

A Cross-Sectional Association Between Screen-Based Sedentary Behavior and Anxiety in Academic College Students: Mediating Role of Negative Emotions and Moderating Role of Emotion Regulation

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Purpose: The study aims to explore the relationship and potential mechanisms between screen time and anxiety and have a clear understanding of the role of negative emotions and emotion regulation, thus providing guidance for Chinese college students to improve mental health.

Methods: We conducted a questionnaire survey by selecting 1721 academic college students from 6 colleges and universities in 5 provinces in China, and the data were analyzed through the Process program of SPSS for mediating effect and moderating effect.

Results: There is a significant positive relationship between screen time and anxiety, negative emotions play a mediating role between the two (indirect effect = 0.32, $p < 0.001$), mediating effect accounts for 59.88% of the total effect, and emotion regulation regulates the direct relationship between screen time and anxiety (interaction effect = 0.027, $p < 0.001$).

Conclusion: This study sheds light on the potential mechanisms by which screen time affects anxiety in academic college students, providing a fresh perspective on anxiety reduction. Screen time positively affects anxiety levels, where negative emotions have a mediating role and emotion regulation has a moderating role. In the future, we can control screen ++time, increase physical activities, reduce negative emotions, and improve the emotional regulation ability to relieve anxiety, so as to improve the mental health of academic college students, and expect to have a positive impact on future learning, life, and planning.

Keywords: college students, sedentary behavior, anxiety, negative emotions, emotion regulation

Introduction

According to the United Nations Children's Fund (UNICEF) and the World Health Organization (WHO), about 20% of 1.2 billion adolescents and young people worldwide between the ages of 10 and 19 suffer from mental health problems, and about 16% of illnesses and injuries suffered by them are triggered by mental health problems. Meanwhile, a report by WHO points out that anxiety has become a highly prevalent and top-ranked mental health problem among college students worldwide.¹ In addition, tons of studies have indicated that early adulthood is a critical period in which psychological internalizing symptoms such as anxiety and depression occur and the risk continues to increase.²⁻⁴ College students are at the early stage of adulthood and will experience an important transition from school to society, mental health problems will thus directly affect their learning, life, and planning. It is imperative to pay attention to the mental health of college students has become a pressing issue that should not be ignored.⁵ The Report on National Mental Health Development in China (2021–2022), jointly published by the Institute of Psychology of the Chinese Academy of Sciences and the Social Sciences Academic Press (China), clearly states that the detectable rate of anxiety among the

Chinese keeps rising, among which the group aged 18–24 years old is at high risk for anxiety. Chronic and excessive anxiety may lead to learning difficulties, decreased self-esteem, increased suicide rates, and other risks.^{6–8} Therefore, exploring the risk factors triggering college students' anxiety and effectively alleviating their anxiety levels have been an urgent research topic.

Currently, numerous studies have pointed out that the fact that lifestyles with low physical activity and high sedentary behaviors are highly correlated with mental health problems such as anxiety.⁹ Over ten countries including China, Canada, and Australia have put forward guidelines on physical activities and sedentary behaviors, and have also made a clear recommendation for a lifestyle of more movement and less sitting.^{10,11} Screen-based sedentary behaviors (hereinafter referred to as screen time) is a representative activity of sedentary behaviors. With the advent of the internet era, electronic products such as mobile phones and computers have become essential to college students learning and social interaction, which leads to a surge in screen time, such as online chatting, watching TV series, playing games online and online shopping anytime and anywhere.¹² Does the increase in screen time bring more pleasure or anxiety to college students? Although studies have tentatively explored the relationship between screen time and anxiety,^{13,14} there are insufficient studies on the potential impact screen time on anxiety. Besides, the latest study has found that emotional dysregulation and negative emotions are important factors affecting mental health.^{15,16} The study also indicates a converging relation among negative emotions and anxiety.^{17–19} Then, does emotion plays a role in the relationship between screen time and anxiety? Therefore, this study aims to explore the potential mechanisms of screen time on college students' anxiety levels, with a view to providing a theoretical basis for alleviating or mitigating college students' mental health problems.

The Relationship Between Screen Time and Anxiety

Sedentary behavior is defined as “any waking behavior characterized by energy expenditure ≤ 1.5 metabolic equivalents (METs) while in a sitting or lying position”.²⁰ Screen time refers to the total amount of time students spend on computers, mobile phones, and other electronic devices. The WHO states that increased sedentary behavior at school and during leisure time is a major current health risk factor.^{21,22} College students' screen time is usually reflected in electronic activities such as using mobile phones, watching TV series, using computers, taking online classes, and playing games.⁵ World Health Organization 2020 Guidelines on Physical Activity and Sedentary Behavior clearly stated recommendations to reduce sedentary time.²¹ In addition, a British study has found a positive association between increased screen time and increased risk of anxiety,¹⁴ and a one-year follow-up study in China has also indicated that there was a significant positive correlation between excessive screen time and anxiety.^{23,24} Therefore, based on existing research, it is clear that screen time can positively predict anxiety levels.

The Mediating Role of Negative Emotions

Negative emotions are an emotional dimension that includes anger, depression, and sadness. Individuals with high trait negative emotions are more sensitive to negative emotions and are difficult to recover once they are aroused.²⁵ Studies have shown that addiction to mobile phones and the Internet is a significant positive predictor of negative emotions for the Internet offers people multiple handy services, including social interaction, online shopping and entertainment, which contributes to more positive emotions, such as happiness, joy and satisfaction.²⁶ However, when people search for positive emotions, they often pay for them with work tasks, and academic performance, thus creating some negative emotions again, leading to a decline in the expected positive emotions.^{27,28} Being addicted to mobile phones and the Internet contributes to increasing screen time, and has a negative impact on students' academic performance, academic tasks, social interaction, and employment, which will lead to negative emotions.²⁹

Disagreements on the relationship between negative emotions and anxiety remain. Madrid and Bauer believe that negative emotions and anxiety tend to be convergent.^{30,31} Although individuals' anxious states are also negative manifestations, they have different goals and tendencies to act compared to negative emotions and can trigger different thoughts and feelings, which are determined by their unique domain. Arsenault, Motowidlo, and Yang argue that negative emotions and anxiety tend to be the same.^{17–19} As negative emotions and anxiety are affected by negative life factors, therefore, there can be an interaction between negative emotions and anxiety.³² From the perspective of convergence,

there are studies showing that more negative emotions will result in a higher level of anxiety,³³ overly anxious children and adults are vulnerable to get frequent and intense mental breakdowns, and tend to be affected by negative emotions.³⁴ Whether screen use by college students with a higher level of negative emotions leads to more anxiety and whether screen use leads to anxiety by first generating negative emotions.

The Moderating Role of Emotion Regulation

Emotion regulation is a process by which individuals regulate their emotions based on the environment and the way people change their emotional responses.³⁵ It is composed of external and internal processes responsible for detecting, evaluating, and changing emotional responses.³⁶ According to emotional dynamics, individuals show differential features in intensity, rise time, range, persistence, and recovery of their emotional responses.³⁷ On one hand, the process of emotion regulation will have an impact on the features mentioned above; on the other hand, emotion regulation has multiple effects that enhance, maintain, and weaken emotions, thus greatly affecting emotional experience.³⁶ Overanxious people tend to engage in repetitive negative thinking when dealing with negative emotions and apply positive reassessment strategies less frequently.³⁸ Insufficient emotion regulation has been proven to be an important reason for anxiety and depression.³⁹ As a result, there seems to be a potential link between screen time, anxiety and emotion regulation. Previous studies have well explained the relationship between multiple variables from the perspectives of screen time and anxiety, screen time and negative emotions, negative emotions and the relationship between emotion regulation and anxiety. However, the relationship, role, and overall impact between these variables are difficult to explain against separate studies, and few studies have explored the relationship between screen time and anxiety in college students and explored its mediating and moderating factors.^{40,41}

Purpose and Hypothesis

The purpose of this study is to explore new mechanisms of how screen time affects college students' anxiety levels. The exploration of potential mechanisms can help college students alleviate their anxiety levels from a multidimensional perspective, provide strategies to develop emotional regulation that are different from other coping strategies for mental health, and provide a theoretical basis for alleviating contemporary college students' mental health problems. On such basis, taking academic college students, this study adopted a process-oriented approach with college students as subjects to test how negative emotions and emotion regulation affect the indirect and direct relationship between screen time and anxiety. This study aims to figure out three problems: (1) Is there a positive relationship between screen time and anxiety among college students in China? (2) Do negative emotions play a mediating role in the relationship between screen time and anxiety among college students? (3) Does emotion regulation play a moderating role in the relationship between screen time and anxiety among college students? The model hypothesis was constructed as shown in Figure 1 with the methodology outlined by Hayes for the study.⁴²

Hypothesis 1 (H1): Screen time is a positive predictor of anxiety.

Hypothesis 2 (H2): Screen time is a positive predictor of negative emotions.

Hypothesis 3 (H3): Negative emotion is a positive predictor of anxiety, and negative emotions play a mediating role in the indirect relationship between screen time and anxiety.

Hypothesis 4 (H4): Emotion regulation plays a moderating role in the direct relationship between screen time and anxiety.

Methods

Participants and Procedure

Based on convenience samples, we select 1721 academic college students from 6 universities in 5 provinces, Shanghai, Jiangsu, Shandong, Guangxi and Hunan as respondent.

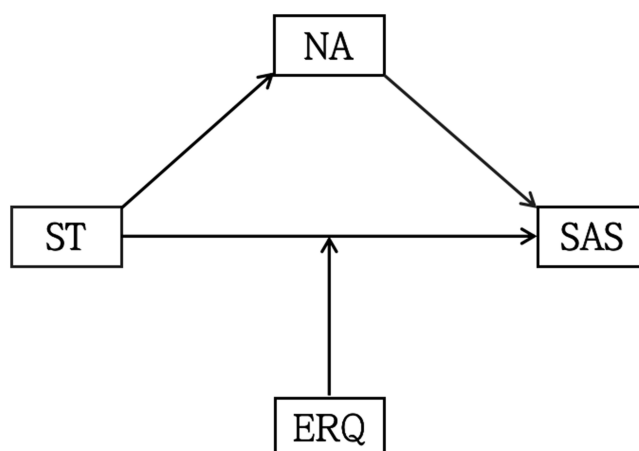


Figure 1 The Mediating Role of Negative Emotions and the Regulatory Model of Emotional Regulation Ability.

Abbreviations: ST, Screen Time; NA, Negative Emotion; SAS, Anxiety; ERQ, Emotion Regulation.

The surveyors consist of teachers in charge and graduate students from each school in the subject area. Prior to the beginning of the survey, two days of training are uniformly provided to the teachers in charge of the six schools, and two graduate students are assigned to each teacher to work together as a team in each region. The survey adopts the form of online questionnaire. Firstly, the survey questionnaire is compiled and sorted into the format of online questionnaire. Besides, the formal survey is started after checking that the paper questionnaire is no different from the online questionnaire through the pre-survey. The questionnaire is voluntary and can be refused. It consists of 56 questions which will take five to ten minutes on average. In order to prevent repeat filling, we set a rule of limiting the number of responses, and each student is allowed to complete the questionnaire only once. After that, 1637 questionnaires were collected, 21 invalid questionnaires were excluded, and the final valid questionnaires were 1616, with a response rate of 94%.

This study was approved by the Ethics Committee of Shanghai University of Sports (102772022RT096). All university students participated voluntarily and all participants were familiar with the survey procedures before data collection.

Measuring Tool

Screen Time Scale (ST)

Screen time was measured with the Screen Time Scale. Participants were asked to report how long they watched movies, played computer games and used computers and other electronic devices for online chatting, browsing the Web, sending and receiving e-mails, and doing homework on weekdays and weekends. The project has been studied among Chinese students with good test-retest reliability ($ICC=0.59$).⁴³ The formula for calculating daily screen time is: (sum of weekday screen time *5 + sum of weekend screen time *2) / 7.

Self-Rating Anxiety Scale (SAS)

There are lots of measuring tools regarding anxiety currently,⁴⁴ among which the Self-Rating Anxiety Scale (SAS) serves as a normative screening tool that taps into the specific nature of anxiety symptoms.^{45,46} The Chinese version have shown good reliability and validity among Chinese people, with Cronbach α coefficients being 0.98.¹³ SAS has four scoring criteria for 20 questions, with items ranging from negative to positive (eg, “I fall asleep easily and sleep well through the night”) experiences, the latter being reverse scored. Negative experiences included psychological symptoms (eg, “I feel scared for no reason” and “I feel like I might be going crazy”) and physical aspects (eg, “I feel like my hands and feet are shaking and trembling” and “I feel like my heart is beating really fast”) Participants were asked to base their responses on what they had experienced in the previous week. The four scoring criteria are as follows, “1” indicating no or very little time for anxiety; “2” indicating sometimes feeling anxious, “3” indicating most of the time feeling anxious, and “4” indicating most or all of the time feeling anxious. The total score of the 20 questions was summed to the raw score, and

the raw score was multiplied by 1.25 as the standard score. Referring to the Handbook of Common Psychological Assessment Scales,⁴⁷ a standard score of 50 on the SAS was specified as the anxiety symptom cut-off value.

Positive and Negative Affect Scale (PANAS)

Several scales have been developed for the assessment of negative emotions.^{48,49} Among them, the Positive and Negative Affect Scale (PANAS),⁵⁰ which is the most widely and commonly used scale for assessing positive and negative emotions,⁵¹ has shown excellent psychometric properties in the general population and in some clinical samples, and has shown good reliability and validity among the Chinese people. The Scale includes two subscales of positive and negative emotions, and the Cronbach's α coefficients for all the PANAS entries were 0.82, and the Cronbach's α coefficients for positive and negative emotions were 0.85 and 0.83, respectively. The test-retest reliability for both positive and negative emotions were 0.47.⁵² The negative emotions subscale in the PANAS was adopted for measurement, consisting of 10 adjectives describing negative emotions, such as upset, irritable, nervous. The Likert 5-level scoring method including 5 choices from left to right was almost none, relatively few, moderate, relatively many, and extremely many, with scores assigned to 1, 2, 3, 4, and 5 respectively. The higher the score, the stronger the emotional expression.

Emotion Regulation Questionnaire (ERQ)

Emotion regulation assessment adopts Emotion Regulation Questionnaire (ERQ),⁵³ which is currently a more widely used tool for measuring levels of emotion regulation and has demonstrated good psychometric properties.⁵⁴ The Questionnaire consists of 10 questions and 7-level rating. The higher the score, the higher the frequency of using emotion regulation strategies. The Questionnaire comprises two dimensions: cognitive reappraisal and expression inhibition. Among them, the measurement of cognitive reappraisal dimension consists of 6 questions (when I am faced with a stressful situation, I allow myself to think in a way that helps me to stay calm; when I want to feel more positive emotions, I change the way I think about the situation, etc.), and the measurement of expression inhibition dimension consists of 4 questions (I control my emotions by not expressing them; when I feel negative emotions, I make sure I do not express them, etc.). The Chinese version has been verified with good reliability and validity. The Cronbach's α coefficients of cognitive reappraisal and expression inhibition are 0.85 and 0.77 respectively.^{53,55}

Data Analysis

Data analysis were conducted by adopting SPSS 26.0. K-S non parametric test was used to test the normality of the data, one-way ANOVA test was used to verify the homoscedasticity of the data, and Pearson Correlation Analysis was performed. The data were tested to be in conformity with normal distribution and satisfied the requirement of homoscedasticity and linearity. Furthermore, as this study adopted a questionnaire self-report format, this may lead to common method biases. Harman's single-factor test was used to test for common method bias for all items in the questionnaire, and the results showed that the first factor explained 24.56% of the total variance, which is less than the critical value of 40%. Therefore, there was no significant common method bias in this study.

Data analysis was conducted by adopting descriptive statistics on gender, grade, ethnicity, and place of residence in the first place. Next, descriptive statistics and difference analysis were performed for height, weight, BMI, screen time, anxiety, negative emotions, and emotion regulation. Finally, when testing the mediating effect and moderating effect, control demographics variables (gender and grade). The Bootstrap confidence interval (CI) determines whether the effects in Model 4 (M is said to be a mediating variable between X and Y or M plays a mediating role between X and Y if the effect of the independent variable X on the dependent variable Y is studied through a variable M) and Model 5 (when studying the effect of the independent variable X on the dependent variable Y, whether it will be affected by the moderating variable W and the mediating variable M? The moderating variable W is the one on the path of the direct relationship between X and Y) are significant based on 5000 repeat sampling. If the CI does not include zero, the effect is considered significant.⁵⁶ The SPSS PROCESS macro Model 4 was adopted to examine the mediating role of negative emotions.⁵⁶ The PROCESS macro Model 59 (when studying the effect of the independent variable X on the dependent variable Y, whether it will be affected by the moderating variable W and mediating variable M. The W is a moderating

variable on the path of the direct relationship of X to Y, and the indirect relationship of X to M and M to Y) was used to test moderating effect of emotion regulation on the direct and indirect paths of the relationship between screen time and anxiety, and it was found that emotion regulation did not have significant effects on the first and second half of the mediating path. Hence, the PROCESS macro Model 5 was adopted finally to examine the moderating role of emotion regulation on the direct relationship between screen time and anxiety.⁵⁷

Results

Analysis of Demographic Differences

As shown in Table 1, a total of 1616 people were included in this study, of which 45.4% were male students and 54.6% were female students. The number of freshmen, sophomores, juniors, and seniors was 154, 1151, 201, and 110, respectively. Compared to ethnic minorities (6.8%), the Han nationality (93.2%) has a higher proportion, while urban (50.1%) and rural (49.9%) students have a similar proportion. The mean and standard deviation of the main variables are shown in Table 2. There are gender differences in terms of BMI, ST, NA, and ERQ, while the difference in SAS is relatively small. The BMI of male students is heavy, while the BMI of female students is in the normal range; the ERQ and NA of male students are higher than that of female students, and the ST of female students is longer than that of male students.

Table 1 Demographic Information

Variables	Total (n=1616)
Gender, n (%)	
Male	734 (45.4)
Female	882 (54.6)
Grade, n (%)	
Freshman	154 (9.5)
Sophomore	1151 (71.2)
Junior	201 (12.4)
Senior	110 (6.8)
Nation, n (%)	
Han	1506 (93.2)
Minority	110 (6.8)
Place of residence before entering university, n (%)	
Urban	809 (50.1)
Rural	807 (49.9)

Table 2 Participants Information

Variables		Male	Female	Total	t test
Height	Mean ± SD	176.01±6.42	163.14±5.91	168.99±8.88	41.60***
Weight	Mean ± SD	75.94±23.48	58.68±17.86	66.52±22.32	16.36***
BMI	Mean ± SD	24.79±8.36	22.14±7.01	23.34±7.76	6.80***
ST	Mean ± SD	5.86±2.93	6.15±2.63	6.02±2.78	-2.04*
SAS	Mean ± SD	44.99±11.21	44.48±9.60	44.72±10.37	1.08
ERQ	Mean ± SD	48.11±10.61	46.30±8.87	47.12±9.74	3.74***
NA	Mean ± SD	23.94±7.65	23.09±6.80	23.48±7.21	2.34*

Notes: *p < 0.05, ***p < 0.001.

Abbreviations: ST, Screen Time; NA, Negative Emotion; SAS, Anxiety; ERQ, Emotion Regulation.

Correlation Analysis

As shown in Table 3, the correlation analysis results of screen time, anxiety, negative emotions, and emotional regulation are suggested. Screen time is correlated with anxiety ($r = 0.14$, $p < 0.01$), negative emotions ($r = 0.13$, $p < 0.01$), and emotional regulation ($r = 0.05$, $p < 0.05$). Anxiety is correlated with negative emotions ($r = 0.63$, $p < 0.01$), and emotional regulation ($r = -0.12$, $p < 0.01$). The correlation coefficients of all four variables reached a significant level, indicating that the data is suitable for the testing of mediating and moderating model. In addition, the correlation between these four variables is consistent with theoretical expectations, providing preliminary support for subsequent testing of research hypotheses.

Analysis of Mediating Effect of Negative Emotions

As can be seen from Table 4, as the positive predictive effect of screen time on anxiety was significant ($\beta = 0.141$, $t = 5.77$, $p < 0.001$), hypothesis 1 held. After including the mediating variables, the positive predictive effect of screen time on negative emotions was significant when negative emotions were the outcome variable ($\beta = 0.135$, $t = 5.53$, $p < 0.001$), hypothesis 2 thus held. The positive predictive effect of screen time on anxiety remained significant when anxiety was the outcome variable ($\beta = 0.057$, $t = 2.93$, $p < 0.01$), as did the positive predictive effect of negative emotions on anxiety ($\beta = 0.623$, $t = 32.31$, $p < 0.001$). As shown in Table 5, screen time not only directly predicted anxiety, but also predicted

Table 3 Correlation Analysis

	ST	SAS	NA	ERQ
ST	1			
SAS	0.14**	1		
NA	0.13**	0.63**	1	
ERQ	0.05*	-0.12**	0.03	1

Notes: * $p < 0.05$, ** $p < 0.01$.

Abbreviations: ST, Screen Time; NA, Negative Emotion; SAS, Anxiety; ERQ, Emotion Regulation.

Table 4 Testing the Mediating Model of Negative Emotions

Predictors	NA		SAS		SAS	
	β	t	β	t	β	t
Gender	-0.065	-2.66**	0.010	0.53	-0.030	-1.25
Grade	0.041	1.69	0.059	3.07**	0.84	3.45***
ST	0.135	5.53***	0.057	2.93**	0.141	5.77***
NA			0.623	32.31***		
R^2	0.03		0.41		0.03	
F	13.27***		280.50***		15.86***	

Notes: ** $p < 0.01$, *** $p < 0.001$.

Abbreviations: ST, Screen Time; NA, Negative Emotion; SAS, Anxiety; ERQ, Emotion Regulation.

Table 5 Analysis of Total Effect, Direct Effect, and Indirect Effect

	Effect	Boot SE	LL95% CI	UL95% CI	Relative Effect Values
Total effect	0.53	0.53	0.30	0.76	
Direct effect	0.21	0.08	0.06	0.37	40.12%
Indirect effect	0.32	0.08	0.17	0.46	59.88%

anxiety through negative emotions which played a partially mediating role. Direct effect and indirect effect were significant and accounted for 40.12% and 59.88% respectively of the total effect, with the indirect effect being greater than the direct effect. Therefore, hypothesis 3, negative emotion is a positive predictor of anxiety, and negative emotions play a mediating role in the indirect relationship between screen time and anxiety, held.

Analysis of the Moderating Effect of Emotion Regulation

The product term of screen time and emotion regulation has a significant impact on anxiety ($\beta = 0.027$, $t = 4.49$, $p < 0.001$), indicating that emotion regulation plays a moderating role in the direct prediction of anxiety by screen time, and emotion regulation mitigates the impact of screen time on anxiety. As shown in Table 6, the Bootstrap 95% CI range for the interaction effect of screen time and emotion regulation on anxiety was 0.02 to 0.04, with 0 excluded indicating that emotion regulation regulates the association between screen time and anxiety. In addition, to further know the essence of the interaction effect and to plot the interaction effect at different levels, the level of emotion regulation was divided into high and low groups by plus or minus one standard deviation as shown in Table 7, with a simple slope as shown in Figure 2. The predictive effect of screen time on anxiety tends to decrease gradually as the students' level of emotion regulation increases. In other words, the effect of screen time on anxiety decreased as the level of emotion regulation increased. As a result, hypothesis 4, emotion regulation plays a moderating role in the direct relationship between screen time and anxiety, held.

Discussion

Construct a mediating effect and moderating effect model for screen time, anxiety, negative emotions, and emotion regulation among Chinese academic college students, while controlling gender and grade. The relationship between the variables was tested by taking screen time as a predictor variable, negative emotion as a mediating variable, emotion

Table 6 Testing the Moderating Effect of Emotion Regulation

	Model 1 (Criterion:NA)			Model 2 (Criterion:SAS)		
	β	SE	95% CI	β	SE	95% CI
Control variables						
Gender	-0.94	-2.66**	[-1.64, -0.25]	-0.001	-0.01	[-0.77,0.77]
Grade	0.436	1.69	[-0.07, 0.94]	0.833	2.93**	[0.28,1.39]
Independent variables						
ST	0.352	5.53***	[0.23, 0.48]	0.200	2.80**	[0.06,0.34]
Mediator						
NA				0.893	32.83***	[0.84,0.95]
Moderator						
ERQ				-0.145	-7.25***	[-0.19,-0.11]
Interaction term						
ST×ERQ				0.027	4.49***	[0.02,0.04]
R^2					0.01	
F					20.15	

Notes: ** $p < 0.01$, *** $p < 0.001$.

Abbreviations: ST, Screen Time; NA, Negative Emotion; SAS, Anxiety; ERQ, Emotion Regulation.

Table 7 Direct Effect at Different Level of Emotion Regulation

Level	Effect Size	Boot SE	LL95% CI	UL95% CI
M-SD	-0.07	0.10	-0.26	0.13
M	0.20	0.07	0.06	0.34
M+SD	0.47	0.09	0.30	0.64

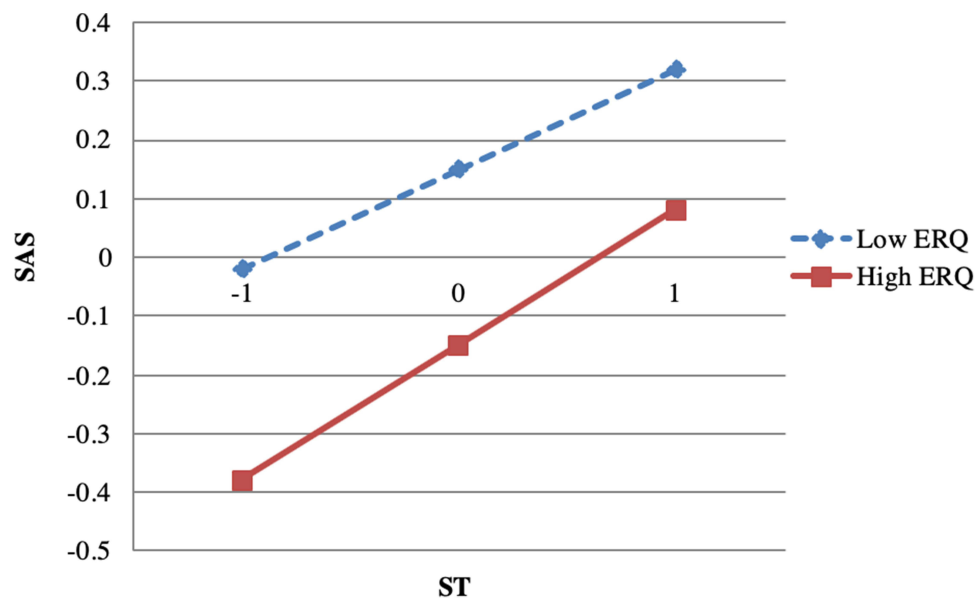


Figure 2 Differences in the Impact of Different Level of Emotion Regulation on Screen Time and Anxiety.

Abbreviations: ST, Screen Time; SAS, Anxiety; Low ERQ, Low Emotion Regulation; High ERQ, High Emotion Regulation.m

regulation as a moderating variable, and anxiety as an outcome variable. It turns out that screen time is a positive predictor of anxiety, negative emotions play a mediating role, and emotion regulation plays a moderating role.

Analysis of Demographic Differences

As shown in Table 2, there were gender differences in BMI, screen time, negative emotions, and emotion regulation among college students. Male students have a heavier and larger BMI than female students, which is consistent with previous research findings.⁵⁸ This is because female students are more conscious of their appearance and body image, and therefore they resort to dieting measures and weight loss supplements to maintain a lower BMI.⁵⁹ Previous studies have also shown that male students have higher levels of emotion regulation and negative emotions than female students.⁶⁰ The former may be due to the impact of traditional Chinese culture, especially the educational concept of “men do not easily shed tears”, which makes male students use more expression inhibition strategies to control their negative emotions.^{58,61,62} The latter is due to the fact that male students need to take on more pressure from the economy, family burdens, employment, and other pressures than female students do when facing graduation, which makes the negative emotions higher than that of female students.⁶³ Studies at home and abroad have reported that male students have a higher level of physical activity than female students.⁶³ According to Displacement Hypothesis,⁶⁴ which suggests that one activity can replace another. Physical activity will replace screen time and female students are addicted to TV series and online shopping.⁶⁵ Therefore, female students spend more screen time compared to male students.

Relationship Between Screen Time and Anxiety

Screen time is in relation to anxiety, and screen time is a positive predictor of anxiety, which is consistent with previous studies.^{13,66,67} Screen time, as a risk factor for anxiety among college students, affects anxiety in a biological way, such as central nervous system arousal, sleep disorder and poor metabolic.^{68–70} The Internet is a double-edged sword. In line with the Use and Gratifications Theory (UGT),^{71,72} college students will use their mobile phones for a long time for brief happiness to relieve their anxiety. Using the Internet brings temporary pleasure and convenience, but also brings disadvantages. College students sacrifice time for outdoor activities, study and socializing because of playing video games and watching instant music videos, leading to a sense of loss and helplessness. In relevant studies, cyberloafing leads to higher levels of anxiety among college students, and will also make college students with anxiety symptoms feel a decrease in subjective well-being and sense of meaning in life.⁷³ The relationship between screen time and anxiety also

varies depending on the type of screen use, with watching TV, movies and video games being associated with higher level of anxiety,^{13,67,74} while there is little evidence indicating that time spent on texting is associated with anxiety.¹⁴ The difference is due to different levels of perceived immersion for individuals. Texting is associated with social behavior and allows for simultaneous multitasking, while playing video games and watching TV requires more attention and persistence. Screen time among college students should be controlled in the future, and more studies are needed to confirm the content-specific results of the current study.

Mediating Role of Negative Emotions

The reasons for screen time a positive predictor of negative emotions are as follows. For one thing, screen time is associated with sleep.^{75,76} College students stay up late for screen time prolongs, resulting in endocrine disorders caused by shorter sleep time and poorer sleep efficiency,⁷⁷ which will affect the study life of college students triggering a series of mental health problems.⁴⁰ For another thing, exposure to violent Internet content and video games can lead to aggressive emotions and behaviors, further triggering negative emotions.⁷⁸ There are also a few people whose negative emotions may come from online bullying, and different studies have indicated that the incidence of online bullying ranges from 3% to 69%.⁷⁹ Victims who are bullied by photo and video editing, incited and threatened with vulgar language, online harassment, and defamation of personal information, all of which can result in serious negative emotions.⁸⁰ In short, screen time is a positive predictor of negative emotions.

Previous studies have pointed out that the fewer negative emotions, the lower level of anxiety, depression, and perceived stress.⁸¹ Further results indicate similarly a positive correlation between negative emotions and anxiety. College students with negative emotions are prone to be anxious during screen use. Negative emotions are related to the nonmaterial problematic use, such as addiction to the Internet and smartphone.⁸² In this process, middle school students are more sensitive to negative news.⁸¹ Emotion-Congruency Effect also indicates that when a man is exposed to negative emotions, he will notice negative information first.^{83,84} In such an era of big data, the short video APP pushes relevant short videos according to the negative emotional state of individuals, which increases negative emotions. During screen use, relevant negative emotions are excessive and persistent to cause anxiety,⁸⁵ which further verifies that negative emotions and anxiety can have an impact on each other.³²

Based on the above findings and evidence from previous studies, it is suggested that the path-mechanism reasons for the indirect relationship between negative emotions mediating screen time and anxiety may lie in following reasons. Screen time causes endocrine disorder by affecting the sleep quality and exposure to inappropriate Internet content can contribute to negative emotions that turn into anxiety. In addition, college students with negative emotions tend to be addicted to Internet and smartphone when using screen, which can produce more negative emotions that exacerbate anxiety. This finding is in line with cognition and behavior theory and cognitive theory of emotion.^{86,87} Emotions will motivate specific goals and cognitions. They play an important mediating role in the triangular interaction of behavior, emotions, and cognition.⁸³ The mediation model reveals that the mediating effect of negative emotion is greater than the direct effect of screen time on anxiety, which shows that part of the important reason for anxiety produced by screen time originates from negative emotion, and as college students can reduce negative emotion in time by strengthening physical activity.⁸⁸ It suggests that attention bias training is likely to be a promising alternative treatment for anxiety,⁸⁹ and this is an important way of effectively alleviating the role of screen time on anxiety.

Moderating Role of Emotion Regulation

The results of the study showed that emotion regulation negatively predicted anxiety levels in line with previous studies indicating this.^{90,91} It is concluded that the higher the frequency of using emotion regulation strategies during screen use, the more significant the impact on the anxiety level of college students. In a previous intervention study, it was found that there is a positive correlation between emotion regulation and anxiety among young people.^{90,91} It is commonly believed that emotional dysregulation is a basic feature of anxiety.⁹² The model study of anxiety disorder uses both emotional reactions and family environment to explain anxiety disorder. By examining three variables (high emotional reactions, restrictive family expression, and negative emotional expression in the family), the results show that all of them affect anxiety through emotional dysregulation.⁹³ Thus, it is clear that emotion regulation is critical to the regulation of anxiety.

Emotion regulation can be introspective, originating from the individual, or interpersonal, involving interactions with others.⁹¹ Emotion regulation of individuals can be more effectively regulated by reappraisal compared to expression inhibition strategies.⁵³ This is because the cognitive reappraisal strategy is adopted in the early stage of emotion regulation, aiming to turn negative emotions into neutral or positive emotions.⁹⁴ Expression inhibition strategy is adopted in the later period, trying to alter the individual's emotional experience by hiding observable emotions from others rather than reducing anxiety. In terms of interpersonal interaction, individuals consider other people as a way to regulate their emotions.⁹⁵ For example, finding someone else to be with or to talk to can regulate an individual's anxiety.

In the integrated model of screen time, anxiety, negative affect, and emotion regulation in this study, emotion regulation had a significant moderating effect on the relationship between screen time and anxiety. According to self-regulation theory,⁹⁶ individual self-regulation ability will regulate their own intentions, emotions and other effects on the target behavior, and emotion regulation as an important aspect of individual self-regulation, can play a "buffer" effect, brought about by the emotion regulation of the "buffer" effect will be significantly inhibited by the use of the screen brought about by the negative experience and adverse effects. To some extent, it supports the strategy-situation matching theory, which emphasizes the flexibility of individuals to use and context-match strategies based on changing situational characteristics, with more adaptive implications for individuals' levels of emotional well-being.⁹⁷ In order to distinguish the level of the moderating effect, high and low levels of emotion regulation were separated by plus or minus one standard deviation, ie, screen time was a more significant positive predictor of anxiety among college students with low levels of emotion regulation relative to those with high levels of emotion regulation. In addition, other studies have shown that emotion regulation flexibility is good for reducing negative emotions,⁹⁷ while in this study, emotion regulation has no moderating effect on the mediating pathway of negative emotions. The reason for this difference may be that college students with a low level of emotion regulation cannot flexibly choose emotion regulation strategies when using screens, which will lead to the accumulation of negative emotions. For example, expression inhibition strategies occur in the later stage, which cannot effectively reduce their negative emotions,⁸⁵ they just try to change emotional experience by hiding observable emotions from others.⁹⁸ The relationship between negative emotions and the use of specific emotion regulation strategies remains to be verified in the future. This study further indicates that a high level of emotional regulation can buffer the positive impact of screen time on college students' anxiety, and improving emotional regulation ability is an effective method to help college students reduce the risk of anxiety caused by screen use. Therefore, in the face of anxiety patients in later treatment, educators or medical staff can take psychological lectures into consideration, establish a psychological counseling hotline and other ways to carry out targeted psychological training to improve the psychological flexibility of college students.

Limitations and Implications

There are limitations to this study. First of all, adopting convenient sampling to select participants can only represent a portion of the academic college students, which may lead to bias in research results. A large-scale random sampling should be conducted in future study. Second, self-report questionnaires in its entirety may result in recall bias. Objective measuring ways and methods should be adopted in the future as much as possible. Third, the cross-sectional study lacked long-term follow-up to determine the causal relationship between screen time and anxiety. The model can be further examined and validated by longitudinal study in the future.

Although this study has certain limitations, it theoretically supports existing research on the relationship between screen time and anxiety in college students, enriching relevant literature on anxiety research. Moreover, an empirical framework through mediating and moderating models of negative emotions and emotional regulation is provided, these findings reveal the potential mechanism of the relationship between screen time and anxiety in college students. From a practical perspective, study has found that it helps to develop effective intervention strategies for college students, such as strengthening physical activity and attention bias training,⁸⁹ and improving emotional regulation ability to help reduce anxiety among college students.

Conclusion

The study has indicated that screen time and anxiety have a positive correlation, negative emotions play a mediating role between screen time and anxiety, the mediating effect is greater than the direct effect, and emotion regulation plays

a moderating role between screen time and anxiety. It provides a clear path to effectively alleviate the anxiety level of college students, ie, by controlling screen time, paying attention to the emotional status of college students, intervening and alleviating their negative emotions as early as possible, and improving their emotional regulation ability, in order to promote the mental health of academic college students and positively affect their future study, life, and planning.

Ethical Approval and Written Consent

This study was approved by the Ethics Committee of Shanghai University of Sports(102772022RT096) and the procedures performed were in accordance with the Declaration of Helsinki. Parents of all participants signed an informed consent form describing the purpose, method, process, and publication plan of the study.

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Disclosure

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