the degradation of relationships among classmates. Nonetheless, the best-fitting SEM uncovered the intricate relationships among lifestyle changes, learning outcomes, and psychological status in response to sudden environmental changes (Fisher's $C = 80.949$, $P = 0.328$). These results highlight the critical role of adaptable, supportive campus policies tailored to meet the diverse needs and interests of students during and beyond crises (Fisher's $C = 59.568$, $P = 0.809$).

Conclusions Our study advocates for a holistic approach that addresses the multifaceted aspects of student life to cultivate a resilient academic community. This approach contributes to a deeper understanding of the effects

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of sudden environmental changes on students' psychological well-being and academic performance in the post-pandemic era.

Keywords Lifestyle, Campus lockdown, College student, COVID-19 pandemic, Psychological status

Introduction

The coronavirus disease 2019 (COVID-19) pandemic has imposed significant disruptions on global education systems, particularly affecting college students transitioning from adolescence to adulthood. This critical period of development is characterized by significant cognitive growth, demanding academic workloads, and heightened sensitivity to environmental changes [1]. Global health crises are believed to detrimentally impact students' academic performance and overall well-being, leading to a spectrum of physical and psychological challenges [2–4]. Psychological distress, manifesting as mood disorders and anxiety, is associated with cognitive and emotional dysfunction, potentially resulting in maladaptive behaviors including excessive screen time, irregular sleep patterns, and decreased physical activity [5, 6]. Despite growing research on the impact of pandemics on this demographic [7, 8], there is a lack of explicit causal relationships between students' behavioral patterns and psychological states during such events.

In response to the COVID-19 pandemic, strategies such as campus quarantines, social distancing protocols, virtual learning environments, and enhanced hygiene practices were implemented, challenging college students to adapt to emergency remote learning and lockdown measures [9–12]. These adaptations have led to considerable health concerns, sociopsychological burdens, and highlighted the necessity to examine the behavioral and psychological adjustments of college students to these rapid environmental transformations [13].

The global imposition of campus lockdown has led to widespread changes in college students' behavioral and psychological patterns [14, 15]. The transition to online learning posed unique challenges, including the infeasibility of experimental and hands-on activities, potentially affecting critical thinking capabilities and academic achievements [16, 17]. Moreover, lockdown has adversely affected students' physical well-being and daily routines, exacerbating issues such as decreased motivation, concentration challenges, erratic sleep cycles, and stress management difficulties [18, 19]. Notably, significant post-traumatic stress symptoms, such as anxiety, confusion, and anger, have been observed among students [7]. For example, a substantial proportion of university participants in the U.S. reported fear, worry, diminished concentration, and sleep disruption [8], with a higher prevalence of depression, anxiety, and stress symptoms compared to the general community [20–22]. These findings highlight the heightened psychosocial vulnerability of college students during the COVID-19 pandemic.

Despite the aforementioned challenges, the pandemic has also presented opportunities for promoting healthier lifestyles among students, including increased physical activity involvement, reduced risk behaviors, improved dietary habits [23–26], and maintaining social connections [27]. These factors can positively influence students' future lifestyles and learning outcomes [27, 28]. Achieving a healthy balance between academics and these activities could potentially mitigate some of the negative effects of online learning during campus lockdown. Recognizing and addressing these expressed needs enables educational institutions to initiate appropriate interventions and devise strategies to alleviate psychological stress in anticipation of future emergencies.

However, there is still a dearth of in-depth studies on the causal relationship between behavioral styles and psychological states during crises. This study aims to address this gap by conducting an online survey of over 3,500 students across 30 provinces, municipalities, and autonomous regions in China, assessing changes in sleep patterns, physical activity involvement, social networks, learning performance, and anxiety levels linked to policy implementation (Fig. 1). Our research offers a comprehensive investigation into the causality between behavioral styles and psychological conditions among college students during campus lockdown, alongside their demands and expectations. The findings aim to enhance our understanding of how college students respond to a sudden environmental change both behaviorally and psychologically, and to outline effective management and therapeutic approaches for their mental and physical health on campus.

Material and methods

Study Design

This study employed a cross-sectional online survey conducted during the second year of the COVID-19 pandemic (the first semester of the 2020–2021 academic year in China, Fig. 1), titled "COVID-19 Pandemic Impact on College Students' Campus Life and Psychological Conditions," designed to investigate the effects of comprehensiveness of campus pandemic measures on: (1) demographics, (2) campus life, (3) opinions on campus lockdown and (4) anxiety level to detect the educational

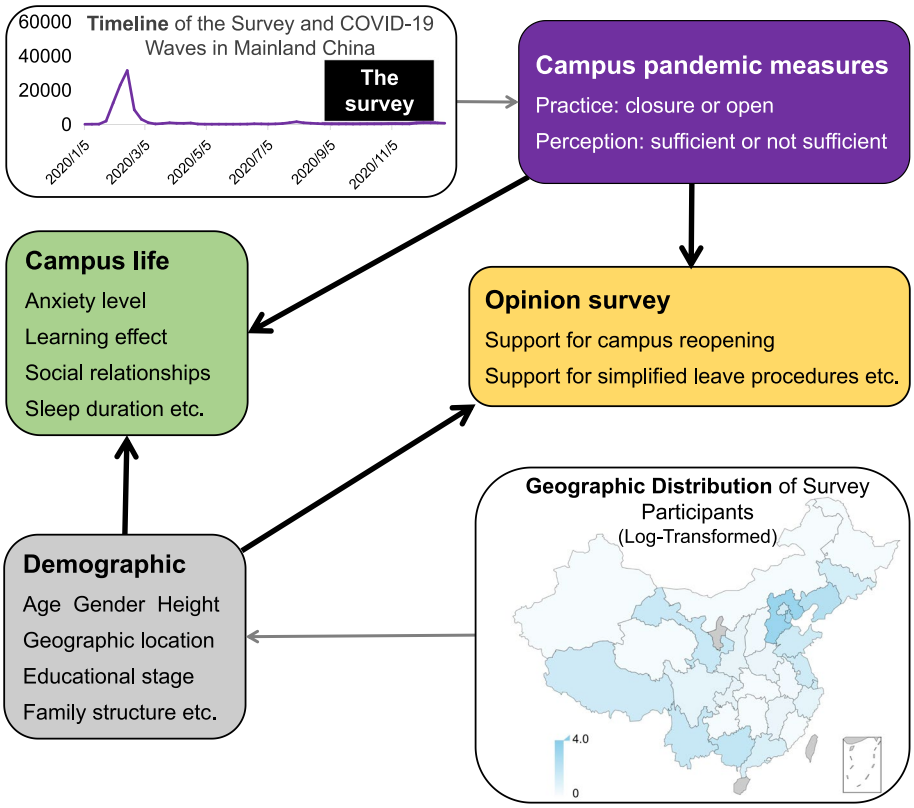

Fig. 1 The flowchart of this study outlines the methodology. The online survey was conducted over a specific duration, approximately 10 months after the first wave of the COVID-19 pandemic, and included participants from 94 public universities and colleges across 30 provinces, municipalities, and autonomous regions in mainland China. The new case data were downloaded from the WHO COVID-19 dashboard: https://data.who.int/dashboards/covid19. We focused on the behavioral and psychological responses of university and college students to campus pandemic measures, considering both objective factors—such as sleep, social contact, learning effect, and anxiety levels—and subjective factors, including their opinions, as well as the internal interactions among these factors, based on their demographic information. The aim was to outline effective management and therapeutic approaches for their mental and physical health on campus, based on their opinions

performance, social relationship, consumption, physical and mental health (such as: sleep, physical activity involvement, learning effect and anxiety of the college students during the pandemic, along with their opinions on the control measures and suggestions (the content of survey was provided in Appendix 1), via WeChat, which is an immensely popular social media platform in China, with the most large user base (over 1.09 billion) that includes a representative sample of the population. Data collection was carried out from September 1 to December 1, 2020 (Fig. 1).

Participants

This study focuses on college/university students. In China, colleges tend to offer associate degrees or vocational training, which usually take 2 to 3 years to complete. They focus on practical skills and applied knowledge. While universities generally offer a broader range of academic programs, including bachelor's, master's, and doctoral degrees. The education at universities is more research-oriented and theory-based.

Participants were randomly recruited from 94 public universities and colleges across 30 provinces, municipalities, and autonomous regions in China (Fig. 1). A total 3,522 randomly sampled participants completed the survey, they are aged 18–25 years, enrolled in full-time study programs as junior colleage, undergraduate and graduate, representing across different disciplines including gender, major, age, family, geographic site, etc. For practical reasons, as our research institution is based in the north of China, the majority of our participants were from universities and colleges in northern China (Fig. 1).

Measurements

The survey comprised 46 questions, covering 4 main sections. (1) Demographics: recording the personal background of the participants related to this study, such as gender, age, education level, major, grade, family type, etc. (2) Campus life: recording educational performance,

social relationship, consumption level, physical health of the participants during the pandemic, such as comprehensiveness of campus pandemic measures, sleep pattern, physical excises, learning effect, relationship with their classmates and roommates, etc. (3) Opinions on campus lockdown: recording the perspective and suggestions towards the campus lockdown measures of the participants during the pandemic. (4) Anxiety levels were assessed using the Zung Self-Rating Anxiety Scale, and range from 20 to 80, following the standard procedure of self-rating anxiety scale (SAS) introduced by Zung [29]. We transformed the categorical responses from the survey into a ranked score range. The binary factors in the survey are coded as 0 for 'no' or 'against,' and 1 for 'yes' or 'for.' The other factors are rated on a scale of 1 to 4, where 1 represents the lowest level and 4 represents the highest.

We checked the homogeneity of variances and the normality of residuals with Levene's test and the Shapiro–Wilk test, respectively. For the data that were not normally distributed or exhibited variance homogeneity, logarithmic or square root transform was applied.

Sample size justification and measurement reliability

The sample size was determined based on detecting effect size (R^2) and a 95% confidence level.The power was calculated with *pwr* package [30]. The reliability of the scales was assessed using Cronbach's alpha (alpha = 0.76, G6 = 0.90) with *psych* package [31].

Statistical methods

Given the large number of correlated items in this survey (46 questions) that needed to be analyzed, a hybrid model-building approach [32] was applied. Our focus was on (1) identifying factors influencing sleep duration, physical activity involvement, relationship with the roommates and classmates, learning effect, and anxiety level since they represent crucial aspects of campus life encompassing study, social relationship, physical and mental well-being; (2) examining opinions on the "campus reopen", "simplifying leave applications", the diversity and price of products offered on campus, as well as activities and cuisines available, since these reflect the most ordinary needs of the students in their campus lives. For each item, we ranked the akaike information criterion (AIC) values obtained from single-predictor regressions against the remaining factors. We selected the model with only significant predictors and the lowest AIC as the most informative base model. We then iteratively built multiple regression models using this approach, adding predictors that improved the AIC scores while meeting the significance criteria. The process continued until no new models could be included in the top model set, either due to having an AIC < 4 compared the previous base model or containing non-significant predictors [33].

We followed a six-step process to develop our models: specification, identification, estimation, testing, modification, and validation. Initially, we specified and identified models with the best explanatory predictors for various aspects of students' campus life, encompassing academic performance, social relationships, physical and mental health, and perspectives on campus pandemic measures and suggestions. Subsequently, we constructed a structural equation model (SEM) with key variables—sleep duration, physical activity, and social relationships—as predictors of learning effect and anxiety levels. Utilizing the piecewiseSEM package [34], we estimated the model through linear regression.

Our strategy for model modification involved systematically exploring significant interconnections by performing piecewise tests of directed separation. We examined each variable in isolation, included significant variables, and removed non-significant ones, ensuring that all important variables were accounted for in the model. The model was rigorously tested by evaluating its goodness of fit (GOF) using Fisher's C statistic (with $P > 0.05$ indicating a good fit) and the Akaike Information Criterion (AIC), favoring models with lower scores [35]. The best-fit model was determined by the lowest Fisher's C value and the highest P-value among all model combinations. We utilized standardized coefficients to assess the direct, indirect, and total effects, considering the varying scales of predictors.

All analyses were conducted in R v4.0.2 [36].

Ethical considerations

Ethical approval was obtained from the Ethics and Animal Welfare Committee of Hebei Normal University (approval number 2020LLSC003). Participants provided informed consent, and data were anonymized to ensure confidentiality. We collected and analyzed data only from completed questionnaires in this study, as incomplete responses might indicate a lack of full consent to participate.

Results

Determinants of learning effect and anxiety level

Employing piecewise structural equation modeling, we assessed the impact of multiple factors including demographics and campus life of the participants (Fig. 2) on learning outcomes and anxiety levels, focusing on those with key contributions (absolute value of significant estimate > 0.1; Tables 1 and 2). The best-fitting SEM (Fisher's C = 80.949, $P = 0.328$) identified several key determinants influencing learning outcomes and mental health among college students during the COVID-19 pandemic.

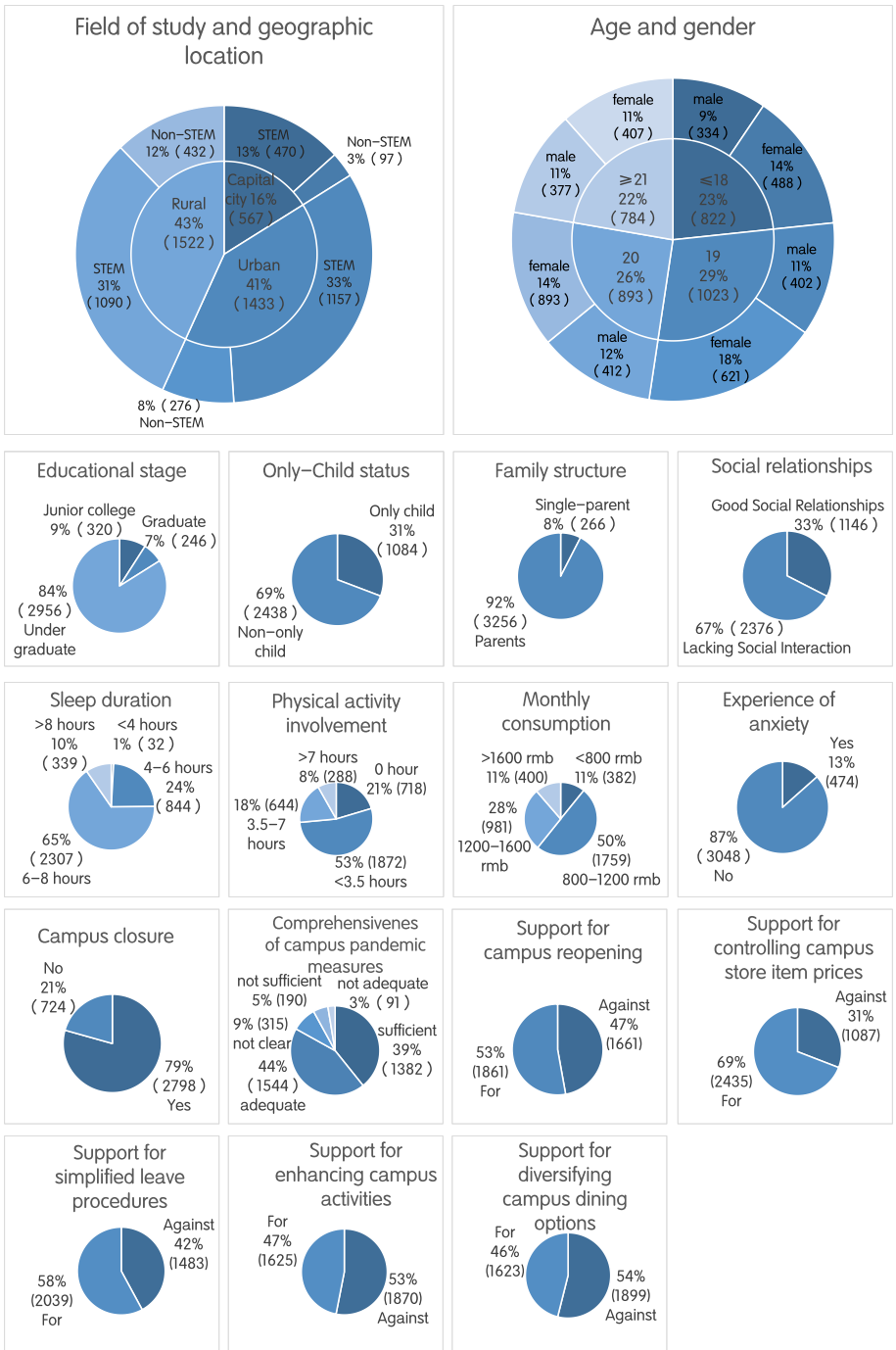

Fig. 2 The demographics, campus life, opinions on campus lockdown, and anxiety levels were examined in the study to detect the impact on social relationships, consumption habits, and the physical and mental health of participants in the online survey. STEM is defined as an acronym for Science, Technology, Engineering, and Mathematics. The proportions of participants in each group were presented, followed by the total number in parentheses

Notably, Sleep duration, physical activity involvement, and the quality of social relationships (with classmates and roommates) emerged as significant predictors of both learning effects and anxiety levels (Table 1; Fig. 3). Specifically, enhanced learning outcomes were associated with improved sleep duration, stronger relationships with classmates and roommates, higher educational attainment levels, regular engagement in physical activity

Table 1 The optimal explanatory models for each item represent the status of students' campus life, encompassing their academic pursuits, social interactions, and physical and mental well-being amidst the COVID-19 pandemic. The primary drivers with standardized estimate > 0.1 were in bold and the measurement "campus closure" and the evaluation of "comprehensiveness of campus pandemic measures" were in purple. These findings are presented in Fig. 2 as a final structural equation model (AIC = 190.949, Fisher's C = 80.949, *P*-value = 0.328). STEM is defined as an acronym for Science, Technology, Engineering, and Mathematics. A 'negative' field of study indicates that the participants were not majoring in STEM subjects

	Predictor	Est. (95% Confidence)	Std.Error	Crit.Value	*P*.Value	Std.Est	R^2	Power
Sleep duration	Dynamics of interpersonal relationships among classmates	0.175 (0.123,0.227)	0.027	6.613	< 0.001	0.159	0.074	0.993
	Gender (male)	0.054 (0.018,0.089)	0.018	2.921	0.004	0.049		
	Dynamics of cohabitation	0.088 (0.039,0.137)	0.025	3.532	< 0.001	0.085		
	Physical activity involvement	0.045 (0.025,0.064)	0.010	4.468	< 0.001	0.076		
	Comprehensiveness of campus pandemic measures	-0.029 (-0.047,-0.011)	0.009	-3.169	0.002	-0.052		
Physical activity involvement	Grade	-0.188 (-0.219,-0.158)	0.016	-12.059	< 0.001	-0.193	0.151	1.000
	Gender (male)	-0.266 (-0.354,-0.179)	0.045	-5.989	< 0.001	-0.144		
	Height	0.013 (0.008,0.018)	0.003	5.173	< 0.001	0.124		
	Field of study (STEM)	0.248 (0.18,0.316)	0.035	7.161	< 0.001	0.114		
	Educational stage (graduate)	-0.185 (-0.252,-0.118)	0.034	-5.409	< 0.001	-0.086		
	Dynamics of interpersonal relationships among classmates	0.095 (0.016,0.175)	0.041	2.342	0.019	0.054		
	Comprehensiveness of campus pandemic measures	0.091 (0.007,0.176)	0.043	2.112	0.035	0.049		
	Campus closure (yes)	0.067 (0.096,0.037)	0.015	4.424	< 0.001	0.070		
Dynamics of cohabitation	Grade	-0.066 (-0.084,-0.047)	0.010	-6.969	< 0.001	-0.118	0.032	0.476
	Comprehensiveness of campus pandemic measures	-0.042 (-0.059,-0.024)	0.009	-4.59	< 0.001	-0.077		
	Social relationships (good)	-0.111 (-0.164,-0.057)	0.027	-4.08	< 0.001	-0.069		
	Campus closure	0.071 (0.114,0.028)	0.022	3.246	0.001	0.055		
	Field of study (STEM)	0.053 (0.011,0.093)	0.021	2.51	0.012	0.042		
Dynamics of interpersonal relationships among classmates	Dynamics of cohabitation	0.689 (0.668,0.71)	0.011	63.851	< 0.001	0.731	0.541	1.000
	Height	0.002 (0.001,0.003)	0.001	3.228	0.001	0.037		
	Geographic location (capital cities)	0.02 (0.005,0.035)	0.008	2.555	0.011	0.029		
	Comprehensiveness of campus pandemic measures	-0.014 (-0.025,-0.002)	0.006	-2.377	0.018	-0.027		
	Campus closure (yes)	0.028 (0.056,0.001)	0.014	2.012	0.044	0.023		
Learning effect	Sleep duration	0.291 (0.255,0.328)	0.019	15.686	< 0.001	0.249	0.184	1.000
	Dynamics of interpersonal relationships among classmates	0.24 (0.182,0.298)	0.029	8.163	< 0.001	0.186		
	Campus closure (yes)	-0.093 (-0.141,-0.044)	0.025	-3.746	< 0.001	-0.059		
	Grade	0.073 (0.052,0.094)	0.011	6.806	< 0.001	0.108		
	Dynamics of cohabitation	0.08 (0.026,0.134)	0.028	2.916	0.004	0.066		
	Physical activity involvement	0.04 (0.019,0.062)	0.011	3.651	< 0.001	0.058		
	Field of study (STEM)	0.089 (0.043,0.136)	0.024	3.795	< 0.001	0.059		
	Comprehensiveness of campus pandemic measures	-0.032 (-0.052,-0.012)	0.010	-3.102	0.002	-0.048		
	Educational stage (graduate)	0.045 (0,0.091)	0.023	1.966	0.049	0.031		

Table 1 (continued)

	Predictor	Est. (95% Confidence)	Std.Error	Crit.Value	*P*.Value	Std.Est	R^2	Power
Self-rating anxiety scale (SAS)	Comprehensiveness of campus pandemic measures	1.36 (1.112,1.608)	0.127	10.749	< 0.001	0.171	0.154	1.000
	Sleep duration	-2.489 (-2.951,-2.028)	0.235	-10.578	< 0.001	-0.176		
	Learning effect	-1.664 (-2.06,-1.268)	0.202	-8.245	< 0.001	-0.138		
	Physical activity involvement	-0.791 (-1.061,-0.521)	0.138	-5.745	< 0.001	-0.095		
	Gender (male)	-1.05 (-1.542,-0.558)	0.251	-4.185	< 0.001	-0.068		
	Family structure (single-parent)	-1.637 (-2.526,-0.747)	0.454	-3.608	< 0.001	-0.057		
	Field of study (STEM)	0.739 (0.165,1.314)	0.293	2.522	0.012	0.041		
	Social relationships (good)	-0.968 (-1.699,-0.238)	0.373	-2.599	0.009	-0.041		
	Campus closure (yes)	1.256 (1.853,0.660)	0.304	4.129	< 0.001	0.066		
	Monthly consumption	0.557 (0.271,0.843)	0.146	3.822	< 0.001	0.061		

involvement activities, as well as enrollment in STEM (science, technology, engineering, mathematics) fields. Conversely, elevated mental stress levels correlated strongly with poor sleep duration, diminished learning outcomes, inadequate physical activity involvement participation rates, strained personal relationships, and being female (Table 1). Interestingly, all these factors showed a negative correlation with comprehensiveness of campus pandemic measures, suggesting that such measures, including strict campus closures, had a slight negative impact on both learning outcomes and anxiety levels (Table 1; Fig. 3).

Relationships among factors affecting learning effect and anxiety level

Among the demographics and campus life of the participants, the best-fitting SEM (Fisher's $C = 59.568$, $P = 0.809$) showed individuals with higher educational levels exhibited weaker relationships with their classmates. Conversely, stronger bonds with classmates and improved sleep duration were associated with better learning outcomes; additionally, higher educational attainment, particularly among males, shorter individuals, and those majoring in STEM fields, was linked to reduced physical activity involvement. Furthermore, a positive relationship between classmate relationships and sleep duration was observed, with both factors contributing to lower anxiety levels alongside better learning outcomes (Table 1; Fig. 3). During the pandemic, 79% (2798/ 3522) of students experienced campus closures. These control measures had a slight negative impact on physical activity involvement, classmate relationships, and anxiety levels, yet, paradoxically, they positively influenced learning outcomes. Notably, the perceived effectiveness of comprehensiveness of campus pandemic measures significantly reduced students' anxiety levels (Table 1; Fig. 3).

Demands and expectations in response to campus control measures during the COVID-19 pandemic

To gain insights into the overall attitudes and expectations of college students towards campus control measures during the pandemic, we analyzed the influence of various factors on these attitudes and expectations. Our results showed that aspects of campus life, such as the diversity and affordability of campus products and cuisine, enhancement of campus activities, simplification of leave applications, and reopening plans for campuses, were associated with learning outcomes and anxiety levels in diverse ways (Table 2). Notably, learning outcomes positively correlated with the diversity of campus activities and cuisine, as well as the simplification of leave applications. Anxiety levels were associated with the simplification of leave applications and the prospect of campus reopening (Table 2). Among these factors, male students displayed a preference for greater diversity and pricing of campus products, negatively predicting attitudes towards campus reopening. In contrast, taller students expressed a desire for a wider range of campus activities, which positively influenced the diversity of available campus cuisine options. Both the variety in campus activities and cuisine were influenced by the diversity and pricing of campus products (Table 2, Fig. 4). Additionally, the simplification of leave applications and existing campus closure measures were positive predictors of

Table 2 The optimal explanatory models for each items representing the opinions and suggestions of students on the control measures during the COVID-19 pandemic. The primary drivers with standardized estimate > 0.1 were in bold and the measurement "campus closure" and the evaluation of "comprehensiveness of campus pandemic measures" were in purple. These findings are presented in Fig. 3 as final structural equation modelling (AIC = 159.568, Fisher's C = 59.568, *P*-value = 0.809). STEM is defined as an acronym for Science, Technology, Engineering, and Mathematics. A 'negative' field of study indicates that the participants were not majoring in STEM subjects

Response	Predictor	Est. (95% Confidence)	Std.Error	Crit.Value	*P*.Value	Std.Est	R^2	Power
Support for controlling campus store item prices	Gender (male)	0.142 (0.110,0.173)	0.016	8.789	< 0.001	0.152	0.054	0.893
	Campus closure (yes)	0.101 (0.063,0.139)	0.019	5.228	< 0.001	0.089		
	Geographic Location (capital cities)	0.042 (0.021,0.064)	0.011	3.818	< 0.001	0.066		
	Educational stage (graduate)	-0.059 (-0.095,-0.023)	0.018	-3.214	0.001	-0.055		
	Physical activity involvement	0.026 (0.008,0.043)	0.009	2.896	0.004	0.051		
	Grade	-0.023 (-0.039,-0.006)	0.009	-2.656	0.008	-0.046		
	Dynamics of cohabitation	0.035 (0.004,0.065)	0.016	2.194	0.028	0.037		
	Only-child status (only-child)	-0.037 (-0.071,-0.003)	0.017	-2.113	0.035	-0.037		
Support for enhancing campus activities	Optimize product and prices	0.276 (0.242,0.311)	0.018	15.737	< 0.001	0.256	0.101	0.999
	Height	0.006 (0.004,0.007)	0.001	5.870	< 0.001	0.097		
	Grade	-0.049 (-0.066,-0.032)	0.009	-5.582	< 0.001	-0.092		
	Educational stage (graduate)	-0.074 (-0.111,-0.036)	0.019	-3.863	< 0.001	-0.063		
	Campus closure (yes)	0.061 (0.101,0.021)	0.020	3.010	0.003	0.050		
	Geographic Location (capital cities)	0.030 (0.008,0.053)	0.012	2.624	0.009	0.044		
	Learning effect	0.034 (0.008,0.061)	0.013	2.59	0.010	0.044		
	Only-child status (only-child)	-0.046 (-0.082,-0.01)	0.018	-2.525	0.012	-0.043		
	Dynamics of cohabitation	0.040 (0.006,0.074)	0.017	2.328	0.020	0.040		
Support for diversifying campus dining options	Optimize product and prices	0.337 (0.303,0.371)	0.017	19.44	< 0.001	0.313	0.163	1.000
	Support for enhancing campus activities	0.161 (0.129,0.193)	0.016	9.936	< 0.001	0.161		
	Grade	0.030 (0.008,0.052)	0.011	2.717	0.007	0.044		
	Geographic Location (capital cities)	0.028 (0.012,0.045)	0.008	3.391	0.001	0.053		
	Family (only child)	0.043 (0.009,0.077)	0.018	2.466	0.014	0.040		
	Educational stage (graduate)	-0.045 (-0.081,-0.009)	0.018	-2.474	0.013	-0.039		
	Learning effect	0.025 (0.001,0.049)	0.012	2.032	0.042	0.032		
Support for simplified leave procedures	Support for controlling campus store item prices	0.212 (0.176,0.248)	0.018	11.68	< 0.001	0.199	0.063	0.963
	Support for enhancing campus activities	0.066 (0.033,0.099)	0.017	3.892	< 0.001	0.066		
	Geographic Location (capital cities)	-0.035 (-0.057,-0.013)	0.011	-3.111	0.002	-0.051		
	Grade	0.025 (0.008,0.043)	0.009	2.910	0.004	0.048		
	Learning effect	-0.036 (-0.062,-0.009)	0.014	-2.614	0.009	-0.046		
	Sleep duration	-0.041 (-0.072,-0.009)	0.016	-2.546	0.011	-0.045		
	SAS	0.003 (0,0.005)	0.001	2.286	0.022	0.039		

Table 2 (continued)

Response	Predictor	Est. (95% Confidence)	Std.Error	Crit.Value	*P*.Value	Std.Est	R^2	Power
Campus re-open	Campus closure (yes)	0.494 (0.529,0.458)	0.018	27.073	< 0.001	0.400	0.260	1.000
	Support for simplified leave procedures	0.223 (0.193,0.252)	0.015	14.696	< 0.001	0.220		
	Support for controlling campus store item prices	-0.129 (-0.164,-0.095)	0.017	-7.419	< 0.001	-0.120		
	Sleep duration	-0.054 (-0.081,-0.027)	0.014	-3.907	< 0.001	-0.059		
	Support for enhancing campus activities	0.056 (0.025,0.086)	0.015	3.609	< 0.001	0.056		
	Educational stage (graduate)	-0.062 (-0.096,-0.029)	0.017	-3.643	< 0.001	-0.054		
	SAS	0.004 (0.002,0.005)	0.001	3.464	0.001	0.053		
	Support for diversifying campus dining options	-0.046 (-0.077,-0.015)	0.016	-2.928	0.003	-0.046		
	Comprehensiveness of campus pandemic measures	0.017 (0.002,0.032)	0.008	2.221	0.026	0.033		

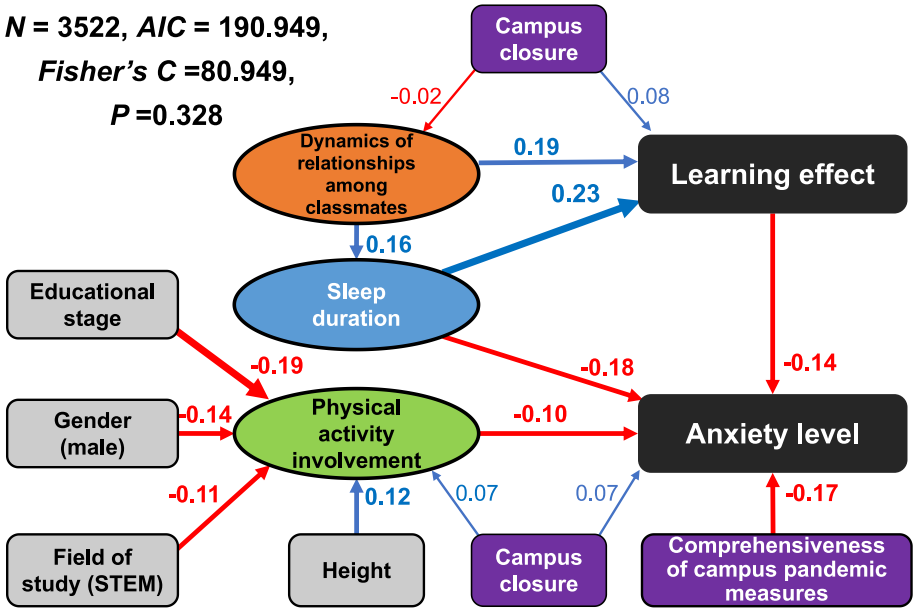

Fig. 3 A structural equation modeling for the relationships among various factors affecting the academic performance and mental well-being of university students during a campus closure caused by the COVID-19 pandemic. The pathways show how these factors are interconnected and influence the learning and anxiety level. Values represent standardized coefficients, with the thickness of each line correlating with the absolute value of the standardized coefficient. Blue arrows denote significant positive correlations, while red arrows denote significant negative correlations. For simplicity, factors directly related to COVID-19 pandemic measures or those with an absolute estimate greater than 0.1 are considered primary drivers and are presented. Further details are provided in Table 1. STEM is defined as an acronym for Science, Technology, Engineering, and Mathematics. A 'negative' field of study indicates that the participants were not majoring in STEM subjects

support for campus reopening, indicating that students who favored simplified leave applications while being subject to closure measures showed a stronger inclination towards resuming normal operations on campus (Table 2, Fig. 4).

Discussion

Importance of sleep duration, physical activity involvement, and social connection

With a large, diverse-scale survey of college and university students in China during the COVID-19 pandemic, we described how students' demographics affected their

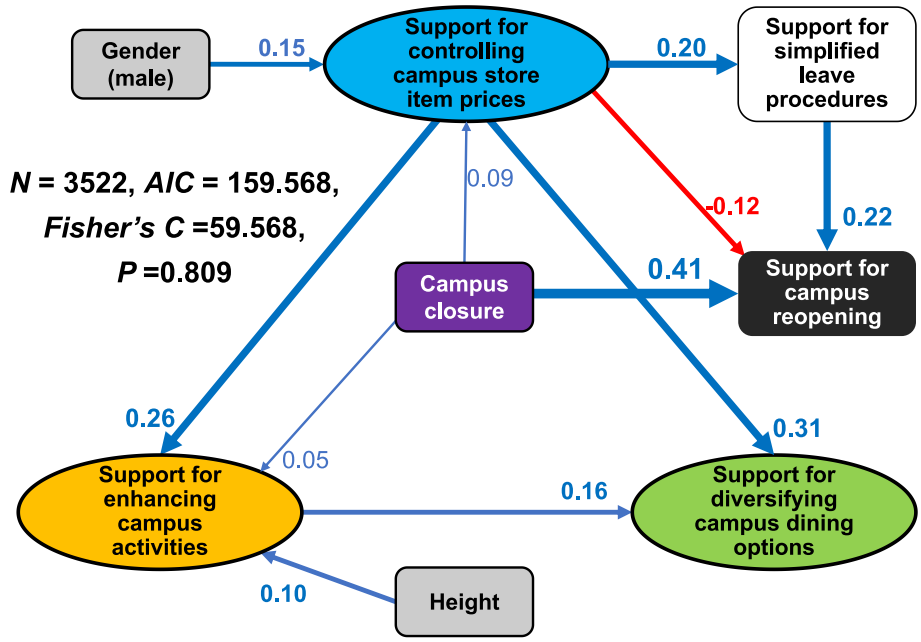

Fig. 4 A structural equation modeling for the relationships among various factors affecting the opinions of university students during a campus closure caused by the COVID-19 pandemic. The pathways demonstrate how these factors are interconnected and impact learning and anxiety levels. Values represent standardized coefficients, with the thickness of each line correlating with the absolute value of the standardized coefficient. Blue arrows denote significant positive correlations, while red arrows denote significant negative correlations. For simplicity, factors directly related to the COVID-19 pandemic measures or those with an absolute estimate greater than 0.1 are considered primary drivers and are presented. Further details can be found in Table 2. STEM is defined as an acronym for Science, Technology, Engineering, and Mathematics. A 'negative' field of study indicates that the participants were not majoring in STEM subjects

campus life behaviorally and psychologically, how campus life changed, and their opinions in response to campus pandemic measures. Our findings highlight three critical factors—high-quality sleep, regular physical activity involvement, and strong social connections—that are essential for maintaining physical and emotional well-being among college students. These factors have also been identified as key contributors to enhancing learning outcomes and mitigating anxiety levels. Consistent with prior research, adequate sleep duration [37–39] and regular physical activity involvement [40–43] have been shown to be cornerstones of physical well-being, which serves as the foundation for maintaining learning effect and coping with stressors such as social isolation and academic challenges. Furthermore, our results underscore the positive influence of strong relationships with classmates on both learning outcomes and sleep duration. This finding aligns with social support models, which emphasize the protective role of robust interpersonal ties in mitigating stress and promoting both physical and mental well-being [44].

The findings highlight the fundamental roles of sleep duration, physical activity involvement, and social connections in not only enhancing learning outcomes but also fostering holistic well-being for students within university settings. Our results further acknowledge individual variations in physical and emotional status based on factors such as grade level, gender, height, and academic major. For instance, female students reported poorer sleep duration and higher anxiety levels, despite dedicating more time to engaging in Physical activity involvement (Table 1). Similarly, students majoring in STEM fields tended to allocate less time for physical activity involvement, have weaker connections with their roommates, report lower learning efficiency, and experience higher anxiety levels (Table 1). These findings suggest that female students and those in STEM majors may face greater challenges in campus life, necessitating tailored programs and interventions. Additionally, variations were observed among students with different educational levels, grade levels, and even physical attributes (e.g., height), as these factors influenced physical activity involvement, social connections, learning efficiency, and anxiety levels. For example, senior students may prioritize social media engagement or romantic relationships over establishing connections with classmates and roommates [45].

Our findings are consistent with previous research indicating that the COVID-19 pandemic has had a profound impact on the health and well-being of students [8,

46, 47]. Contrary to expectations, our study found no significant deterioration in sleep duration among Chinese college students during the pandemic, despite challenges such as disrupted sleep patterns and delayed bedtimes due to increased telecommuting and blurred weekday/weekend distinctions [8, 48, 49]. This finding may be attributed to the accompanying support and guidance provided by teaching and administrative staff during the lockdown period in China. However, the enforced containment and extended cohabitation during lockdown could hinder Physical activity involvement and disrupt social ties, potentially increasing anxiety levels [50].

Notably, students' perceptions of the effectiveness of comprehensiveness of campus pandemic measures played a crucial role in reducing anxiety during the pandemic, underscoring the significance of clear communication, transparency, and involving students in the development and implementation of these measures. Establishing trust and a sense of safety in pandemic response strategies is essential for supporting student mental health during challenging circumstances [49]. In Chinese traditional culture, a sense of safety often takes precedence over other needs in difficult times, suggesting that the initial closure of campuses might have engendered confidence among students amidst pervasive uncertainty caused by the pandemic. These findings emphasize the need for robust management strategies during crises. Although prolonged campus lockdowns themselves may exacerbate anxiety, aligning with research suggesting that lockdown has a modest anxiety-reducing effect [51, 52], the confidence that control measures could protect students from uncertain threats would largely alleviate stress. Above all, the key requirements for addressing student anxiety, especially amid the challenges of extended lockdown, would be creating a supportive environment for (1) improving sleep duration, (2) encouraging physical activity involvement, and (3) cultivating supportive social networks. Such efforts by universities are crucial in bolstering student mental/ physical well-being and resilience during uncertain times.

Potential strategies for formulating reasonable countermeasures

To address the unique challenges posed by the COVID-19 pandemic, our comprehensive surveys have assessed student attitudes toward campus life, The findings reveal a strong desire for the reopening of universities and a simplification of leave application processes under lockdown measures, consistent with previous research [51, 53]. This sentiment underscores the necessity for adaptable regulations that prioritize student well-being while upholding essential safety protocols [54]. Additionally, it advocates incorporating a supportive campus environment and providing alternative engagements that could redirect student focus or foster a sense of community [46, 55], potentially alleviating the stress associated with the lockdown and enriching the collegiate experience during this unprecedented time or future crises [56].

Our analysis revealed a critical demand for a broader and more diverse range of campus amenities, with significant gender differences emerging, particularly after the implementation of campus lockdown policies [57]. This finding suggests that customizing campus services to align with the unique interests of students in areas such as recreational activities, culinary options, and product availability while taking into account specific demographic needs, can significantly enhance the campus experience and foster a deeper sense of community inclusion [51]. The disruption of standard campus operations by lockdown necessitates the provision of a variety of virtual events, health and wellness programs, and accessible remote learning tools, all designed with gender-specific interests and physical needs in mind. Such measures can sustain student engagement and academic motivation [55, 56]. Demonstrating the university's active commitment to addressing the health, educational needs, and well-being of all students, even in restricted conditions, may reduce the urgency for campus reopening [54, 58]. Through targeted interventions and the cultivation of a supportive campus environment, universities could mitigate the negative effects of the pandemic on student life and foster a more inclusive and resilient academic community. The proposed approach not only effectively tackles immediate challenges but also proactively equips the institution to handle future crises, thereby ensuring the utmost priority is given to the well-being of its students.

Potential effects of other factors and limitations

Our findings primarily address the immediate behavioral and psychological effects of the pandemic on college students in China and highlight the need for universities and colleges in this region to implement supportive measures. These measures include promoting physical activity and ensuring adequate sleep to mitigate the psychological impact of campus closures. Emphasizing the importance of a proactive approach to adversity, we highlight the role of self-care practices—including balanced nutrition, regular physical activity involvement, and consistent sleep patterns—as key strategies for mitigating anxiety [57, 59]. Educational institutions are encouraged to adopt supportive strategies to ease students' transition back to campus life and manage stress effectively. These strategies may involve implementing new counseling protocols, developing digital

psychological resources, and enhancing mental health services both in-person and online, while also closely monitoring students' online learning engagement and outcomes [55, 60]. The significance of family support, including emotional and financial assistance, during this transitional phase cannot be overstated [55]. This underscores the need for initiatives that foster constructive activities, social engagement, and skill development, especially for senior students.

Our study, though comprehensive, acknowledges certain limitations. Firstly, its cross-sectional design limits the ability to draw causal inferences, even though the SEM was introduced. Secondly, the majority of our participants were from universities and colleges in northern China. This geographical focus may limit the generalizability of our findings to other educational systems and cultural contexts. Future research should delve into the longitudinal ramifications of such global crises on mental health and assess the effectiveness of different intervention strategies. This assessment should consider countries with various cultural contexts, university systems, and socioeconomic conditions, recognizing that student behaviors and responses to the pandemic may vary widely.

Conclusions

In this study, we evaluated the effects of sudden environmental changes, specifically the campus lockdown during the COVID-19 pandemic in China, on college students' behavioral patterns and psychological well-being. Our findings reveal the causal links between lifestyle adjustments, academic performance, and psychological health in the face of a public health emergency. They emphasize the importance of sufficient sleep, regular exercise, and robust social networks in countering the negative impacts of campus closures on students' learning and mental health.

Furthermore, the study highlights the need to reassess campus policies and services to accommodate the diverse needs of students, advocating for more inclusive and supportive educational settings. As higher education faces ongoing challenges from unpredictable environmental changes in the post-pandemic world, it's clear that building a resilient academic community demands a comprehensive approach to student life.

There's an urgent need for educational stakeholders to formulate policies that address both the immediate and long-term behavioral and psychological effects of the COVID-19 pandemic, as well as any similar future events on students.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12889-024-19744-8.

Supplementary Material 1

Supplementary Material 2

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Authors' contributions

D.L., Y.W., Y.Z., and S.L. conceived the ideas and designed the methodology; Y.W., Y.Z., J.W., S.L., L.W., and D.L. collected the data; Y.W., Y.Z., and D.L. implemented data analyses; Y.W., D.L., and S.L. wrote the first draft; N.J., W.G., L.W., and Y.Z. substantially revised the manuscript. All authors contributed critically to drafts and gave final approval for publication.

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Availability of data and materials

All data are available as supplementary material, and the questionnaire for collecting the data is provided as an appendix.

Declarations

Ethics approval and consent to participate

All procedures performed in this study involving human participants were conducted in accordance with ethical standards. The study was approved by the Ethics and Animal Welfare Committee of Hebei Normal University (2020LLSC003). Participants were informed that completion of the questionnaire signified their informed consent and commitment to maintaining full confidentiality of the data.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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