Iran J Public Health, Vol. 52, No. 11, Nov 2023, pp.2333-2342

Original Article

Analysis on the Relationships of Smartphone Addiction, Learning Engagement, Depression, and Anxiety: Evidence from China

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(Received 10 Mar 2023; accepted 27 May 2023)

Abstract

Background: With the popularization of the Internet and smartphones, smartphone addiction among college students is becoming increasingly common, causing the problems of their learning engagement, anxiety, and depression. The study aimed to analyze the relationships of smartphone addiction, learning engagement, anxiety and depression among Chinese college students.

Method: Based on the Self-Determination Theory, in January 2023, 780 college students from 6 universities in Heilongjiang Province in China were selected as examples for the study. Internet Addiction Test, Utrecht Work Engagement Scale-Student, Chinese version of Beck Depression Inventory-II, and Spielberger Trait Anxiety Inventory were employed to measure smartphone use, learning engagement, depression, and anxiety among college students. Pearson correlation and multiple logistic regressions were also used.

Results: Smartphone use was negatively correlated with learning engagement ($r = -0.097$, $P < 0.001$), whereas it was positively correlated with depression ($r = 0.184$) and anxiety ($r = 0.18$, $P < 0.001$). Significant differences were observed in learning engagement and depression and anxiety symptoms in different degrees of smartphone use. Taking severe smartphone addiction as a comparison standard, depression and anxiety symptoms had a significant influence on different levels of smartphone use, whereas learning engagement did not have a significant influence on different smartphone use levels.

Conclusion: The intervention and prevention of college students' smartphone addiction can improve their learning engagement, relieve their anxiety and depression, and enhance their mental health level.

Keywords: Smartphone addiction; Mental health; Learning engagement; Depression; Anxiety

Introduction

Information and communication technologies greatly promote economic growth of developing countries (1). With the economic growth, the Internet has become a vital part in people's daily life, social communication, and entertainment (2, 3), and smartphones are highly convenient for college students to contact and communicate with the world nowadays. Given that the 5G has made the Internet more accessible, college students are more likely to become addicted to smartphones or overuse smartphones. Smartphone addiction refers to individuals' psychological dependence on smartphones, leading to a constant increase of the amount of time they

spend online. Individuals will feel happy or satisfied when surfing the Internet while feeling uncomfortable without it. They are liable to surf the Internet in the virtual world to escape their troubles or stress in real life. Smartphone addiction has been viewed as one of the major global public health issues. Among the netizens in China, students are the largest proportion, accounting for 26.9% (http://www.cnnic.net.cn). High incidence of smartphone addiction exists among Chinese college students. Smartphone addiction can cause problems related to their health and development (4). Therefore, the study on college students' smartphone addiction is considerably significant for their mental health.

Smartphone addiction makes students spend considerable time into virtual activities irrelevant to their learning or scientific study, distracting their learning energy and affecting their learning engagement. Learning engagement is a lasting, positive, and complete emotional and cognitive psychological state related to learning, scientific study, or employment. Many American college students spend considerable time indulging in mobile phones (5), and excessive involvement in virtual activities will lead to a decrease in individuals' learning engagement (6). Smartphone addiction has a direct influence on learning disorders (7), and the prevention of smartphone addiction is remarkably crucial for improving students' autonomous learning ability (8). Additionally, learning engagement is one of the important indicators of students' mental health. It reflects students' positive and healthy psychological state, and is an essential indicator of students' positive learning psychology (9). The mental health status of senior high school students in the Tibetan and Qiang areas in China had a significantly positive influence on their learning engagement and academic self-efficacy (10). However, studies on the relationships of smartphone addiction among college students and their learning engagement in China are rare. Therefore, the relationships of smartphone addiction and learning engagement among college students in China need to be investigated.

Moreover, smartphone addiction could cause individuals to have symptoms such as anxiety and depression. Individuals have psychological desire and tolerance due to smartphone addiction, which makes them unable to control their smartphone use, thereby affecting their daily lives and causing their psychological or behavioral problems (11, 12). College students' smartphone addiction is positively correlated with their depression and anxiety (13, 14). A significantly positive correlation exists between smartphone addiction and depression among nursing students (15). Additionally, reducing Internet addiction could lower college students' anxiety (16). Depression and anxiety have also been regarded as significant indicators of college students' mental health, which will greatly influence their daily life, learning and scientific study activities. Anxiety is an individual's general state of worrying about future difficulties or threats (17). Depression is an individual's psychological state of mind or emotion, characterized by low self-worth or guilt, and decreased ability to enjoy life. Depression is extremely common among college students, which weakens them and affects their academic performance (18). However, in China, studies on the relationships of college students' smartphone addiction, depression and anxiety have not received sufficient attention.

Self-Determination Theory (SDT) is a popular research-based psychological theory (19). Self-determination means that individuals make free options about their behaviors based on fully understanding their personal needs and the environment. As a motivation theory, SDT can be used to study the relationships of smartphone addiction and mental health among college students. Students' degrees of smartphone use are related to their intrinsic motivation. Students driven by intrinsic motivation will normally use smartphones and have a high level of mental health. Contrarily, external regulation and internal regulation are closely related to low mental health level.

Therefore, based on SDT, this study aimed to analyze the relationships of smartphone addic-

tion, learning engagement, anxiety, and depression among Chinese college students.

Methods

Data resources

A total of 780 college students from 6 universities in Heilongjiang Province in China were selected as examples. Electronic questionnaires were distributed, which took about 20 min. A total of 780 valid questionnaires were recovered, with an effective recovery rate of 100%.

Ethics approval

The study was approved by the Harbin Shuanghua Hospital in Heilongjiang Province of China. All college students in this study gave informed consent and also signed informed consent.

Research instruments

The study was carried out in January 2023. Internet Addiction Test (IAT) (20) was adopted to measure students' degrees of smartphone use. The IAT consisted of 20 items, and scored using a 5-point Likert scale, where 1 = none, 2 = few, 3 = occasional, 4 = frequent, and 5 = always. The total score ranged from 20 to 100. In the study, 20-30 points reflected a normal degree of smartphone use; scores ranging from 31 to 49 demonstrated a mild degree of smartphone addiction; scores from 50 to 79 showed a moderate degree; and 80 to 100 revealed a severe degree (20). The Cronbach's alpha of the scale was 0.93.

Utrecht Work Engagement Scale-Student (UWES-S) (21) was used to measure students' learning engagement. The scale consisted of 17 items, using a seven-point Likert-type scale. Scores were 1 = never, 2 = almost never, 3 = often not, 4 = uncertain, 5 = occasionally, 6 = often, and 7 = always/every day, with a total score of 17-119 points. In this study, scores of 17-69, 70-84, and 85-119 indicated low, moderate, and high degree of learning engagement, respectively. The Cronbach's alpha was between 0.82 and 0.95.

Students' depression symptoms were measured by Chinese version of Beck Depression Inventory-II (BDI-II) (22). The BDI-II contained 21 items, with scores from 0 to 3. Scores of 0-13 indicated no depression, and scores of 14-19, 20-28, and 29-63 indicated mild, moderate, and severe degree of depression, respectively. The Cronbach's alpha was 0. 86.

Spielberger Trait Anxiety Inventory (STAI-T) (23) rated students' anxiety. The score of each question was 1 = almost none, 2 = some, 3 = moderate or frequent, and 4 = very obvious or almost always, and the total scores were from 20 to 80. According to Ruffinengo et al. (24), scores of 20-29, 30-37, 38-44, and 45-80 reflected no anxiety symptoms, mild anxiety, moderate anxiety, and high anxiety, respectively. In this study, the Cronbach's alpha was 0.93, and the concurrent validity was 0.52-0.80.

Statistical analysis

Descriptive statistics, including the mean (M) and standard deviation (SD) of continuous variables and the number and percentage of classified variables, were used to study the distributions of smartphone use, learning engagement, depression, and anxiety among college students. Pearson correlation coefficients were used to evaluate the relationships of smartphone use, learning engagement, depression, and anxiety. A multiple logistic regression was used to investigate the relationships of smartphone use, learning engagement, depression, and anxiety. SPSS software, version 25.0, (IBM Corp., Armonk, NY, USA) was adopted to analyze the data, and the data with a P value of ≤ 0.05 were statistically significant.

Results

Distributions of smartphone use, learning engagement, depression and anxiety symptoms

The distributions of smartphone use, learning engagement, depression symptoms, and anxiety symptoms were shown in Table 1. Accordingly, 83.46% of college students had smartphone ad-

diction problem, 49.36% had a high degree of learning engagement, 21.79% had severe depression symptoms, and 71.03% had severe anxiety symptoms. Smartphone use was negatively correlated with learning engagement (r = -0.097, $P < 0.001$), whereas it was positively correlated with depression (r = 0.184, $P < 0.001$) and anxiety (r = 0.18, $P < 0.001$). Moreover, learning engagement was negatively correlated with depression (r = -0.309, $P < 0.001$), whereas it was significantly correlated with anxiety (r = 0.349, $P < 0.001$), and depression was negatively correlated with anxiety (r = -0.11, $P < 0.001$).

Table 1: Distributions of smartphone use, learning engagement, depression symptoms and anxiety symptoms (n=780)

Variable	**Distribution**			**Pearson correlation**		
	n	%	M± SD	Learning engagement	Depression symptoms	Anxiety symptoms
Smartphone use			48.84±17.04	-0.097**	0.184**	0.18**
Normal degree of SU (20-30 points)	129	16.54				
Mild degree of SA (31-49 points)	252	32.3				
Moderate degree of SA (50-79 points)	368	47.18				
Severe degree of SA (80-100 points)	31	3.97				
Learning engagement			79.79±27.24	1.00	-0.309**	0.349**
Low degree of LE (17-69 points)	229	29.36				
Medium degree of LE (70-84 points)	166	21.28				
High degree of LE (85-119 points)	385	49.36				
Depression symptoms			25.96±8.58	-0.309**	1.00	-0.11**
No DS (0-13 points)	0	0				
Mild degree of DS (14-19 points)	0	0				
Moderate degree of DS (20-28 points)	610	78.21				
Severe degree of DS (29-63 points)	170	21.79				
Anxiety symptoms			47.51±9.06	0.349**	-0.11**	1.00
No DS (20-29 points)	33	4.23				
Mild degree of DS (30-37 points)	36	4.62				
Moderate degree of DS (38-44 points)	157	20.13				
Severe degree of DS (45-80 points)	554	71.03				

M = Mean; SD = Standard deviation; SU = Smartphone use; SA = Smartphone addiction; LE = Learning engagement; DS = Depression symptom; AS = Anxiety symptom; * $P < .05$; ** $P < .001$

Relationships of smartphone use, learning engagement, depression symptoms, and anxiety symptoms

Table 2 reflected the influences of different levels of smartphone use on learning engagement, depression, and anxiety. Distributions of learning engagement, depression symptoms, and anxiety symptoms with different degrees of smartphone use were also shown in Table 2. The average scores of severe smartphone addiction, moderate smartphone addiction, mild smartphone addiction, and normal smartphone use in depression were 29.16 ± 16.242, 27.02 ± 8.598, 25.19 ± 6.608, and 23.64 ± 8.711, respectively. The *P* value of ANOVA was 0.000** < 0.05, so the statistical results were significant, indicating significant differences in depression among different degrees of smartphone use. The average scores of severe smartphone addiction, moderate smartphone addiction, mild smartphone addiction, and normal smartphone use in anxiety were 55.74 ± 16.683, 47.27 ± 7.713, 47.72 ± 6.982, and 45.81 ± 12.198, respectively. The *P* value of ANOVA was 0.000** < 0.05, so the statistical results were significant, implying significant differences in the anxiety of different degrees of smartphone use. The average scores of severe smartphone addiction, moderate smartphone addiction, mild smartphone addiction, and normal smartphone use in learning engagement were 88.61 ± 36.627, 75.77 ± 21.768, 80.96 ± 24.357, and 86.84 ± 39.490, respectively. The *P* value of ANOVA was 0.000** < 0.05, so the statistical results were significant, indicating significant differences in learning engagement in different degrees of smartphone use.

Table 2: Influence of smartphone use on learning engagement, depression symptoms, and anxiety symptoms (n=780)

Variable	**Smartphone use**					
	Normal **n=129** **n (%)**	***Mild*** **n=252** **n (%)**	***Moderate*** **n=368** **n (%)**	***Severe*** **n=31** **n (%)**	**F(df)**	***P***
Learning engagement (M±SD)	86.84±39.490	80.96±24.357	75.77±21.768	88.61±36.627	6.956	0.000**
Low (17-69)	33	65	124	7		
Medium (70-84)	6	52	105	3		
High (85-119)	90	135	139	21		
Depression symptoms (M±SD)	23.64±8.711	25.19±6.608	27.02±8.598	29.16±16.242	7.314	0.000**
No (0-13)	0	0	0	0		
Mild (14-19)	0	0	0	0		
Moderate (20-28)	118	204	263	25		
Severe (29-63)	11	48	105	6		
Anxiety symptoms (M±SD)	45.81±12.198	47.72±6.982	47.27±7.713	55.74±16.683	10.552	0.000**
No (20-29)	19	5	7	2		
Mild (30-37)	3	7	25	1		
Moderate (38-44)	11	56	86	4		
Severe (45-80)	96	184	250	24		

F(df) = Degrees of freedom; * *P* < .05; ** *P* < .001

Table 3 revealed the influences of learning engagement, depression, and anxiety on different degrees of smartphone use. For normal smartphone use, the *P* value of depression was

0.000, which was horizontally significant. Therefore, depression had a significant influence on the classification of smartphone use, that is, the probability of smartphone use being classified as normal smartphone use was 10.1% lower than that of severe smartphone addiction. The *P* value of anxiety was 0.000, which was also horizontally significant. Therefore, anxiety symptoms had a significant influence on the classification of smartphone use, that is, the probability of smartphone use being classified as normal was 11.8% lower than that of severe smartphone addiction. The *P* value of learning engagement was 0.893, which was not horizontally significant. Therefore, learning engagement did not have a significant influence on the classification of smartphone use.

For mild smartphone addiction, the *P* value of depression was 0.002, which was horizontally significant. Therefore, depression significantly influenced the classification of smartphone use, that is, the probability of smartphone use being classified as mild smartphone addiction was 6.1% lower than that of severe smartphone addiction. The *P* value of anxiety was 0.000, which was horizontally significant. Therefore, anxiety had a significant influence on the classification of smartphone use, that is, the probability of smartphone use being classified as mild smartphone addiction was 7.9% lower than that of severe smartphone addiction. The *P* value of learning engagement was 0.252, which was not horizontally significant, so learning engagement did not have a significant influence on the classification of smartphone use.

For moderate smartphone addiction, the *P* value of depression was 0.025, which was horizontally significant. Therefore, depression had significantly affected the smartphone use classification, that is, the probability of smartphone use being classified as moderate smartphone addiction was 3.9% lower than that of severe smartphone addiction. The *P* value of anxiety was 0.000, which was horizontally significant, so anxiety symptoms significantly influenced the smartphone use classification, that is, the probability of smartphone use being classified as moderate smartphone addiction was 7.6% lower than that of severe smartphone addiction. The *P* value of learning engagement was 0.082, which was not significant horizontally, so learning engagement did not have a significant influence on smartphone use classification.

Table 3: Influence of learning engagement, depression symptoms, and anxiety symptoms on different degrees of smartphone use in multiple regression models (n=780)

Smartphone use				
Variable	Normal	Mild	Moderate	Severe
Learning engagement				
OR (95% CI)	1.001[0.982,1.022]	0.989[0.971,1.008]	0.984[0.966,1.002]	1.00
aOR (95% CI)[a]	1.011[0.992,1.032]	0.979[0.961,0.998]	0.975[0.957,0.993]	1.00
P	0.893	0.252	0.082	
Depression				
OR (95% CI)	0.899[0.853,0.948]	0.939[0.904,0.976]	0.961[0.928,0.995]	1.00
aOR (95% CI)[a]	0.872[0.826,0.921]	0.919[0.884,0.956]	0.943[0.91,0.977]	1.00
P	0.000**	0.002**	0.025**	
Anxiety				
OR (95% CI)	0.882[0.845,0.92]	0.921[0.887,0.957]	0.924[0.89,0.959]	1.00
aOR (95% CI)[a]	0.86[0.823,0.898]	0.902[0.868,0.938]	0.905[0.871,0.94]	1.00
P	0.000**	0.000**	0.000**	

OR = Odds ratio; aOR = Adjusted odds ratio; CI = Confidence interval; [a] aORs and their 95% CIs were obtained after adjusting for all variables listed in this table; * $P < .05$; ** $P < .001$

Discussion

Relationships of smartphone use and learning engagement

Smartphone addiction leads to students' low degree of learning engagement. In this study, smartphone use is found to be negatively correlated with learning engagement (r = -0.097, $P < 0.001$), and significant differences exist among students' high smartphone addiction, moderate smartphone addiction, mild smartphone addiction, and normal smartphone use in learning engagement. This finding is consistent with Li's (25) finding, that is, a significant correlation exists between Internet addiction and learning engagement. Internet addiction negatively affects learning enthusiasm and individuals' bodies and mind, and will seriously lead to psychological diseases, such as depression. In other words, a significantly negative correlation exists between Internet addiction and learning engagement. The outcome also aligns with the following findings. For instance, spending considerable time in virtual activities (e.g., mobile phones) may lead to a decline in college students' learning engagement (5). The use of mobile phones is related to high anxiety and insomnia, that is, the degree of mobile phone addiction is negatively related to sleep quality (26), and poor sleep quality at night will lead to the decline of individual activities during the day (27). Smartphone addiction will make college students put more of their limited resources into their mobile phones. The finding of this study also supports the views of Baumeister et al. (28) that individuals' energy resources are limited, and resource consumption on one task will inevitably hinder resource consumption on other tasks. The finding also agrees with Zhuang et al.'s (29) opinion that learning engagement is a vital psychological resource for learning, so excessive addiction to the network will consume individual resources and lead to insufficient resources for learning.

As intermediaries between individuals and the virtual world, smartphones have gradually become one of the most important and indispensable daily tools in people's daily life. However, smartphones are also a double-edged sword. Students using smartphones appropriately can improve their learning engagement to a certain extent. They can use smartphones to surf the Internet for activities related to learning and scientific study to improve their learning efficiency and quality. However, students spending most of their online time doing activities unrelated to their learning and scientific study will lower their learning engagement. Therefore, taking severe smartphone addiction as a comparison standard, this study also finds that learning engagement does not have a significant influence on different degrees of smartphone use.

Relationships of smartphone use and depression and anxiety

In this study, smartphone use is positively correlated with depression (r = 0.184) and anxiety (r = 0.18, $P < 0.001$). Significant differences exist in the depression and anxiety symptoms in different degrees of smartphone use, and smartphone addiction will lead to depression and anxiety among students. Taking severe smartphone addiction as a comparison standard, depression and anxiety symptoms have significant influences on different degrees of smartphone use.

The findings of this study agree with Shi et al.'s (30) view that Internet addiction aggravates the deterioration of college students' mental health. Overreliance on smartphones results in interpersonal barriers, deviation of values, partial imbalance of cognitive functions, anxiety and depression of willpower among college students. College students' smartphone addiction will lead to their depression, lack of interest in real life and study, and even the emotions of aversion and resistance, loss of confidence in learning, solitary and laziness, anxiety, and depression in real life.

College students' smartphone addiction causes interpersonal obstacles. They indulge excessively in the virtual world of the Internet, thereby reducing their participation with others and affecting their interpersonal communication in the real world, leading to the degradation of social functions and the shrinkage of the scope of real interpersonal communication. Over time, smartphone

addiction will weaken students' sensitivity to real life, disrupt communication in face-to-face interactions, and produce feelings of rejection in real-life situations. Moreover, college students addicted to smartphones may transfer their dissatisfaction in real life to the Internet to seek compensation in the virtual world. During the process, students' personal roles and images are often extremely different from those in the real world, and a huge psychological gap emerges easily in the frequent shift and comparison between reality and virtuality, thereby triggering students' psychological problems, such as anxiety and depression. This study is also congruent with the finding of Huang et al. (16) that reducing Internet addiction can decrease college students' anxiety.

However, the current study had some limitations. The smartphone use, learning engagement, depression, and anxiety of the college students were measured at one time temporarily. The results may not indicate the students' usual state. So, the temporal changes in their smartphone use, learning engagement, depression, and anxiety symptoms could not be examined after the study. The data sources were college students from just 6 universities in Heilongjiang Province. Students from different grades, and different genders were considered separately. As a result, the relationships of smartphone addiction, learning engagement, depression, and anxiety among students from different grades and genders may not revealed.

Conclusion

A negative correlation exists between smartphone use and learning engagement, whereas learning engagement has no significant influence on smartphone use in different degrees. A significantly positive correlation exists between smartphone use and depression and anxiety, and depression and anxiety symptoms significantly affect smartphone use in different degrees. Significant differences exist in learning engagement, depression symptoms, and anxiety symptoms in different degrees of smartphone use. The study highlights that smartphone addiction will cause students' low learning engagement and depression and anxiety symptoms. Hence, the intervention and prevention of college students' smartphone addiction are conducive to improving their learning engagement and alleviating their depression and anxiety symptoms, thereby improving their mental health.

Journalism Ethical considerations

Ethical issues (Including plagiarism, Informed Consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the author.

Acknowledgements

This work was supported by the Heilongjiang Province Higher Education Teaching Reform Project (Grant No. SJGY20220329); The 11th China Foreign Language Education Fund Project (Grant No. ZGWYJYJJ11A116); World Language and Culture Study Project of China Foreign Language Strategy Research Center (Grant No. WYZL2022HL0004).

Conflict of Interest

The authors declare that there is no conflict of interests.

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