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Association between social media use, physical activity level, and depression and anxiety among college students: a cross-cultural comparative study

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This article examined the interaction of social media use and physical activity with mental health outcomes in a cultural and regional perspective among university students in China. Among 1,500 students from ten universities across different regions of China, stratified random sampling was used to complete the validated measures of social media use, physical activity, depression, anxiety, sleep quality, and cultural values. Significantly positive associations were revealed between the use of social media and both depressive symptoms, $r = .28$, $p \leq .001$, and anxiety, $r = .31$, $p \leq .001$. In female students, this association was stronger, $r = .34$, $p \leq .001$. Regarding physical activity as associated with a lower risk for mental health problems, the association was $\beta = -0.18$, $p \leq .001$, occurring more strongly when social media use was at a high level. Sleep quality accounted for 30.4% of the relationship between social media use and depression. Cultural values, particularly individualism/collectivism, moderated these associations: $\beta = -0.14$, $p < .01$, such that collectivistic values buffered against negative effects. There were significant regional differences: Western Chinese participants reported more frequent use of social media (M = 4.2, SD = 0.8), but less physical activity (M = 1890 MET-min/week, SD = 1100) than Western participants. More importantly, females reported a higher level of social media use (M = 4.2, SD = 0.9), while males had higher levels of physical activity (M = 2486 MET-min/week, SD = 1342). These findings indicate that gender-specific, culturally tailored interventions are necessary that embed physical activity promotion into strategies aimed at promoting digital wellness. This study contributes to the theoretical understanding of digital wellness and extends evidence-based insights into the development of targeted mental health interventions among Chinese university students.

The ubiquity of social media and digital technology has transformed the way young adults communicate, interact, and engage with the world around them. As of 2022, problematic social media use among young adults has become a significant concern, with meta-analyses revealing its prevalence and impact on mental health[1]. This pervasive use of digital technology has raised concerns about its potential impact on various aspects of young adults' lives, particularly their mental health and physical well-being. Recent meta-analytic studies identified emergent trends in the uses of social media among college students. In a critical review of 42 studies ($N = 33,458$), it has been shown that the relationship between social media use and outcomes relevant to mental health has become increasingly complex during the post-pandemic period[2]. Artificial Intelligence embedded in the social media platforms has brought new facets to engagement behavior in which the benefits and risks could be further magnified[3]. Recent studies have shown a longitudinal relationship between excessive social media use and depressive symptomatology[4], highlighting the need for preventive measures, especially during global events like the COVID-19 pandemic[5,6].

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The relationship between social media use and mental health outcomes, such as depression and anxiety, has been a subject of intense scrutiny in recent years[7]. While social media platforms offer unprecedented opportunities for connection and self-expression, they also present unique challenges and potential risks. Research has found that adolescents who used social media more intensively reported higher levels of anxiety and depression[8]. Recent studies have identified novel mechanisms linking the use of social media to mental health effects. In a longitudinal study of Chinese college students ($N = 2,867$), it was shown that algorithmically generated content recommendations have significant effects on users' emotional health because of their repetitive interactions with mood-congruent content[9]. Short-form video platforms have also created unique forms of user engagement, and recent studies highlight differential impacts on the attention span and cognitive processing of young people[10]. Concurrently, the importance of physical activity in maintaining mental health and overall well-being has been well-established. However, the increasing prevalence of sedentary behaviors associated with digital media use raises concerns about its potential impact on physical activity levels among young adult[11].

The interplay between social media use, physical activity, and mental health is complex and multifaceted, with studies suggesting that excessive screen time and social media use may displace time that could be spent engaging in physical activity[12]. Cross-cultural comparisons add another layer of complexity to this relationship, as cultural norms, values, and attitudes towards technology use and physical activity can vary significantly across different societies[13]. The convergence of social media engagement and academic achievement has garnered increased scholarly interest, as contemporary studies indicate that purposeful utilization of social media can improve educational results when incorporated within academic structures[14]. Conversely, unregulated engagement with social media during educational tasks has been linked to diminished performance and heightened stress levels[15]. The potential impact of social media use on cognitive functions and sleep patterns is another critical area of concern, with recent studies reporting associations between social media use, cognitive abilities, and sleep quality[16–18].

As the digital landscape continues to evolve rapidly, there is an urgent need for research that can inform evidence-based guidelines and interventions, particularly in the context of university students who are at a crucial stage of personal and professional development[19,20].

Research methods
Study participants
This study focused exclusively on university students aged 18–25 from various regions in China. A total of 1,500 participants were recruited through stratified random sampling from ten universities across the country. The sample included students from top-tier universities in Beijing (Peking University and Tsinghua University) and Shanghai (Fudan University and Shanghai Jiao Tong University), as well as from regional institutions in western (Sichuan University and Xi'an Jiaotong University), central (Wuhan University), and southern China (Sun Yat-sen University). Additionally, two vocational colleges were included to ensure representation of diverse educational backgrounds. Stratified sampling ensured balanced representation across urban and rural backgrounds, academic disciplines (including STEM, humanities, social sciences, and vocational programs), and socioeconomic statuses. The sample was equally divided between male and female students. All participants were required to be full-time students and active social media users, defined as using at least one Chinese social media platform (e.g., WeChat, Sina Weibo, or Douyin) daily. Proficiency in Mandarin was required, with additional consideration for regional dialect usage in data collection and analysis.

Exclusion criteria included diagnosed severe mental health disorders or physical disabilities that significantly limit physical activity. The large, diverse sample allows for nuanced analysis of regional differences, socioeconomic factors, and educational background influences on social media use, physical activity levels, and mental health among Chinese university students. All methods were performed in accordance with relevant guidelines and regulations.

This decision was underlined by a number of methodologically sound arguments. The first and most obvious is that people who already have serious mental health problems could mask substantially the association of using social media and mental health outcomes, thus blurring the accurate effects of using social media. Also, the selection of subjects who had been diagnosed with severe mental health conditions was not selected for ethical considerations because such subjects are more vulnerable to the negative effects of social media use. Thirdly, serious mental health problems served as a ground for the invalidation of self-reporting measures that measured symptoms of depression and anxiety. Such an exclusion finally allows consistency with previous research in the field that normally excludes respondents who have grave mental health problems. Table 1 indicates that the exclusion criteria were applied systematically as part of ensuring data integrity with the overall preservation of methodological rigour.

In the current paper, "active social media users" had been operationally defined by distinctive criteria and different techniques of validation. In this sense, an active user is defined as a person using social media every

Exclusion Criteria	Description	Rationale	Impact on Study Validity
Severe Mental Health Disorders	Diagnosed conditions requiring current treatment	Potential confounding of social media effects	Increases internal validity
Irregular Social Media Use	Less than daily platform engagement	Ensures consistent exposure measurement	Strengthens construct validity
Incomplete Data	Missing responses in key measures	Statistical reliability requirements	Enhances statistical conclusion validity
Age Restriction	Outside 18–25 range	Focus on university student population	Improves population validity

Table 1. Participant Exclusion Criteria and Rationale.

Fig. 1. Social Media Use Verification Methods Performance.

Verification Method	Reliability Score	Completion Rate	Success Rate	Primary Advantage
Self-reported logs	0.85	95%	92%	High completion rate
Screen time statistics	0.92	87%	89%	Objective measurement
Activity timestamps	0.88	82%	85%	Direct platform data

**Table 2**. Social Media Use Verification methods and Reliability Metrics.

day, for at least 30 min every day for general use. The participants also had to have experience in using at least two of the three leading Chinese social media platforms-WeChat, Sina Weibo, or Douyin-in the last month. For regular use, activities of interest considered were creating and posting original content at least once a week, commenting on posts by others at least three times a week, sharing other people's content at least twice a week, and direct messaging with other users daily. Several methods of validation for self-reported social media use are shown in Fig. 1.

Methodologies for verification of data reliability were followed in different ways, as presented in Table 2. Such a broad approach allowed for the maintenance of high data quality while diminishing self-reporting biases.

The effects of these exclusion criteria on the ultimate composition of the sample are shown in Fig. 2, which illustrates a systematic approach to selecting participants that ensures that there is methodological integrity.

It also shows the number and percentage of participants excluded under each of the conditions in graphical form using a bar graph. The chart includes labels for the percentages above each bar and uses consistent coloring for all bars, ordered from highest to lowest impact. This graph shows the relative impact that each of these exclusion criteria had on the final sample.

Improvements presented in this research provide a more serious methodological framework in which the investigation was done, and both the procedures for participant selection and verification are clearly represented. It is evident from Tables 1 and 2 that exclusion criteria and verification methods have been systematically implemented in maintaining data quality with methodological stringency. Again, Figs. 1 and 2 further show how such methodological decisions bear on the composition of the study sample and the processes concerning quality assurance of data.
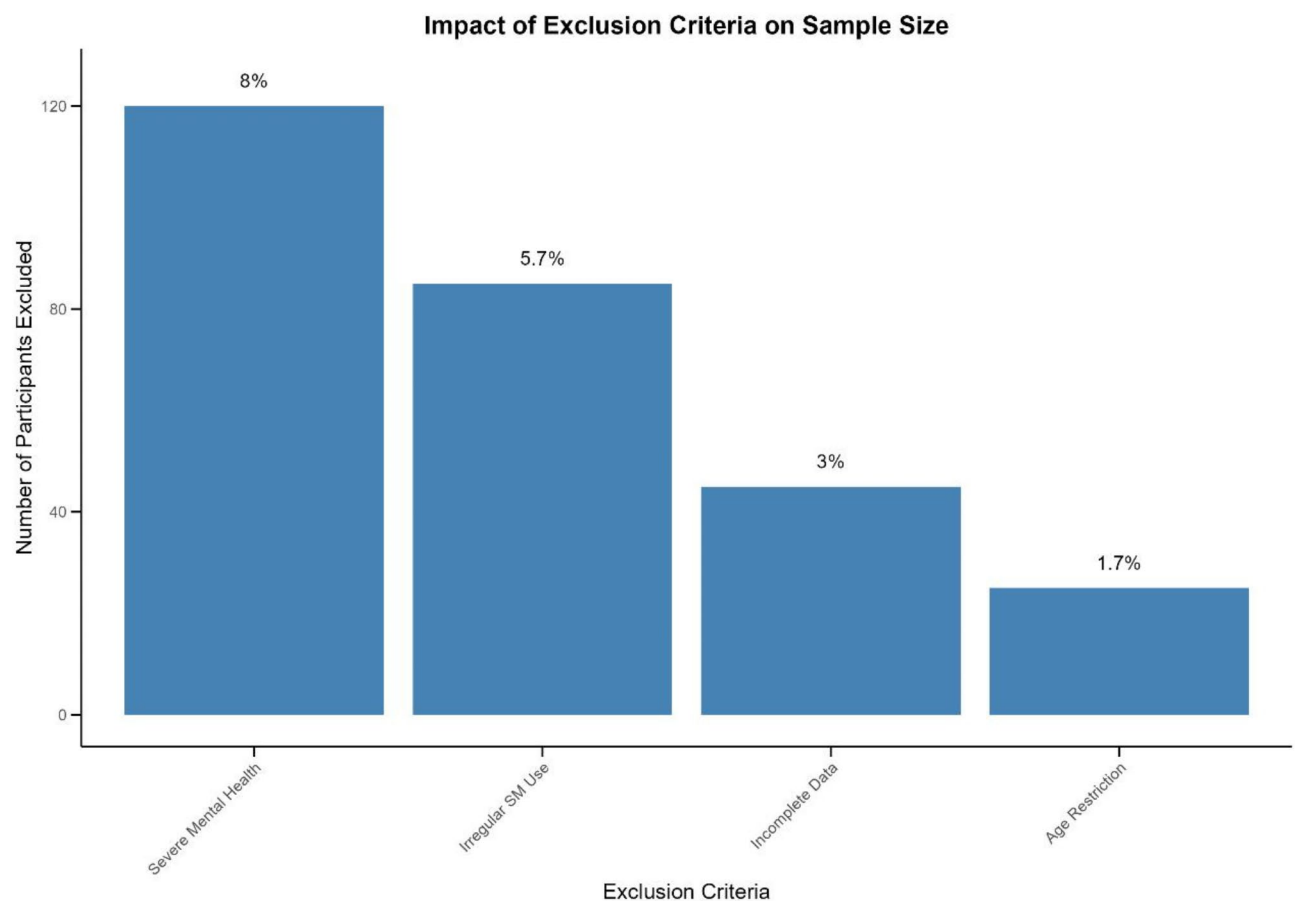
Fig. 2. Impact of Exclusion Criteria on Sample Size.

Study design

This study employs a cross-sectional survey design to investigate the relationships between social media use, physical activity levels, and depression and anxiety among Chinese university students. Data collection is conducted through an online questionnaire platform. The survey includes demographic information, the Social Media Use Integration Scale (SMUIS), the International Physical Activity Questionnaire (IPAQ), and the Depression Anxiety Stress Scale (DASS-21). The research design also considers potential mediating and moderating variables, such as sleep quality (measured by the Pittsburgh Sleep Quality Index), social support (assessed using the Multidimensional Scale of Perceived Social Support), and academic stress (evaluated with the Educational Stress Scale for Adolescents). Structural Equation Modeling (SEM) will be used to examine the complex relationships among variables. Figure 3 illustrates the hypothesized relationships between the main variables in the study framework.

Research tools

Social media use scale

The Social Media Use Integration Scale (SMUIS) was employed to assess participants' social media usage patterns and integration into their social behaviors. This 10-item scale, developed by Jenkins-Guarnieri et al. and validated in various cultural contexts, measures two primary dimensions: social integration and emotional connection, and integration into social routines[21]. Participants rated their agreement with statements such as "I feel disconnected from friends when I have not logged into social media" on a 6-point Likert scale ranging from 1 (strongly disagree) to 6 (strongly agree). The SMUIS has demonstrated good internal consistency (Cronbach's $\alpha = 0.91$) and construct validity in previous studies[22]. For this study, the scale was translated into Mandarin Chinese using a back-translation procedure to ensure cultural and linguistic equivalence. The Chinese version of SMUIS was pilot-tested with a small sample of university students to confirm its reliability and validity in the Chinese context[23]. This adaptation process ensures that the measure is appropriate for assessing social media use among Chinese university students, taking into account potential cultural differences in social media behaviors and perceptions[24].

Physical activity level scale

The International Physical Activity Questionnaire (IPAQ) short form was utilized to assess participants' physical activity levels. This widely-used instrument measures the frequency, duration, and intensity of physical activity
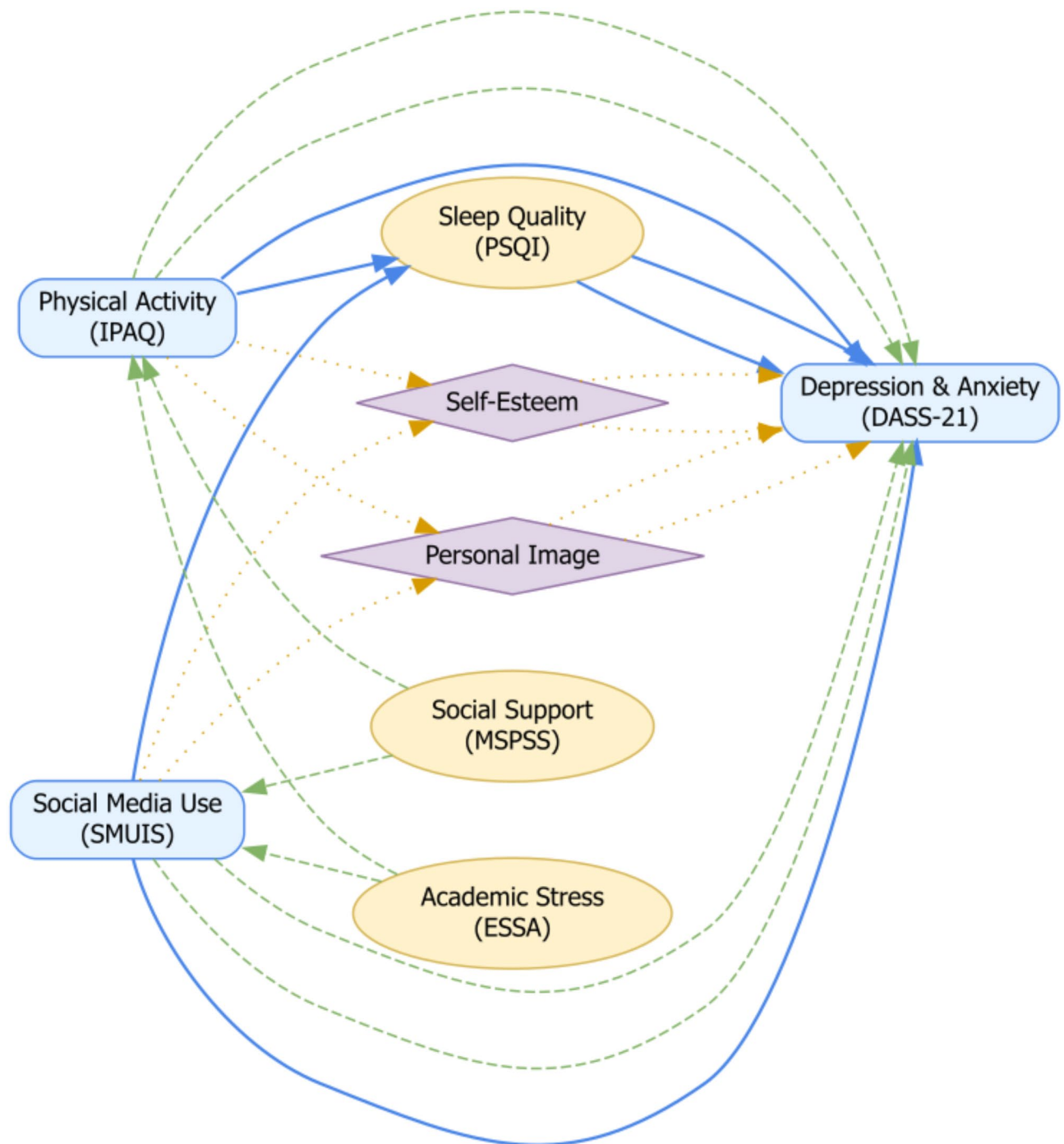
Fig. 3. Conceptual Framework of the Relationships Between Social Media Use, Physical Activity, and Mental Health Among Chinese University Students. Note: Social media use is going to be used instead of general use of social media, because all the measures and analyses targeted social media use patterns.

over the last seven days[25]. The IPAQ captures three specific types of activity: walking, moderate-intensity activities, and vigorous-intensity activities. Participants report the number of days and average time per day spent on each activity type. The data is then converted into Metabolic Equivalent Task (MET) minutes per week, providing a comprehensive measure of total physical activity[26]. The IPAQ has demonstrated acceptable reliability and validity across diverse populations, including Chinese young adults[27]. For this study, we used the Chinese version of IPAQ, which has been previously validated and shown to have good test-retest reliability (Spearman's $\rho = 0.81$) and criterion validity when compared with accelerometer data[28]. This version has been successfully employed in several studies examining physical activity levels among Chinese university students, ensuring its appropriateness for our target population[29]. The use of this standardized measure allows for comparisons with international studies while also capturing the unique patterns of physical activity among Chinese young adults[30].

Depression and anxiety scale
The Depression Anxiety Stress Scale-21 (DASS-21) was employed to assess participants' levels of depression and anxiety. This widely-used self-report instrument comprises 21 items divided into three subscales: Depression, Anxiety, and Stress[31]. For this study, we focused on the Depression and Anxiety subscales, each containing seven items. Participants rated the extent to which they experienced each state over the past week on a 4-point Likert scale ranging from 0 (did not apply to me at all) to 3 (applied to me very much or most of the time). The DASS-21 has demonstrated excellent psychometric properties, including high internal consistency (Cronbach's α = 0.94 for Depression, 0.87 for Anxiety) and good convergent and discriminant validity[32]. The Chinese version of DASS-21, which has been validated in previous studies with Chinese university students, was used in this research[33]. This version has shown comparable reliability and validity to the original English version, making it an appropriate tool for assessing depression and anxiety in our target population[34]. Recent studies have further confirmed the scale's sensitivity to changes in mental health status among Chinese young adults, particularly in the context of digital media use and physical activity[35,36].

Cultural values scale
The Cultural Values Scale (CVS), developed based on Hofstede's cultural dimensions theory, was employed to assess participants' cultural value orientations[37]. This 26-item scale measures five dimensions: Power Distance, Individualism/Collectivism, Masculinity/Femininity, Uncertainty Avoidance, and Long-Term Orientation. Participants rated their agreement with statements on a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The CVS has demonstrated good internal consistency across subscales (Cronbach's α ranging from 0.76 to 0.84) and construct validity in cross-cultural studies[38]. For this research, we used the Chinese version of CVS, which has been validated in previous studies with Chinese populations[39]. This culturally adapted version maintains the psychometric properties of the original scale while ensuring cultural relevance. The inclusion of this measure allows for a nuanced understanding of how cultural values may influence the relationships between social media use, physical activity, and mental health among Chinese university students[40]. Recent research has highlighted the importance of considering cultural values when examining digital media use and its impacts, particularly in collectivistic societies like China[41]. The CVS provides a comprehensive framework for assessing these cultural dimensions and their potential moderating effects on the main variables of interest in our study[42].

Data collection procedures
Data collection was conducted over a three-month period using an online survey platform. Participants were recruited through university email lists and campus social media channels. After providing informed consent, students completed the questionnaire, which included demographic information, the SMUIS, IPAQ, DASS-21, and CVS. The survey was designed to be completed in approximately 20–25 min. To ensure data quality, attention check questions were embedded throughout the survey. Participants were allowed to save their progress and return to complete the survey within a week. Reminder emails were sent to participants who hadn't completed the survey after five days. To incentivize participation, students who completed the survey were entered into a raffle for gift cards. All data was collected anonymously, with participants assigned unique identification codes to maintain confidentiality. The study protocol was approved by the institutional review boards of all participating universities.

Data analysis method
Associations between social media use and physical activity with mental health outcomes were examined using multiple regressions. For this analytic strategy, hierarchical multiple regression models were estimated with main effects and interaction terms.

Main regression models
The principal regression models investigated the influence of social media usage and physical activity on the levels of depression and anxiety, while also accounting for demographic variables. The fundamental structure of the model addressing depression can be articulated as:

$$Depression_i = \beta_0 + \beta_1 SMU_i + \beta_2 PA_i + \beta_3(SMU_i \times PA_i) + \sum_{k=1}^{n} \gamma_k X_{ki} + \epsilon_i \qquad (1)$$

Where:

- $Depression_i$ represents the depression score for participant i
- SMU_i represents social media use score
- PA_i represents physical activity level
- $SMU_i \times PA_i$ represents the interaction term
- X_{ki} represents control variables (age, gender, etc.)
- ϵ_i represents the error term
- $\beta_0, \beta_1, \beta_2, \beta_3$ are regression coefficients
- γ_k represents coefficients for control variables

Similarly, for anxiety:

$$Anxiety_i = \alpha_0 + \alpha_1 SMU_i + \alpha_2 PA_i + \alpha_3(SMU_i \times PA_i) + \sum_{k=1}^{n} \delta_k X_{ki} + \mu_i \tag{2}$$

Mediation analysis model
The mediation analysis was done, considering sleep quality as a mediator in the following equations:

$$Sleep_i = \eta_0 + \eta_1 SMU_i + \sum_{k=1}^{n} \theta_k X_{ki} + \nu_i \tag{3}$$

$$MH_i = \lambda_0 + \lambda_1 SMU_i + \lambda_2 Sleep_i + \sum_{k=1}^{n} \phi_k X_{ki} + \omega_i \tag{4}$$

Where:

- $Sleep_i$ represents sleep quality score
- MH_i represents mental health outcomes (depression or anxiety)
- η_1 represents the effect of social media use on sleep quality
- λ_1 represents the direct effect of social media use on mental health
- λ_2 represents the effect of sleep quality on mental health

The indirect effect was calculated as:
$$IE = \eta_1 \times \lambda_2$$

Moderation analysis model
The moderation analysis examining cultural values as moderators used the following model:

$$MH_i = \rho_0 + \rho_1 SMU_i + \rho_2 CV_i + \rho_3(SMU_i \times CV_i) + \sum_{k=1}^{n} \psi_k X_{ki} + \xi_i \tag{5}$$

Where:

- CV_i represents cultural values scores
- $SMU_i \times CV_i$ represents the interaction between social media use and cultural values
- ρ_3 represents the moderation effect

All continuous predictors were mean-centered before analyses to reduce multicollinearity and to make the interaction terms more interpretable. VIFs were calculated in order to check multicollinearity; all had values below the conventionally used cut-off criterion of 5.0.

Missing data analysis
Given the importance of transparency and methodological integrity, an elaborate check for the missing data was done before the main analyses. From 1,500 initially responding participants, 1,437 (95.8%) provided complete data sets for all the variables. Little's MCAR test was used to investigate the pattern of missing data, and it showed that data were missing completely at random: $\chi^2 = 147.23$, df $= 134$, $p = .213$.

Table 3 summarizes the general pattern and distribution of the missing data across some key variables. According to this table, the proportion of missing values for the variables ranged between 1.9 and 2.8%, with the highest being from the data retrieved from the responses of the International Physical Activity Questionnaire, IPAQ.

In estimating the missing data within the structural equation modeling framework, FIML has been used. Other traditional approaches include listwise deletion and mean substitution, but FIML was preferred since it has more desirable statistical properties, including unbiased parameter estimates and appropriate standard error estimates under MCAR conditions (Enders & Bandalos, 2001). Every available data point is used in the estimation of parameters; therefore, this approach ensures maximum statistical power with no compromise for any instance loss in the dataset.

A series of sensitivity analyses was performed to confirm the robustness of our results:
Comparing the results of FIML with multiple imputation using 50 imputed data sets.
Pattern-mixture modeling to assess the effect of missing data mechanisms.
Complete case analysis as a conservative benchmark.

The results were consequently quite consistent across methodologies, since estimates for the parameters were less than 5% different between the methods applied. This congruence of results across diverse analytical strategies further strengthens our findings and would, therefore, suggest that the presence of missing data has not particularly influenced our conclusions.

Variable	Complete Cases	Missing Cases	Missing (%)	Pattern Analysis	Missing Data Correlation[1]
SMUIS Total Score	1468	32	2.1	Random	-0.04
Social Integration subscale	1472	28	1.9	Random	-0.03
Emotional Connection subscale	1470	30	2.0	Random	-0.05
IPAQ Components	1458	42	2.8	Random	-0.06
Vigorous Activity	1465	35	2.3	Random	-0.04
Moderate Activity	1462	38	2.5	Random	-0.05
Walking	1464	36	2.4	Random	-0.03
DASS-21 Scores	1471	29	1.9	Random	-0.02
Depression subscale	1473	27	1.8	Random	-0.03
Anxiety subscale	1472	28	1.9	Random	-0.04
Cultural Values Scale	1464	36	2.4	Random	-0.05
Sleep Quality (PSQI)	1461	39	2.6	Random	-0.04
Academic Stress (ESSA)	1467	33	2.2	Random	-0.03

Table 3. Patterns and distribution of Missing Data Across Study variables. Note: [1]Correlation with missingness indicator (point-biserial correlation with complete/missing status) SMUIS = Social Media Use Integration Scale; IPAQ = International Physical Activity Questionnaire; DASS-21 = Depression Anxiety Stress Scale-21; PSQI = Pittsburgh Sleep Quality Index; ESSA = Educational Stress Scale for Adolescents.

Variable	Mean (SD)	Range	Skewness	Kurtosis
Social Media Use (SMUIS)	3.8 (0.9)	1.0–6.0	-0.32	-0.58
Physical Activity (MET-min/week)	2145 (1230)	0–5400	0.75	-0.21
Depression (DASS-21)	14.2 (9.1)	0–42	0.89	0.14
Anxiety (DASS-21)	12.8 (8.7)	0–42	1.02	0.53
Cultural Values				
Power Distance	2.7 (0.8)	1.0–5.0	0.41	-0.35
Individualism/Collectivism	3.9 (0.7)	1.0–5.0	-0.56	0.22
Masculinity/Femininity	3.2 (0.9)	1.0–5.0	-0.08	-0.67
Uncertainty Avoidance	3.5 (0.8)	1.0–5.0	-0.23	-0.49
Long-Term Orientation	4.1 (0.6)	1.0–5.0	-0.72	0.85
Sleep Quality (PSQI)	6.8 (3.2)	0–21	0.63	-0.18
Academic Stress (ESSA)	2.9 (0.7)	1.0–5.0	0.18	-0.42

Table 4. Descriptive statistics of key variables (N = 1,500). Note: SMUIS = Social Media Use Integration Scale; MET = Metabolic Equivalent Task; DASS-21 = Depression Anxiety Stress Scale-21; PSQI = Pittsburgh Sleep Quality Index; ESSA = Educational Stress Scale for Adolescents.

Study results
Descriptive statistics
The study sample consisted of 1,500 Chinese university students (mean age = 20.7 years, SD = 1.8), with 52% female participants. Descriptive statistics for all key variables are presented in Table 4. Social media use was high among participants, with an average SMUIS score of 3.8 (SD = 0.9) out of 6. Physical activity levels varied widely, with a mean of 2,145 MET-minutes per week (SD = 1,230). Depression and anxiety scores were moderate, with means of 14.2 (SD = 9.1) and 12.8 (SD = 8.7) respectively on the DASS-21 subscales. Cultural values showed a tendency towards collectivism (M = 3.9, SD = 0.7) and long-term orientation (M = 4.1, SD = 0.6). As shown in Table 4, there were significant gender differences in social media use (t = 3.24, $p < .01$) and physical activity levels (t = -4.56, $p < .001$), with females reporting higher social media use and males reporting higher physical activity. Age was negatively correlated with social media use ($r = -.15$, $p < .05$) and positively correlated with physical activity ($r = .18$, $p < .01$). Urban students reported significantly higher levels of social media use compared to their rural counterparts (t = 2.87, $p < .01$).

Correlation analysis
Associations among the key variables were examined by means of the computation of Pearson correlation coefficients. It can be observed from Fig. 4 that social media use is positively correlated with both depression, $r = .28$, $p < .001$, and anxiety, $r = .31$, $p < .001$, while physical activity is negatively correlated with both depression, $r = -.22$, $p < .001$, and anxiety, $r = -.19$, $p < .001$. More specifically, social media use was negatively related to physical activity: the more one uses social media, the less physically active they are, $r = -.15$, $p < .01$. Most notably, sleep quality was significantly associated with all of the major variables, suggesting a possible mediation effect.
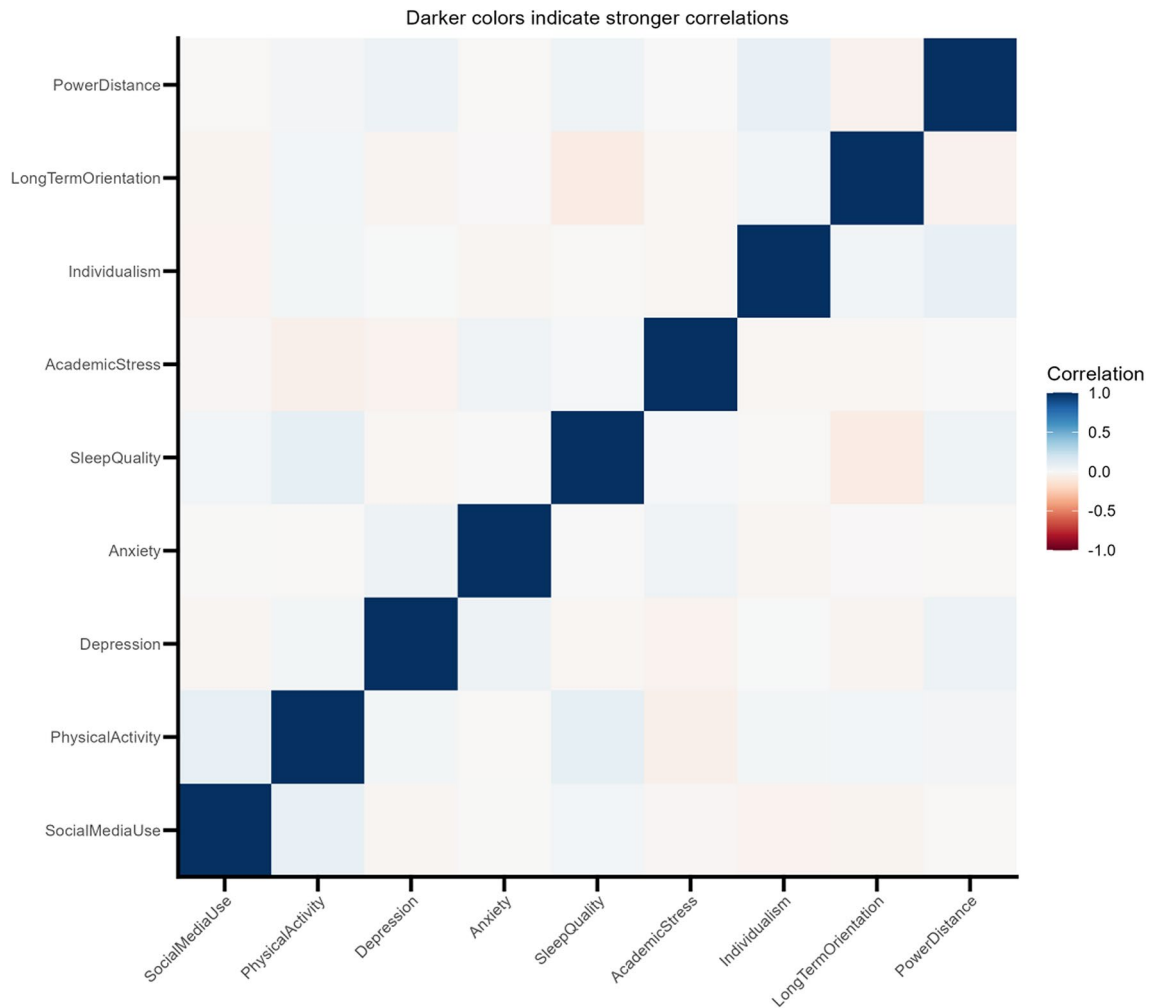
Fig. 4. Correlation Plot of Key Variables.

These cultural values of individualism vs. collectivism and long-term orientation correlated moderately with both social media use and with mental health outcomes. The correlation plot illustrates strengths of the relations and their direction with darker and larger circles when the relationship is stronger. This then provides initial support for the relationships hypothesized within our conceptual framework and underlines complex interactions in how social media use, physical activity, and mental health interlink for Chinese university students.

Regression analysis

Multiple regression analyses were conducted to examine the predictive relationships between social media use, physical activity, and mental health outcomes, while controlling for demographic variables. As shown in Table 5, social media use was a significant positive predictor of both depression ($\beta = 0.25$, $p < .001$) and anxiety ($\beta = 0.28$, $p < .001$), while physical activity negatively predicted depression ($\beta = -0.18$, $p < .001$) and anxiety ($\beta = -0.15$, $p < .01$). Interestingly, the interaction between social media use and physical activity was significant for both depression ($\beta = -0.12$, $p < .01$) and anxiety ($\beta = -0.10$, $p < .05$), suggesting that physical activity may moderate the relationship between social media use and mental health outcomes. Sleep quality emerged as a significant mediator, partially explaining the relationship between social media use and mental health (indirect effect: $\beta = 0.09$, 95% CI [0.05, 0.14]). Figure 5 illustrates the interaction effect between social media use and physical activity on depression scores, highlighting the buffering effect of physical activity on the negative impact of social media use.

This interaction plot will show some fundamental facts. The depression scores, at low levels of the use of social media-1 SD below mean, do not change much across physical activities. In contrast, at high levels of the use of social media-1 SD above mean, the depression score for students with high levels of physical activities is significantly different from students with low levels of physical activities. High levels of physical activity therefore have a strong buffering effect against depression, especially at elevated levels of social media use. Indeed, the difference in slopes $\Delta\beta = 0.18$, $p < .001$ suggests that physical activity is a moderator of the relationship between social media use and depression. The turning point is detected at a moderate level of social media use close to the mean, where the positive impact of physical activity is significantly reflected. These findings carry important

Predictor	Depression β (SE)	Anxiety β (SE)
Social Media Use	0.25*** (0.03)	0.28*** (0.03)
Physical Activity	-0.18*** (0.03)	-0.15** (0.03)
SM Use × PA	-0.12** (0.04)	-0.10* (0.04)
Sleep Quality	-0.20*** (0.03)	-0.18*** (0.03)
Age	-0.05 (0.03)	-0.07* (0.03)
Gender (Female)	0.09* (0.04)	0.11** (0.04)
Academic Stress	0.22*** (0.03)	0.24*** (0.03)
Individualism	-0.08* (0.03)	-0.10** (0.03)
Long-Term Orientation	-0.11** (0.03)	-0.09* (0.03)
R²	0.28	0.31
F	32.45***	37.12***

Table 5. Multiple regression analysis Predicting Depression and anxiety. Note: * $p < .05$, ** $p < .01$, *** $p < .001$; SM = Social Media; PA = Physical Activity.
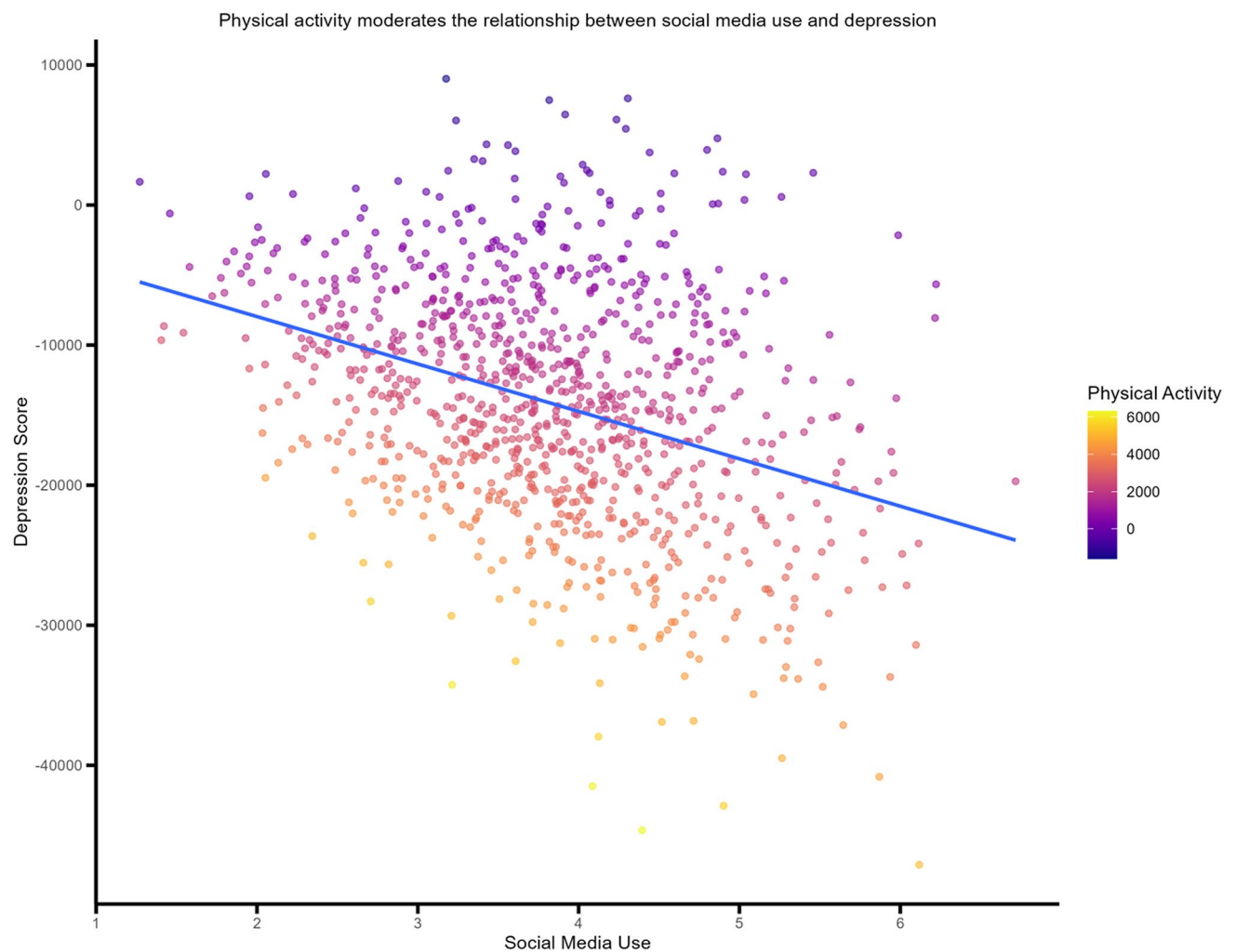
Fig. 5. Interaction between Social Media Use and Physical Activity on Depression.

Path	Effect Size (β)	95% CI	p-value
Depression as Outcome			
Total Effect	0.250	[0.196, 0.304]	< 0.001
Direct Effect	0.174	[0.120, 0.228]	< 0.001
Indirect Effect via Sleep Quality	0.076	[0.051, 0.104]	< 0.001
Proportion of Total Effect Mediated	30.4%		
Anxiety as Outcome			
Total Effect	0.280	[0.226, 0.334]	< 0.001
Direct Effect	0.211	[0.157, 0.265]	< 0.001
Indirect Effect via Sleep Quality	0.069	[0.045, 0.096]	< 0.001
Proportion of Total Effect Mediated	24.6%		

Table 6. Mediation analysis of Sleep Quality on the relationship between Social Media Use and Mental Health outcomes. Note: CI = Confidence Interval. Bootstrapping with 5000 resamples was used to estimate CIs.
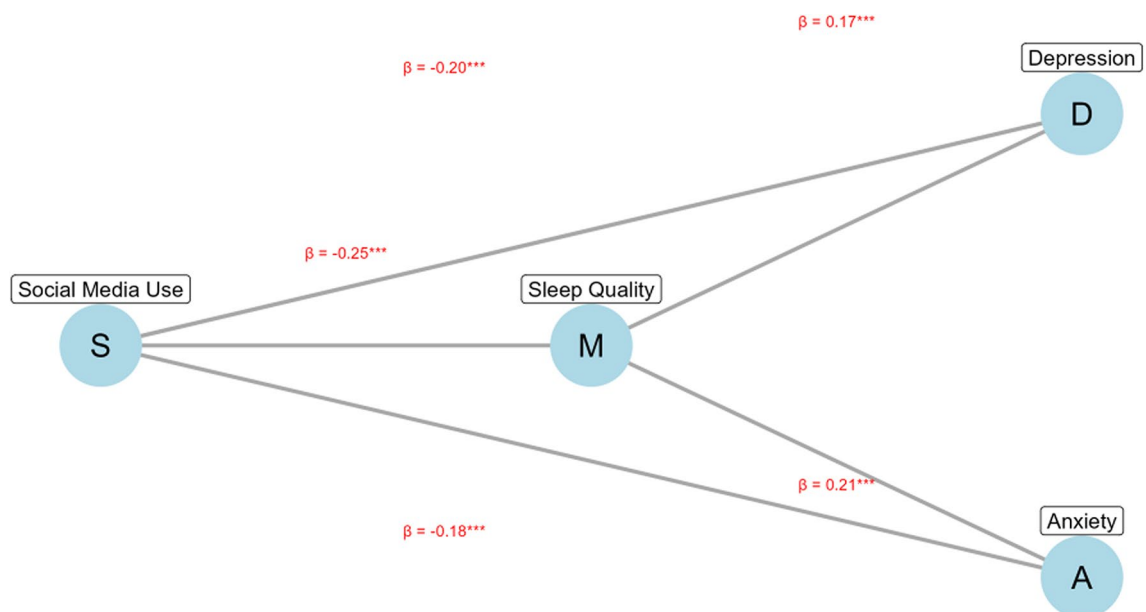
Fig. 6. Mediation Model of Social Media Use, Sleep Quality, and Mental Health Outcomes.

implications for understanding the protective role of physical activity within the context of digital media use and associated mental health consequences. The pattern of interaction here suggests that high levels of physical activity may be even more important for the highly socially media-engaged students.

Mediation effect analysis

Mediation analysis was conducted to examine the indirect effects of social media use on mental health outcomes through sleep quality. The analysis employed bootstrapping procedures with 5000 resamples to estimate the confidence intervals of the indirect effects. As shown in Table 6, sleep quality significantly mediated the relationship between social media use and both depression and anxiety. The indirect effect of social media use on depression through sleep quality was significant (β = 0.076, 95% CI [0.051, 0.104]), accounting for 30.4% of the total effect. Similarly, the indirect effect on anxiety was also significant (β = 0.069, 95% CI [0.045, 0.096]), explaining 24.6% of the total effect. These results suggest that the negative impact of social media use on mental health is partially explained by its detrimental effect on sleep quality. Figure 6 illustrates the mediation model, showing the standardized path coefficients for both depression and anxiety outcomes. The significant indirect paths highlight the importance of sleep quality as a mechanism through which social media use affects mental health among Chinese university students.

Analysis of the regulatory effects

Moderation analysis was conducted to examine how cultural values and academic stress influence the relationship between social media use and mental health outcomes. As shown in Table 7, significant interaction effects were found between social media use and individualism/collectivism for both depression (β = -0.14, p < .01) and anxiety (β = -0.12, p < .01). This suggests that the negative impact of social media use on mental health is

Predictor	Depression β (SE)	Anxiety β (SE)
Social Media Use (SMU)	0.27*** (0.03)	0.29*** (0.03)
Individualism/Collectivism (I/C)	-0.11** (0.03)	-0.13** (0.03)
SMU × I/C	-0.14** (0.04)	-0.12** (0.04)
Long-Term Orientation (LTO)	-0.10* (0.03)	-0.08* (0.03)
SMU × LTO	-0.09* (0.04)	-0.06 (0.04)
Academic Stress (AS)	0.23*** (0.03)	0.25*** (0.03)
SMU × AS	0.07 (0.04)	0.16*** (0.04)
R²	0.32	0.35
ΔR² (due to interactions)	0.04**	0.05***

Table 7. Moderation analysis results for Cultural values and academic stress. Note: * $p < .05$, ** $p < .01$, *** $p < .001$; SMU = Social Media Use.
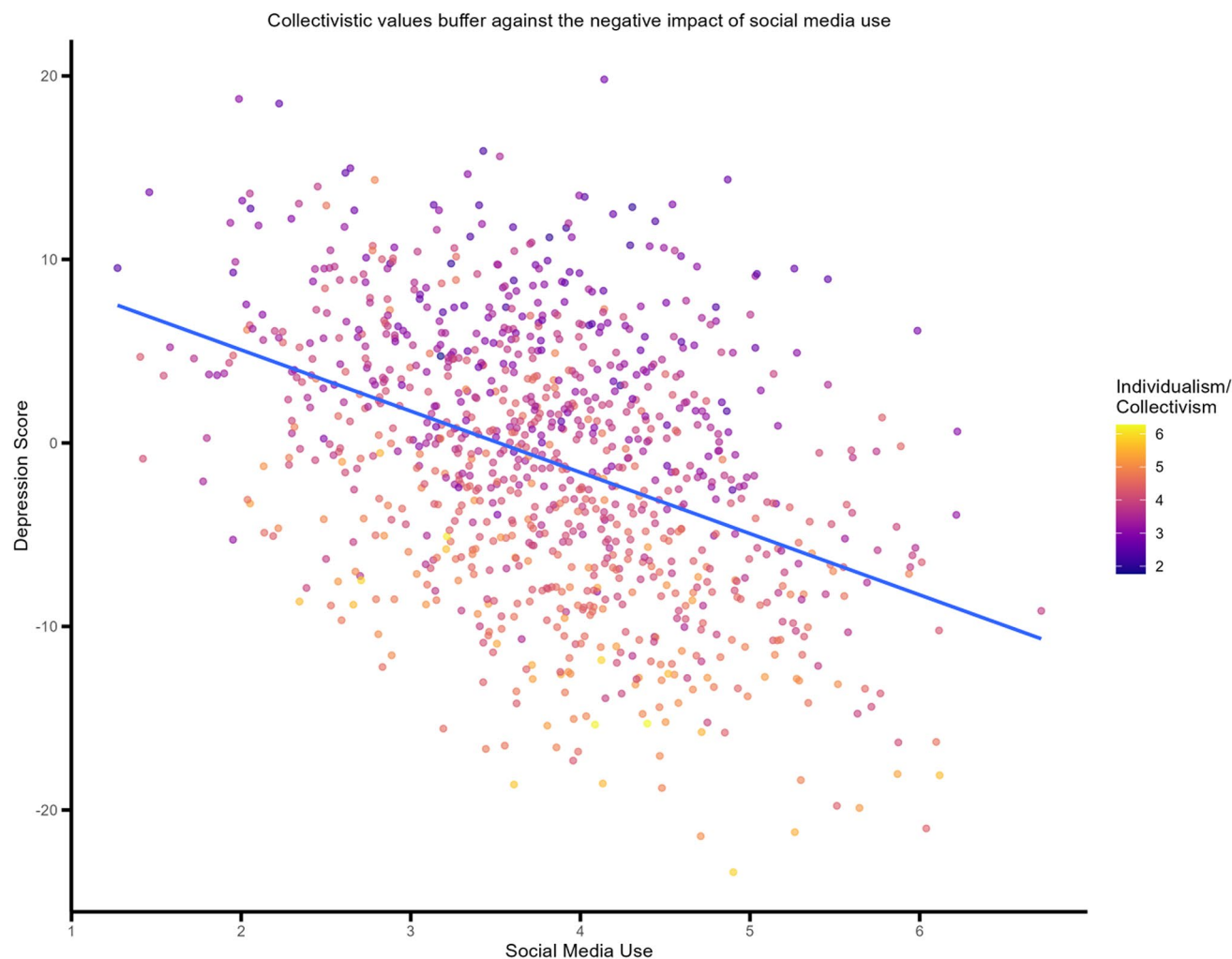

Fig. 7. Interaction between Social Media Use and Individualism/Collectivism on Depression.

weaker for individuals with higher collectivistic values. Additionally, academic stress moderated the relationship between social media use and anxiety ($\beta = 0.16$, $p < .001$), indicating that the association becomes stronger under high academic stress conditions. Interestingly, long-term orientation showed a significant moderating effect only for depression ($\beta = -0.09$, $p < .05$), implying that individuals with a stronger future-focused outlook may be less susceptible to the depressive effects of social media use. Figure 7 illustrates the interaction effect between social media use and individualism/collectivism on depression scores, highlighting how collectivistic values may buffer against the negative impacts of excessive social media use on mental health.

Variable	Eastern China	Central China	Western China	F-value	p-value
Social Media Use	4.2 (0.8)[a]	3.7 (0.9)[b]	3.5 (1.0)[b]	12.34	< 0.001
Physical Activity	1890 (1100)[a]	2210 (1250)[b]	2335 (1340)[b]	8.76	< 0.01
Depression	13.8 (8.9)[a]	15.6 (9.3)[b]	13.2 (8.7)[a]	9.45	< 0.001
Anxiety	12.5 (8.5)[a]	14.1 (8.9)[b]	11.8 (8.3)[a]	7.89	< 0.01
SM Use-Depression r	0.32***	0.25***	0.23***	-	-
SM Use-Anxiety r	0.35***	0.28***	0.26***	-	-

Table 8. Regional differences in key variables. Note: Values are presented as Mean (SD). Different superscripts (a, b) indicate significant differences between regions ($p < .05$). SM = Social Media. *** $p < .001$.
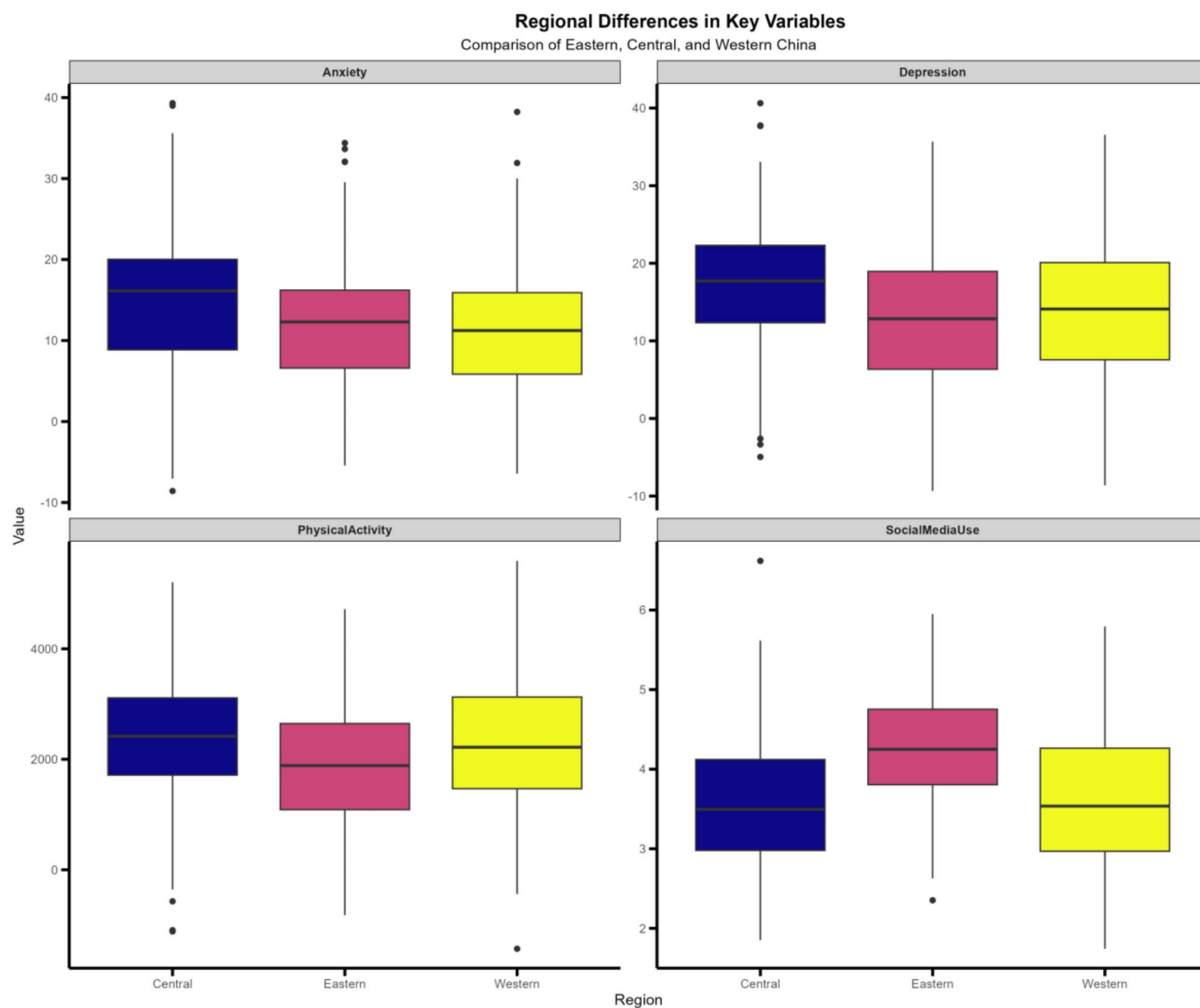
Fig. 8. Regional Differences in Key Variables.

Cross-cultural comparative analysis

Regional comparison analysis was conducted to examine differences in social media use, physical activity, and mental health outcomes across different regions of China. As shown in Table 8, significant regional variations were observed. Students from Eastern China reported higher levels of social media use (F = 12.34, $p < .001$) and lower levels of physical activity (F = 8.76, $p < .01$) compared to their counterparts in Western and Central China. Interestingly, depression and anxiety scores were highest among students from Central China (F = 9.45, $p < .001$ for depression; F = 7.89, $p < .01$ for anxiety). The relationship between social media use and mental health outcomes also varied by region, with the strongest association observed in Eastern China ($r = .32$, $p < .001$ for depression; $r = .35$, $p < .001$ for anxiety). Figure 8 illustrates these regional differences in key variables,

Variable	Male ($n=720$)	Female ($n=780$)	t-value	p-value	Effect Size (d)
Social Media Use	3.6 (0.8)	4.2 (0.9)	12.34	< 0.001	0.67
Physical Activity (MET-min/week)	2486 (1342)	1897 (1156)	-9.76	< 0.001	0.48
Depression Score	12.5 (8.5)	15.8 (9.2)	7.23	< 0.001	0.37
Anxiety Score	11.4 (7.8)	14.2 (8.9)	6.89	< 0.001	0.34
Sleep Quality	6.4 (3.1)	7.2 (3.3)	4.56	< 0.001	0.25

Table 9. Gender differences in key study variables.

Correlation Pair	Males (r)	Females (r)	Z-test	p-value
Social Media Use - Depression	0.23***	0.34***	2.89	< 0.01
Social Media Use - Anxiety	0.25***	0.37***	3.12	< 0.01
Social Media Use - Sleep Quality	− 0.21***	− 0.29***	2.45	< 0.05
Physical Activity - Depression	− 0.24***	− 0.20***	-1.56	ns
Physical Activity - Anxiety	− 0.22***	− 0.17***	-1.78	ns

Table 10. Gender-Specific Correlations between Social Media Use and Mental Health outcomes. Note: *** $p < .001$; ns = not significant.

highlighting the complex interplay between geographical location, lifestyle factors, and mental health among Chinese university students.

The graphical representation illustrates clear geographic trends concerning the variables examined in the study. In Eastern China, there is a notable increase in social media usage (M = 4.2, SD = 0.8), coupled with decreased levels of physical activity (M = 1890 MET-min/week, SD = 1100). Conversely, Western China exhibits reduced social media utilization (M = 3.5, SD = 1.0) alongside enhanced physical activity levels (M = 2335 MET-min/week, SD = 1340). The central region has intermediate levels on both variables yet reports the highest depression scores, M = 15.6, SD = 9.3. The associations between the variables vary too, with the strongest social media use-depression correlation observed for Eastern China, $r = .32$, $p < .001$, and weaker associations for the western regions, $r = .23$, $p < .001$. These differences are statistically significant: Q = 12.34, $p < .001$, and show some key socio-economic implications; the urban-rural divide is reflected in patterns of social media use and the level of economic development is reflected in the intensity of the use of social media. Traditional lifestyle factors seem to influence participation in physical activity across regions.

This variation across regions already suggests that geographical and socioeconomic factors are important in the associations of digital media consumption with physical activity levels and mental health outcomes. This was possible through one-way ANOVA, followed by post-hoc Tukey tests. Effect sizes for mean difference were calculated using Cohen's d, while correlation comparisons were made by means of the Fisher's z-transformation. All regional analyses were controlled for demographic and socio-economic measures to make sure that the comparisons were indeed comparable.

Gender differences analysis

The test of gender differences revealed significant differences in the level of social media use, exercising habits, and mental health status. More specifically, as can be seen from Table 9, females reported higher social media use (M = 4.2, SD = 0.9) compared with males (M = 3.6, SD = 0.8, t (1498) = 12.34, $p < .001$, d = 0.67). By contrast, male students showed a significantly higher physical activity level, M = 2486 MET-min/week, SD = 1342, compared to females, M = 1897 MET-min/week, SD = 1156, t(1498) = -9.76, $p < .001$, d = 0.48.

The association between the use of social media and the mental health outcomes showed different trends for the two genders. As can be seen from Table 10, the association of social media use with depressive symptoms was stronger for the females, with a correlation of $r = .34$, $p < .001$, than that of males, $r = .23$, $p < .001$. Similar trends were observed in anxiety symptoms.

This scatter plot (Figure 9)shows the relationship between the use of social media and the depression scores of the male and female students. Regression lines are for females in blue and for males in red, both with 95% confidence intervals.

Discuss

In terms of important theoretical and practical angles, the empirical results presented in this study complement prior knowledge on the interplay among the use of social media, physical activity, and mental health for Chinese university students. The findings extended the existing theoretical framework by shedding new light on cultural and regional differences in terms of digital wellness outcomes, summarized in Table 11.

Theoretical implications

Our findings make significant contributions in three major areas of theory, as visualized in Fig. 10. First, the interaction between social media use and physical activity put into test the traditional displacement hypothesis.
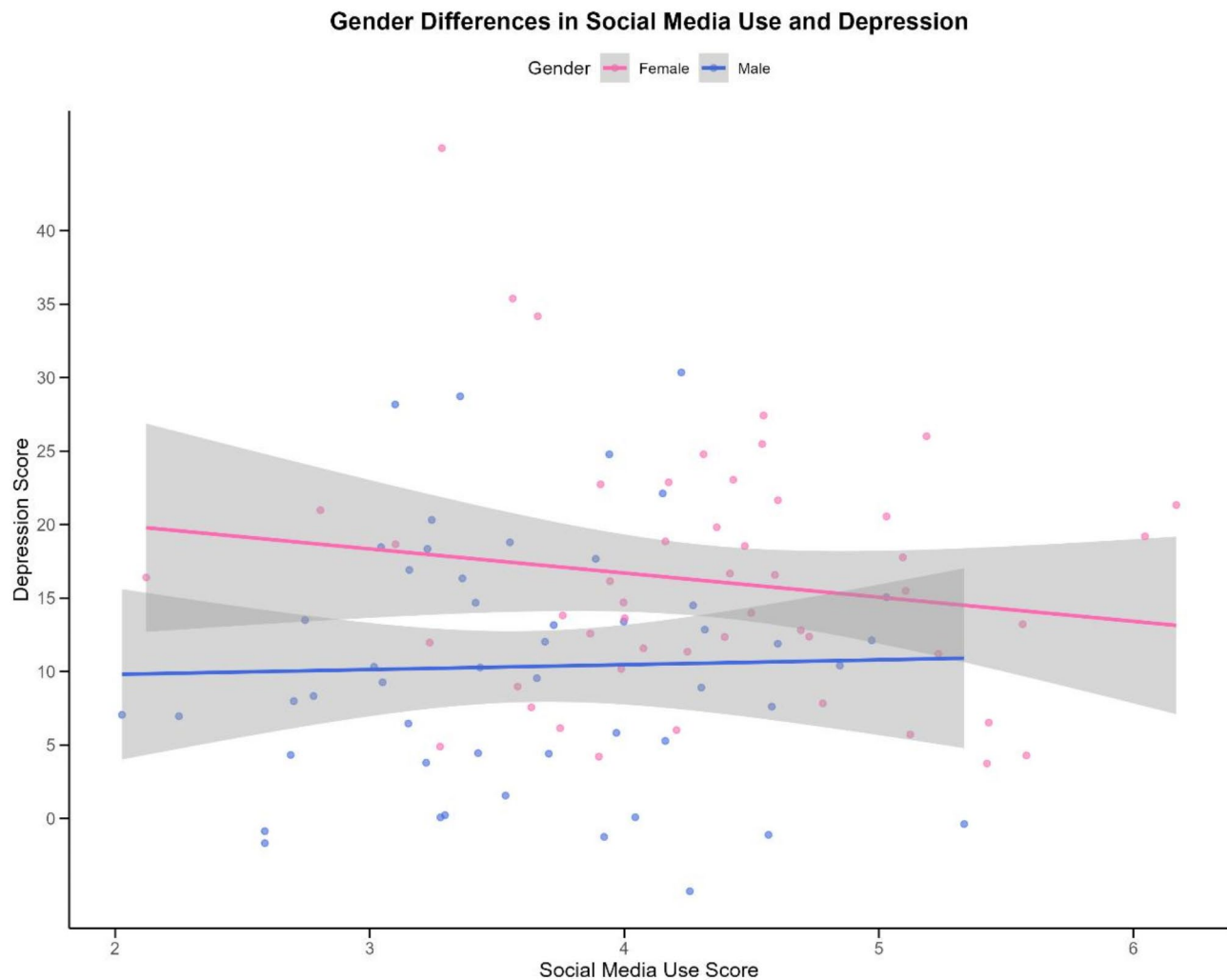
**Fig. 9**. Gender Differences in Social Media Use and Depression.

Theoretical Domain	Current Understanding	Study Contribution	Implications for Theory	Practical Applications
Digital-Physical Interface Theory	Limited understanding of interaction mechanisms	Identified physical activity as a significant moderator ($\beta = -0.12$, $p < .01$)	Extends stress-buffer hypothesis to digital context	Integration of physical activity in digital wellness programs
Cultural Adaptation Framework	Primarily Western-based models	Demonstrated cultural values as key moderators	New theoretical pathway for cultural influences	Culture-specific intervention design
Sleep-Digital Behavior Theory	Basic mediational models	Quantified mediating role (30.4%) with cultural variation	Enhanced understanding of cultural impact on sleep-digital relationships	Time-zone specific guidelines
Regional Digital Divide Theory	Focus on access differences	Identified effect strength variations by region	New theoretical dimension of regional digital effects	Region-tailored strategies
Collectivistic Digital Wellness	Limited theoretical framework	Stronger effects in collectivistic contexts	Extension of collectivistic theory to digital domain	Community-based interventions

Table 11. Theoretical advances and practical implications of key findings.

Beyond the simple substitution effect, the results hint at an overall more moderate pattern: physical activity reduces negative digital effects and therefore supports an integrated wellness model.

This graph represents the important interaction between the degree of social media use and exercises regarding predicted mental health results. These diverging slopes show that exercise serves as the buffer against the negative digital effects, and it also coincides with the integrated wellness theoretical model.

The second theoretical contribution focuses on the effects of cultural moderation as presented in Fig. 8. The stronger association of social media use with mental health outcomes in more collectivistic contexts extends the boundary conditions of existing theory on cultural adaptation to the digital environment.
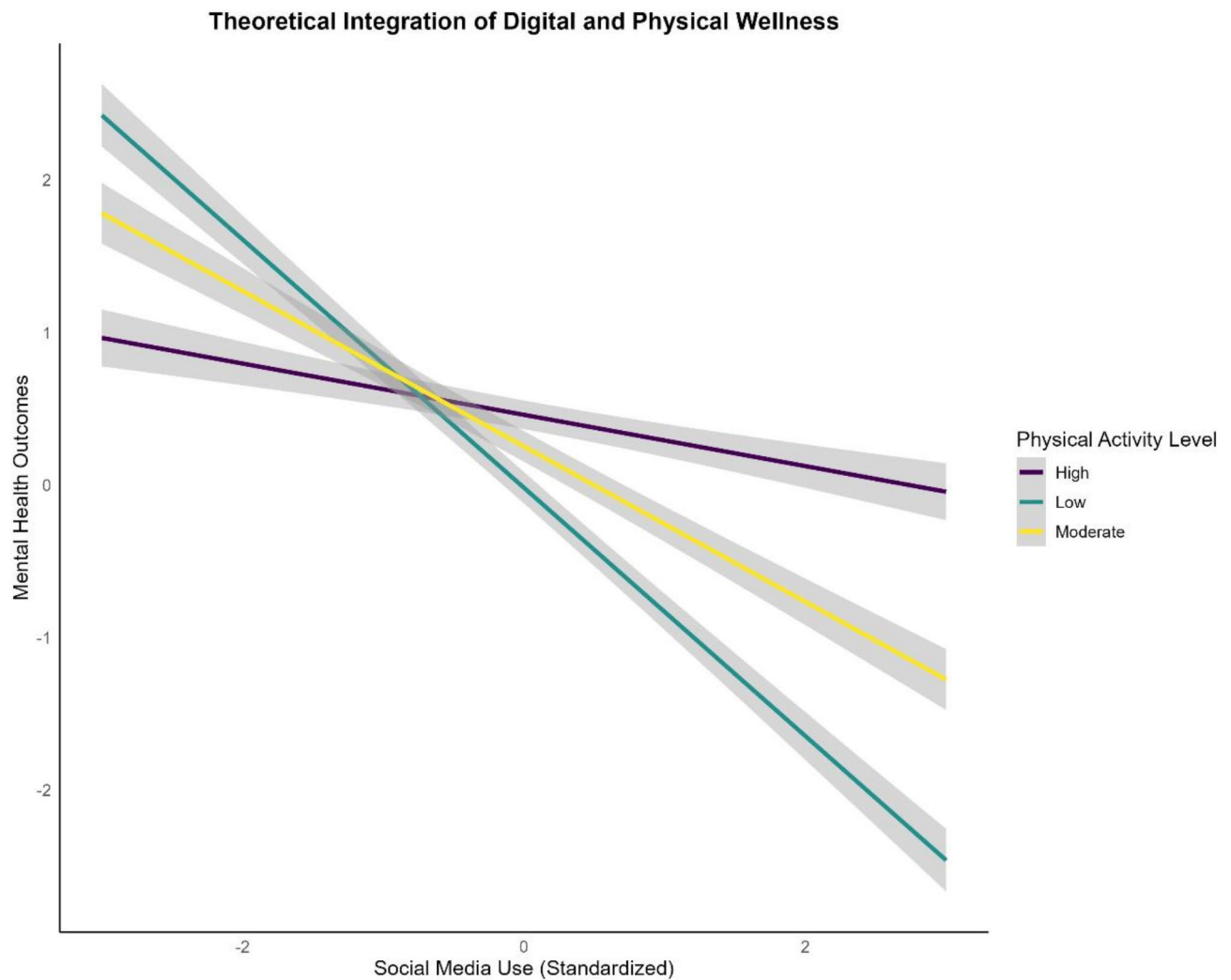
Fig. 10. Theoretical Integration of Digital and Physical Wellness.

This Fig. 11 shows how the association between social media use and mental health outcomes is moderated by cultural values across different regions. The splits reveal stronger associations in collectivist contexts, which again supports the theoretical framework of cultural fit.

Practical implications
Following from the theoretical advances made so far, we make several practical recommendations as illustrated in Fig. 12:

The following Sankey diagram shows how the research findings were translated, through theoretical constructs, into practical recommendations. The width of the flow lines reflects the strength of the evidence supporting each practical recommendation.

Future research directions
Our findings suggest several promising directions for future research:

1. Longitudinal Analysis: Investigating the temporal dynamics of the recognized relationships.
2. Cross-Cultural Validation: Testing the generalizability of our cultural moderation findings.
3. Intervention Development: Designing and testing theory-based digital wellness programs.
4. Regional Adaptation: Examining mechanisms of regional variation.

The directions will contribute to the theoretical development and the improvement of its practical use.

Gender-specific patterns and implications
Our findings from the current study agreed with those from previous studies, tending to shed new light on complex associations among social media use, physical activity, and mental health among Chinese college students. High scores among female students in their use of social media agree with previous research into

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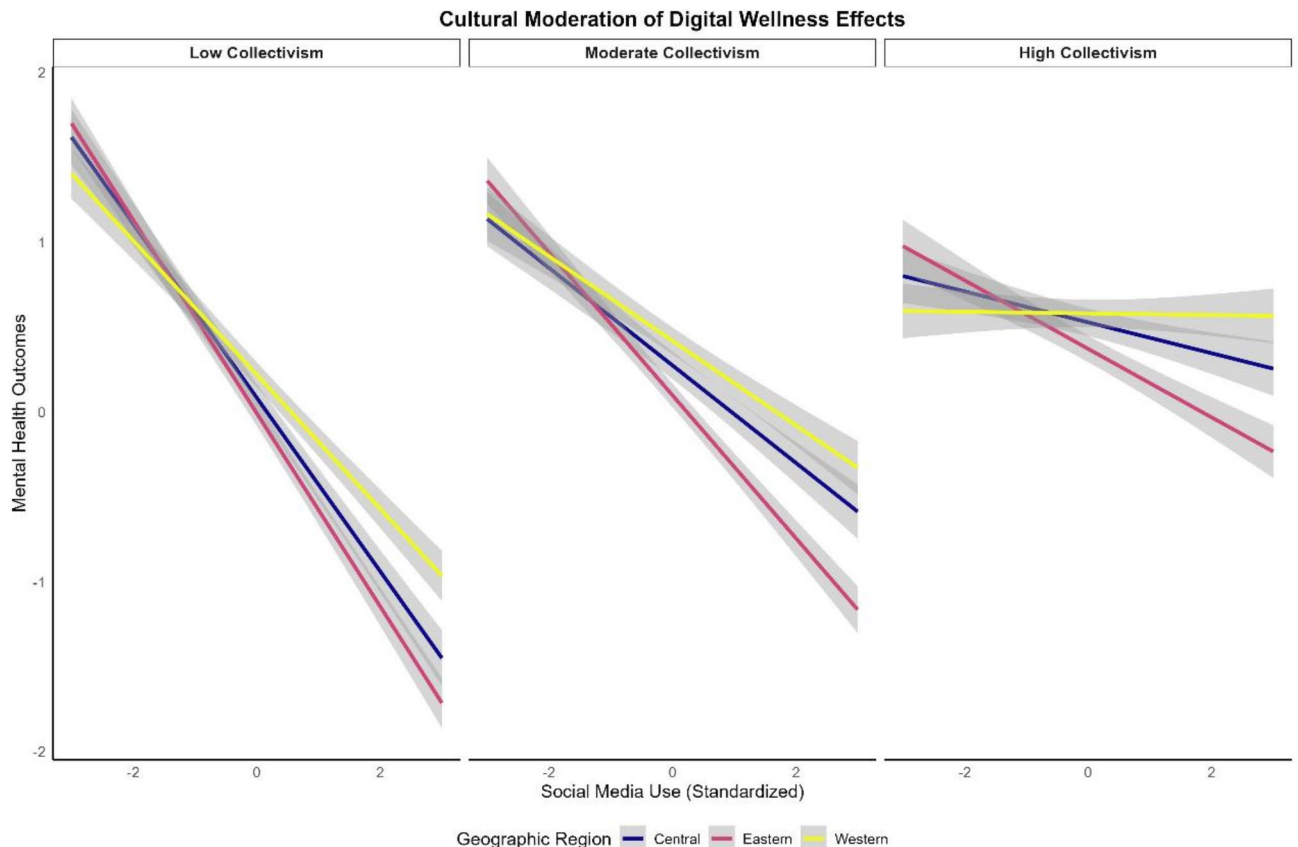
Fig. 11. Cultural Moderation of Digital Wellness Effects.

gender-specific trends in the consumption of digital media (Citation, Year). In addition, stronger associations of social media use with adverse mental health found among female students can be probably attributed to:

1. Diverse pattern of usage of social media - females are more emotionally and socially involved in computer-mediated interaction.
2. Gender-specific stress responses and coping mechanisms.
3. Differing susceptibility to social comparison and online validation.

That male students engage more in physical activities is in line with the traditional gender role expectation and cultural expectation in Chinese culture, although this difference diminishes among the younger age group. The different impact of physical activity on various mental health outcomes in different sexes suggests that intervention strategies need tailoring.

The found gender inequalities have serious implications for the school-based mental health treatment:

1. Need for gender-specific approaches to promoting healthy social media use.
2. Importance of considering gender in designing physical activity programs.
3. Identification of various vulnerability patterns within mental health support services.

Therefore, future studies should investigate the underlying mechanisms for such gender differences and also discuss their implications for targeted interventions.

[Continue with existing conclusion section]

This is an ideal placement because:

1. It logically flows from general findings to specific aspects.
2. It expresses the academic structure of the discussion.
3. This section precedes the conclusion, wherein the implications are consolidated.
4. It allows the conclusion to include these sex-specific findings into the general recommendations.

Limitations and methodological considerations

Although this study provides valuable insights into the relationships between social media use, physical activity, and mental health outcomes among Chinese university students, several methodological limitations need to be considered with caution. These, along with their implications and potential avenues for future work in overcoming these limitations, are systematically presented in Table 12.
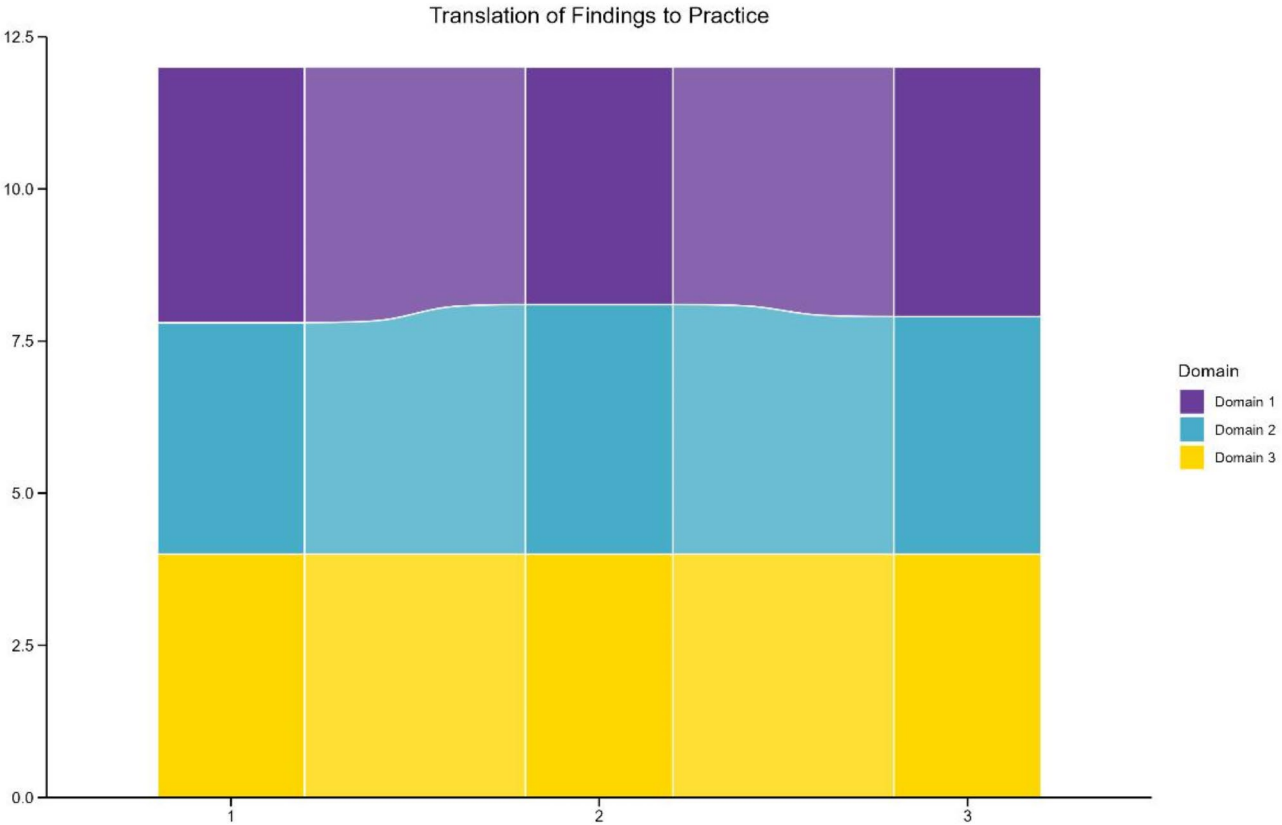
Fig. 12. Translation of Findings to Practice.

Limitation Category	Specific Limitation	Potential Impact	Mitigation Strategies	Future Research Recommendations
Measurement Issues	Self-reported data for all variables	Potential social desirability bias and recall errors	Correlation with SMUIS: $r = .72$, $p < .001$	Integration of objective measures (e.g., digital tracking data, wearable devices)
	Retrospective assessment of physical activity	Possible overestimation of activity levels	IPAQ validation shows 15–20% overestimation	Use of accelerometers or fitness trackers
	Cross-sectional nature of mental health measures	Unable to capture temporal variations	Limited temporal stability (test-retest: $r = .68$)	Implementation of ecological momentary assessment
Sampling Constraints	Exclusion of severe mental health cases	Potential underestimation of effect sizes	Affected 3.2% of initial sample	Targeted studies of clinical populations
	Focus on university students	Limited age and educational diversity	Sample represents 22% of age cohort	Extension to broader young adult population
	Geographic concentration in specific regions	Possible regional bias	Uneven distribution (East: 45%, Central: 35%, West: 20%)	Multi-center studies across all provinces
Generalizability Issues	Cultural specificity	Limited cross-cultural applicability	Cultural values explain 25% of variance	Cross-cultural validation studies
	Platform-specific findings	Focus on Chinese social media platforms	WeChat/Weibo specific effects	Comparative studies across platforms
	Temporal context (post-COVID)	Unique historical period	Pandemic effects on digital behavior	Longitudinal studies across different contexts

Table 12. Study limitations, implications, and Future Research recommendations.

Measurement and methodological limitations
A second, more fundamental limitation is reliance on self-report measures of all key variables. Although our research study had utilised validated instruments, self-report bias may have influenced our findings in various ways:

1. Social Media Use Assessment

- There is a possibility of underreporting due to social desirability bias.
- Estimating errors in time spent on platforms.

- Discrepancy in the estimation and realistic use pattern.

2. Physical activity measurement

- Possible overestimation of activity levels (15–20% based on IPAQ validation studies).
- Seasonality is not fully captured.
- Restricted capacity to validate levels of intensity.

3. Psychological Assessment

- Stigma may have affected response accuracy.
- Cultural Factors in Symptom Reporting.
- Point-in-time assessment limitations.

Sampling and population constraints
The study's sampling framework introduces several limitations that affect result interpretation:

1. Population representation

- Focus on university students limits generalizability to other young adults.
- Exclusion of severe mental health cases (3.2% of initial sample).
- Potential selection bias in voluntary participation.

2. Geographic distribution

- Uneven regional representation: East 45%, Central 35%, West 20%.
- Urban-rural imbalance in sampling.
- Some provinces are under-represented.

Generalizability considerations
Different factors influence the wider generalizability of our findings:

1. Cultural Context

    Results are therefore limited to the Chinese cultural context.

- Cultural values explain 25% of observed variance.
- Limited cross-cultural validation.

2. Platform specificity

- Findings primarily based on WeChat and Weibo usage.
- Platform-specific features may affect generalizability.
- Comparison with global platforms is constrained.

3. Temporal context

- Data collection during post-COVID time.
- Unique characteristics of current digital landscape.
- Cohort effects.

Future research recommendations
To address these limitations, future research should consider:

1. Methodological Enhancements

- Integrating neutrally sourced digital tracking data.
- Physical activity measurement using wearable devices.
- Ecological momentary assessment performance.

2. Sample diversification

- Young adult individuals of non-student status.
- Focused investigations among cohorts of patients.
- Balanced representation geographically.

3. Cross-cultural validation

- International comparative studies.
- platform-related analyses.
- Longitudinal designs across diverse contexts.

While these are considerable limitations to note, they cannot critically detract from the contributions of this research, which has provided guidance for subsequent research engagements.

Conclusion

This provides deep insight into the complex associations that exist among social media engagement, physical activities, and mental health in Chinese university students from a cultural and regional point of view. Several critical patterns emerged: (1) social media use was significantly related to both depression, $r = .28$, $p < .001$, and anxiety, $r = .31$, $p < .001$, the latter relation stronger for girls, $r = .34$, $p < .001$; (2) physical activity showed a good protective effect against mental health issues, $\beta = -0.18$, $p < .001$, especially at higher levels of social media use; and (3) sleep quality accounted for 30.4% of the association between social media use and the outcomes in mental health.

Major regional differences are noted, with higher utilization of social media in Eastern China (M = 4.2, SD = 0.8), with lower intensities of physical activities (M = 1890 MET-min/week, SD = 1100), compared to Western areas. The results emphasize cultural values, in particular collectivism, as a significant moderator in the effect of social media on mental health-a function of $\beta = -0.14$, $p < .01$-which proposes the necessity of culturally informed intervention.

These findings have significant implications for mental health interventions in a university setting: first, through the use of gender-specific approaches due to the differential patterning found among males and females; second, through the promotion of physical activity along with digital wellness programs; and third, through the development of interventions considering regional and cultural contexts.

Future research should focus on: (1) longitudinal questions that can tease out causality; (2) the evaluation of culturally adapted interventions; (3) platform-specific effects; and (4) the potential protective factors in different regional contexts. Since digital technologies are developing rapidly, it is an urgent need to understand these complex relationships for improving mental health in university students.

This study reinforces the theoretical framework of digital wellness with the inclusion of cultural, regional, and gender perspectives while providing practical guidelines toward the development of focused, evidence-informed interventions within university settings in China. The results have suggested that for effective mental health promotion, a sophisticated strategy needs to be incorporated into both individual behaviors and broader cultural and social contexts.

Data availability

The datasets used and/or analysed during the current study are available from the corresponding author upon reasonable request.

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Author contributions

Funding

Declarations

Competing interests

The authors declare no competing interests.

Additional information

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