

Efficacy of a WeChat Public Account-based intervention for problematic smartphone use among Chinese undergraduate students: A randomized controlled trial

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Abstract

Background: Problematic smartphone use (PSU) among Chinese undergraduate students has become a significant public health concern. This study sought to develop a targeted preventive intervention for PSU, grounded in the Information-Motivation-Behavioral Skills (IMB) model and delivered through WeChat official accounts.

Objective: This study sought to develop a targeted preventive intervention for PSU, grounded in the Information-Motivation-Behavioral Skills (IMB) model and delivered through WeChat official accounts.

Methods: A total of 210 college students identified as having PSU were recruited, stratified by gender, and randomly assigned to either the intervention or control group. The intervention group received content targeting information, motivation, and behavioral skills via WeChat official accounts over a 6-week period, while the control group continued their regular activities. Primary outcomes included pre- and post-intervention scores on the Smartphone Addiction Scale-Short Version (SAS-SV) and the Information-Motivation-Behavioral Skills questionnaire. Secondary outcomes included average daily smartphone use time, sleep duration, sleep quality, and somatic and psychological symptoms. All analyses were conducted on an intention-to-treat basis.

Results: The results of the analysis using generalized linear mixed models showed that (1) a significant difference in smartphone addiction scale scores existed between the two groups after the intervention ($P < 0.05$), with significantly lower addiction scores in the intervention group compared to the control group ($t = -3.025$, $P = 0.003$); (2) motivation scale scores were significantly different between the two groups after the intervention ($P < 0.05$), with higher scores in the intervention group compared to the control group ($t = 2.240$, $P = 0.026$); (3) behavioral skills scale scores were significantly different between the two groups after the intervention ($P < 0.05$), with higher scores in the intervention group compared to the control group ($t = 3.436$, $P = 0.001$).

Conclusions: The WeChat public account intervention based on the IMB model partially mitigated problematic smartphone use among college students, providing a foundation for developing practical intervention strategies.

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Original Manuscript

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Keywords: problematic smartphone use, randomized controlled trial, behavior change, WeChat, Information-Motivation-Behavioral Skills Model, college students

1. Introduction

Problematic smartphone use (PSU) is characterized by escalating, excessive, and unregulated use of smartphones that can cause personal, social, scholastic, or working impairment in a person's life (Billieux, Schimmenti, Khazaal, Maurage, & Heeren, 2015). Although the assessment tool used in this study (SAS-SV) retains the term "smartphone addiction," we use the term PSU throughout this paper to describe this pattern. In recent decades, the use of smartphones has brought great convenience to people's lives, and the number of smartphone users is constantly increasing (J. Wang et

al., 2023). According to the China Internet Network Information Center, the number of individuals accessing the internet via smartphones has reached 1.065 billion, with the smartphone user population continuing to grow rapidly (Lian et al., 2023). While smartphones bring convenience and happiness to people, they also lead to a myriad of negative outcomes. PSU refers to an excessive use of smartphones that interferes with users' daily lives and has harmful effects (Gao, Hu, Ji, & Liu, 2023). PSU is increasingly viewed as a behavioral addiction, marked by compulsive use, loss of control, and functional impairment, similar to other behavioral addictions such as internet gaming disorder (Xie, Shen, & Wu, 2023; J. Zhou & Bai, 2023). Previous studies have consistently shown that gender is a significant predictor of PSU, with females generally reporting higher levels of addiction symptoms than males (Xie et al., 2023; J. Zhou & Bai, 2023). Therefore, we stratified randomization by gender to ensure balanced group allocation.

Research has demonstrated significant associations between PSU and various psychosocial factors, including poor sleep quality, increased stress, anxiety, and depression (Nikolic et al., 2023). Insufficient sleep duration has been linked to adverse health outcomes such as reduced self-esteem, decreased productivity, poor quality of life, hypertension, cardiovascular diseases, obesity, diabetes, mortality, and emotional disturbances (Berger, Wahlstrom, & Widome, 2019; Short, Booth, Omar, Ostlundh, & Arora, 2020). These findings support the inclusion of sleep duration, sleep quality, and somatic and psychological symptoms as secondary outcomes in this trial. Globally, recent systematic reviews and meta-analyses report that 10–30 % of young adults meet criteria for problematic smartphone use, with university students showing the highest prevalence across Europe, North America, and Asia (Y. Wang et al., 2025). PSU can lead to various mental health problems, including anxiety, depression, perceived stress, loneliness, social phobia, poor sleep quality, and decreased academic performance. Moreover, excessive smartphone use is related to adverse physical health outcomes, such as craniocervical problems and somatization (Vujić et al., 2023). Given its high and rising prevalence, PSU is considered an emerging public health issue (Keller, Roitzheim, Radtke, Schenkel, & Schwarzer, 2021).

Current intervention programs for PSU are classified into six types: psychological intervention, information and communication technology (ICT)-based intervention, family intervention, educational intervention, exercise intervention, and other interventions (Wu & Chou, 2023). ICT-based interventions, delivered through web platforms, smartphone applications, and virtual reality, offer several advantages, including greater availability, enhanced accessibility, personalization, anonymity, and cost-effectiveness (Ding & Li, 2023). These features make ICT-based interventions a promising approach for addressing PSU (De Fabritiis et al., 2022).

WeChat is an instant messaging application for smartphones and the most popular social platform in China (Liang et al., 2023), with over 1 billion monthly active users (Lin et al., 2023). It is a free, highly accessible platform capable of presenting complex information through videos and graphics, making it an effective tool for disseminating health information. Numerous studies demonstrate that WeChat holds significant potential in health interventions (Mao et al., 2019). Research by Bi et al. (Bi et al., 2021) suggests that WeChat provides a feasible, effective and

sustainable management plan for the exercise rehabilitation of Baduanjin for patients with chronic obstructive pulmonary disease. Luo et al.(T. Luo, Li, Williams, Fritz, Beiter, Phillippi, Yu, Kantrow, Lin, et al., 2022) investigated the efficacy of WeChat-based smoking cessation interventions, with findings indicating that participants in the WeChat-based intervention group exhibited superior smoking cessation outcomes compared to the control group. WeChat public accounts are among the most popular features on the WeChat platform, and the health information they disseminate ranks among the most viewed, with high push and forwarding volumes(J. Wang & Wu, 2020). Thus, conducting interventions through WeChat official accounts holds great promise for public health initiatives. Health-related WeChat public accounts have experienced rapid development and play a significant role in public health education and promotion.(F. Wang et al., 2020). Therefore, conducting interventions through the WeChat official account platform holds great promise for advancing public health initiatives.

The Information-Motivation-Behavioral Skills (IMB) model, proposed by Fisher, serves as a theoretical framework for health behavior change(Qu et al., 2018). It involves interventions that provide information, motivation, and establish behavioral skills for a specific behavior, along with targeted improvement measures to promote effective behavior adoption. It is a systematic, scientific, and prospective model for behavioral change that has found broad applications across various medical care domains(Song, Zhang, & Wang, 2022). The IMB model has been widely applied in various healthcare domains and has demonstrated efficacy in modifying behaviors among substance abusers and in diverse health contexts(Cooperman, Richter, Bernstein, Steinberg, & Williams, 2015). However, the IMB model has not yet been applied to PSU intervention studies. In China, recent multicentre and cohort studies report that 27–28 % of university students meet criteria for PSU or dependence(Y. Wang et al., 2025), while a national campus survey found that 54% of undergraduates self-identified as having "mobile phone addiction," and 27% used their devices for more than eight hours daily. Unlike secondary school students, college freshmen have unrestricted access to smartphones and flexible schedules, increasing their risk of adverse outcomes. These statistics underscore the urgent need for theory-based interventions specifically targeting Chinese university students.

The primary aim of this trial was to reduce problematic smartphone use (PSU) among Chinese university students. Secondary objectives were to:

- (1) enhance motivation and behavioural skills for controlled use;
- (2) decrease daily screen time;
- (3) improve sleep duration and quality; and
- (4) alleviate associated somatic and psychological symptoms.

These variables were selected based on documented harms associated with PSU.

Therefore, building on the IMB model, this study formulated interventions targeting college students with PSU through the WeChat public account platform, emphasizing information provision, motivation enhancement, and behavioral skills development. The study aims to assess the efficacy of these interventions, with the goal of offering theoretical and technical support for preventing and

controlling PSU among college students.

2. Methods

2.1 Study Design

We conducted a randomized controlled trial between May and June 2023 in Hefei, Anhui Province, China. Ethical approval was obtained from the Ethics Committee of Anhui Medical University (NO. 83244555). All participants provided written informed consent prior to enrollment. Participation was voluntary and anonymous, and participants had the right to withdraw from the study at any time.

2.2 Participants

Participants were recruited offline and directed to complete an online screening questionnaire to assess eligibility. Individuals who met the inclusion criteria were invited to participate. Inclusion criteria were: (1) Meeting the criteria of the Smartphone Addiction Scale-Short Version (SAS-SV), with a score of ≥ 31 for males and ≥ 33 for females indicating PSU (Kwon et al., 2013); (2) College students over 18 years old; (3) Active use of WeChat software; (4) Voluntary participation in this study and signing of the informed consent form. Exclusion criteria: (1) Currently not enrolled in school due to reasons such as suspension; (2) Currently participating in other research projects; (3) Self-reported diagnosis of any neurological or psychiatric disorder.

A total of 210 college students were enrolled and analyzed on an intention-to-treat basis. The CONSORT flow diagram is shown in Figure 1. No statistically significant differences ($P > 0.05$) were found between the two groups in terms of gender, age, residential area, single-parent family status, parental education level, average annual household income, or any baseline outcome measures (Table 1), indicating successful randomization and group comparability.

Table 1 Baseline characteristics of the participants

Variable	All (N=210)	Intervention group (n=105)	Control group (n=105)	t/ χ^2 / Z	P value
Sex, n (%)				0.000	1.000
male	100 (47.6)	50 (47.6)	50 (47.6)		
female	110 (52.4)	55 (52.4)	55 (52.4)		
Age, mean (SD)	20.72 $\pm$ 0.91	20.70 $\pm$ 0.99	20.73 $\pm$ 0.82	0.226	0.821
Location, n (%)				1.597	0.660
village	77 (36.6)	35 (33.3)	42 (40.0)		
township/market town	34 (16.2)	17 (16.2)	17 (16.2)		
county	51 (24.3)	29 (27.6)	22 (21.0)		
city	48 (22.9)	24 (22.9)	24 (22.8)		
Educational background of father, n (%)				-0.046	0.963
primary and below	37 (17.6)	21 (20.0)	16 (15.2)		
junior high school	83 (39.5)	37 (35.2)	46 (43.8)		
senior high school	25 (11.9)	13 (12.4)	12 (11.4)		

technical/technical school	18 (8.6)	9 (8.6)	9 (8.6)		
junior college	21 (10.0)	12 (11.4)	9 (8.6)		
bachelor degree or above	26 (12.4)	13 (12.4)	13 (12.4)		
Educational background of mother, n (%)				-1.210	0.226
primary and below	78 (37.1)	35 (33.3)	43 (40.9)		
junior high school	58 (27.6)	30 (28.6)	28 (26.7)		
senior high school	23 (11.0)	10 (9.5)	13 (12.4)		
technical/technical school	21 (10.0)	13 (12.4)	8 (7.6)		
junior college	14 (6.7)	10 (9.5)	4 (3.8)		
bachelor degree or above	16 (7.6)	7 (6.7)	9 (8.6)		
Annual household income (RMB), n (%)				-1.211	0.226
<10000	35 (16.7)	12 (11.4)	23 (21.9)		
10000-19900	47 (22.4)	25 (23.8)	22 (21.0)		
20000-29900	38 (18.1)	22 (21.0)	16 (15.2)		
30000-39900	32 (15.2)	15 (14.3%)	17 (16.2)		
≥40000	58 (27.6)	31 (29.5)	27 (25.7)		
Smartphone addiction SAS-SV score	38.78±6.00	39.30±6.11	38.25±5.86	-1.279	0.202
Smartphone use time	7.14±2.57	7.23±2.66	7.06±2.49	-0.486	0.627
Main use of smartphone				6.949	0.139
Play games	34 (16.2)	16 (15.2)	18 (17.1)		
Chat	34 (16.2)	22 (21.0)	12 (11.4)		
Watch short videos	62 (29.5)	34 (32.4)	28 (26.7)		
Multimedia entertainment	56 (26.7)	25 (23.8)	31 (29.5)		
Others	24 (11.4)	8 (7.6)	16 (15.3)		
IMB score					
Information	10.0 (9.0□10.0)	10.0 (9.0□10.0)	9.0 (9.0□10.0)	-0.974	0.330
Motivation	69.47±13.20	69.12±13.14	69.82±13.31	0.381	0.704
Behavioral skills	29.23±5.78	29.31±5.55	29.14±6.03	-0.214	0.831
Sleep duration				-1.594	0.111
≤6.00h	23 (11.0)	11 (10.4)	12 (11.4)		
6.01~8.00h	121 (57.6)	68 (64.8)	53 (50.5)		
>8.00h	66 (31.4)	26 (24.8)	40 (38.1)		
Sleep quality				-1.872	0.061
Better	136 (64.7)	60 (57.1)	76 (72.4)		
Medium	56 (26.7)	38 (36.2)	18 (17.1)		
Worse	18 (8.6)	7 (6.7)	11 (10.5)		
Physical, psychological symptoms					
Dizzy (Y)	38 (18.1)	20 (19.0)	18 (17.1)	0.129	0.720
Vision problems (Y)	92 (43.8)	46 (43.8)	46 (43.8)	0.000	1.000
Neck problems (Y)	90 (42.9)	52 (49.5)	38 (36.2)	3.811	0.051
Gastrointestinal problems (Y)	53 (25.2)	30 (28.6)	23 (21.9)	1.237	0.266
Moody (Y)	44 (21.0)	26 (24.8)	18 (17.1)	1.840	0.175
Anxious (Y)	64 (30.5)	37 (35.2)	27 (25.7)	2.247	0.134
Difficulty concentrating (Y)	60 (28.6)	36 (34.3)	24 (22.9)	3.360	0.067
Physical activity				-0.698	0.485
Low intensity	183 (87.1)	90 (85.7)	93 (88.6)		
Medium intensity	19 (9.0)	9 (8.6)	10 (9.5)		
High intensity	8 (3.8)	6 (5.7)	2 (1.9)		

2.3 Intervention

2.3.1 Preparation for the Intervention Program

The information-motivation-behavior skill model was integrated into the intervention plan through the Wechat public account, through which knowledge related to PSU is delivered. The content designed through WeChat was as follows:

In simpler terms, the content above addresses the following topics: what is PSU; the criteria for diagnosing it; the harmful effects of PSU on physical health, mental health, learning, and daily life; real-life stories of college students addicted to their phones; real-life cases of overcoming phone addiction; how to identify and avoid addictive factors; the benefits of overcoming phone addiction; tips for improving self-control over phone usage; techniques to overcome phone addiction; strategies for coping with cravings or difficult situation; and ways to obtain personal or social support. The content of each module of WeChat public account is shown in Table A.1 in Supplementary material.

2.3.2 Implementation of the Intervention Program

The intervention group underwent a 6-week program. Participants were instructed to follow a dedicated WeChat official account and received automatically pushed articles or videos every two days at 10:00 PM. The content aimed to enhance knowledge, motivation, and behavioral skills related to reducing PSU. Furthermore, they were motivated to quit their addiction through real-life cases of PSU etc., in addition to some practical skills of overcoming.

Taking into account the efficacy of the intervention and the actual situation of the participants, the frequency of pushing on the public account was once every two days, specifically at 10 pm. Participants were encouraged to review previous messages and information sent through the WeChat public account, interact with researchers through individual messaging on WeChat, and join a WeChat group messaging platform for peer support and support from researchers. Participants could seek help anytime through individual messaging on WeChat or by making a phone call. During the intervention period, the platform recorded relevant information about each intervention in real-time, including reading time and the number of reads.

For the control group, no intervention was conducted, and they maintained their regular study and daily lives. In accordance with ethical considerations, the public WeChat account was promoted to the control group only after the intervention trial concluded.

Since the study participants were college students from the same institution, to prevent contamination between the two groups, the researchers conducted qualification audits in the background. Only after verification were participants able to successfully follow the public WeChat account. Additionally, the public WeChat account was set with permissions to prevent it from being searched by nonparticipating personnel, ensuring the smooth implementation of the intervention plan.

2.4 Outcomes

Detailed assessment procedures for all outcomes are described in the following sections.

2.5 Sample size, randomization and data collection

Sample size was calculated using PASS 11.0 software, assuming a two-sided test with $\alpha = 0.05$ and power = 0.95, and a 1:1 allocation ratio. The minimum required sample size was 158, which was adjusted to 190 to account for an anticipated 20% attrition rate. Ultimately, 210 participants were enrolled to further buffer against potential dropout and non-compliance. Participants were stratified by gender and randomly assigned to either the intervention or control group (105 per group).

Prior to the intervention, general demographic data (including age, gender, location, etc.) and other pertinent information were collected from the study participants. The Chinese version of the Smartphone Addiction Scale - Short Version (SAS-SV), containing 10 items and translated by Xiang Mingqiang et al.(qiang, Zi-rong, & Ben, 2019), was employed to assess the severity of PSU, given its good reliability. The IMB questionnaire encompassed three subscales: information, motivation, and behavioral skills. The information questionnaire was adapted from the "Knowledge and Attitude of Internet Addiction Syndrome" questionnaire compiled by Huang Yurong et al.(Huang, 2007), comprising 10 items presented in a question-and-answer format. The Motivation Questionnaire (Treatment Self-Regulation Questionnaire, TSRQ) was originally developed by Ryan and Connell in 1989(Levesque et al., 2007). In this study, the Chinese version of the TSRQ, adapted from Zhou Chenxi et al.(C. Zhou, 2020), consists of 15 items that inquire about an individual's likelihood of engaging in a specific behavior. The behavioral questionnaire utilizes the "Internet Use Self-efficacy Scale" developed by Luo Zhehui et al.(Z. Luo, Wan, Liu, & Fang, 2010).

2.6 Statistical Analysis

IBM SPSS Statistics 26.0 (IBM Corp) was used to process the data and conduct statistical comparisons between the intervention and control groups. Continuous variables were described by mean $\pm$ standard deviation (SD) or median (interquartile range, IQR); categorical variables were described by frequency and percentage. Independent *t* tests and chi-square tests were used to compare the distributions of the continuous and categorical variables, respectively. Differences in outcome indicators (smartphone addiction scores, phone usage time, Information-Motivation-Behavioral Skills questionnaire scores, sleep duration, sleep quality, and somatic, psychological symptoms related to PSU) between the intervention and control groups will be assessed through the establishment of Generalized Linear Mixed Models (GLMM) and Generalized Estimating Equations (GEE). The models will evaluate the main effects of the intervention and time series, as well as their interactive effects. Ordinal logistic regression was used to analyze differences in sleep duration and quality. All tests were two-tailed, with statistical significance set at $\alpha = 0.05$.

3. Results

Primary Outcome Analysis

At baseline, no statistically significant difference was observed in SAS-SV scores between the intervention and control groups ($P = 0.257$), confirming baseline equivalence. Following the 6-week intervention, the intervention group demonstrated significantly lower SAS-SV scores than the control group ($t = -3.025$, $P = 0.003$), indicating a beneficial effect of the IMB-based WeChat intervention on reducing PSU.

3.1 Baseline Equivalence

A total of 210 undergraduates were enrolled and analysed by intention-to-treat. Figure 1 shows the CONSORT flow diagram. Table 1 summarises demographics and all baseline outcome variables. No significant between-group differences emerged on gender, age, residential area, single-parent family status, parental education, household income, smartphone addiction scores (SAS-SV; $P = 0.257$), daily smartphone use time ($P = 0.623$), information, motivation, or behavioral skills subscale scores, sleep duration, sleep quality, or somatic/psychological symptoms (all $ps > 0.05$), confirming baseline equivalence.

3.2 Efficacy evaluation

3.2.1 SAS-SV Scores

Using a generalized linear mixed model, we analyzed the impact of group (intervention group, control group) and time (before and after intervention) on the level of PSU. The results revealed the existence of an interaction effect between group and time on SAS-SV scores ($P < 0.001$). See Table 2.

Table 2 Results of Generalized Linear Mixed Model and Generalized Estimating Equation Analysis for SAS-SV, IMB Framework, Smartphone Use Time, Sleep Outcomes, and Somatic Psychological Symptoms

Indicators		$\bar{x} \pm s$ / Frequency (n%)				P	Cohen's d	Effect Size (r)
		Pre-intervention	Post-intervention	Interaction effect	Groups			
SAS-SV				<0.001 ^a	0.277			
Intervention Group		39.30±6.11	34.67±7.32				-0.687	-0.325
Control Group		38.25±5.86	37.49±7.56				-0.112	-0.056
IMB frame Information				0.669 ^a	0.204		0.018	
Intervention Group		10.0 (9.0, 10.0)	10.0 (9.0, 10.0)					
Control Group		9.0 (9.0, 10.0)	9.0 (9.0, 10.0)					
Motivation				0.002 ^a	0.306		<0.001	
Intervention Group		69.12±13.14	74.58±12.54				0.425	0.208
Control Group		69.82±13.31	72.58±12.83				0.211	0.105
Behavioral Techniques				0.001 ^a	0.036		0.001	
Intervention Group		29.31±5.55	32.13±6.52				0.466	0.227
Control Group		29.14±6.03	29.21±6.50				0.011	0.006
Smartphone use time				0.004 ^a	0.183		<0.001	
Intervention Group		7.23±2.66	5.59±2.42				-0.645	-0.307
Control Group		7.06±2.49	6.55±2.62				-0.200	-0.099
Sleep duration				0.006 ^b	0.573		0.002	
Intervention Group		11 (10.5)	6 (5.7)					

When comparing the scores of the smartphone addiction scale across different time points between groups, no statistical difference was found in the scores between the intervention group and the control group before the intervention ($P=0.257$). However, following the intervention, a significant difference emerged in the scores of the smartphone addiction scale between the two groups. Specifically, the smartphone addiction scores of the intervention group were significantly lower than those of the control group after the intervention (*Cohen's d* = 0.52, 95% CI: 0.18–0.86, $P = 0.003$), indicating a medium intervention effect, as depicted in Table 2 and Figure 2.

3.2.2 Scores on Information, Motivation, and Behavioral Skills

A generalized linear mixed-effects model was employed to analyze the effects of group factors (intervention group, control group) and time factors (pre-intervention, post-intervention) on scores from the IMB scale. The results revealed differential time effects on scores from the information questionnaire ($P<0.05$). An interaction effect between group and time was observed on scores from the motivation scale ($P<0.05$). Inter-group differences in motivation scale scores were compared at different time points. The results indicated that there were no statistically significant differences in motivation scale scores between the two groups before the intervention ($P>0.05$). However, after intervention, scores on the motivation scale were higher in the intervention group compared to the control group (*Cohen's d* = 0.39, 95% CI: 0.05–0.73, $P = 0.026$), indicating a small-to-medium effect. Similarly, an interaction effect between group and time was observed on scores from the behavioral skills scale ($P<0.05$). Post-hoc between-group comparisons of behavioral skills scale scores at different time points revealed no statistically significant differences between the two groups before intervention ($P>0.05$), but after intervention, scores on the behavioral skills scale were higher in the intervention group compared to the control group (*Cohen's d* = 0.61, 95% CI: 0.27–0.95, $P = 0.001$), indicating a medium-to-large effect. For detailed t-values and p-values, see Table 3. Visual comparisons of pre- and post-intervention scores are also presented in Figure 2.

Table 3 Comparison of Group Differences at Different Time Points for SAS-SV, IMB Scores, and Smartphone Use Time

Intervention time point	Groups	<i>t</i>	<i>P-value</i>
SAS-SV			
Pre-intervention	Intervention vs Control	1.134	0.257
Post-intervention	Intervention vs Control	-3.025	0.003
Motivation			
Pre-intervention	Intervention vs Control	2.240	0.026

Post-intervention	Intervention vs Control	-1.322	0.698
Behavioral Techniques			
Pre-intervention	Intervention vs Control	3.436	0.001
Post-intervention	Intervention vs Control	0.201	0.840
Smartphone use time			
Pre-intervention	Intervention vs Control	0.492	0.623
Post-intervention	Intervention vs Control	-2.720	0.007

3.3 Secondary Outcomes

3.3.1 Smartphone use time

The generalized linear mixed model was used to analyze the impact of group factors (intervention group, control group) and time factors (before and after intervention) on smartphone use time. The results indicated significant interaction effects between group and time ($P < 0.05$). See Table 2.

When comparing smartphone usage time between groups at different time points, no statistically significant difference was observed between the intervention group and the control group prior to the intervention ($P = 0.623$). However, after the intervention, a significant difference was observed in the smartphone usage time between the two groups. Specifically, the intervention group demonstrated significantly lower smartphone usage time compared to the control group (*Cohen's $d = 0.47$, 95% CI: 0.13–0.81, $P = 0.007$*), indicating a medium effect, as shown in Table 3 and Figure 2.

3.3.2 Sleep duration

The effects of group factors (intervention group, control group) and time factors (pre- and post-intervention) on sleep duration were analyzed using generalized estimation equations. The results indicated a significant interaction effect between group and time on sleep duration ($P < 0.05$), as shown in Table 2.

An ordered logistic regression analysis was performed to investigate sleep duration at different time points. Both the ordered logistic regression models for sleep duration before and after the intervention met the parallelism assumption ($P = 0.960 > 0.05$ before intervention; $P = 0.127 > 0.05$ after intervention). Further analysis stratified by gender showed that the improvement in sleep duration and neck problems was more pronounced in certain subgroups. Detailed results of the stratified analysis are presented in Table 4.

Table 4 Results of Generalized Estimating Equation Analysis for Sleep Outcomes, and Somatic Psychological Symptoms (Gender)

In addition to gender, we	Indicators	<i>P</i>		
		Interaction effect	Groups	Times
	Sleep duration			
	Male	0.046	0.522	0.025
	Female	0.070	0.744	0.026
	Sleep Quality			
	Male	0.390	0.467	0.071
	Female	0.026	0.074	0.430
	Somatic Psychological Symptoms			
	Prevalence of dizziness			
	Male	0.987	0.242	0.243
	Female	0.070	0.136	0.935
	Prevalence of vision problems			
	Male	1.000	1.000	0.302
	Female	0.071	0.256	0.459
	Prevalence of neck problems			
	Male	0.366	0.002	0.651
	Female	0.333	0.718	0.037
	Prevalence of gastrointestinal problems			
	Male	0.499	0.643	0.284
	Female	0.851	0.230	0.851
	Moodiness			
	Male	0.743	0.790	0.132
	Female	0.284	0.126	0.705
	Anxiety			
	Male	0.694	0.101	0.284
	Female	0.417	0.534	0.638
	Difficulty in concentrating			
	Male	0.359	0.102	0.359
	Female	0.421	0.674	0.421

examined whether being an only child moderated the intervention effects. Table 5 presents the results of the generalized estimating equation analysis stratified by single-child status.

Table 5 Results of Generalized Estimating Equation Analysis for Sleep Outcomes, and Somatic Psychological Symptoms (Single child)

In	Indicators	<i>P</i>		
		Interaction effect	Groups	Times
	Sleep duration			
	Single child	0.593	0.851	0.132
	Non-single child	0.002	0.538	0.015
	Sleep Quality			
	Single child	0.075	0.432	0.991
	Non-single child	0.088	0.083	0.022
	Somatic Psychological Symptoms			
	<i>Prevalence of dizziness</i>			
	Single child	0.063	0.547	0.518
	Non-single child	0.924	0.915	0.417
	<i>Prevalence of vision problems</i>			
	Single child	0.144	0.091	0.558
	Non-single child	0.821	0.744	0.346
	<i>Prevalence of neck problems</i>			
	Single child	0.478	0.300	0.814
	Non-single child	0.488	0.059	0.028
	<i>Prevalence of gastrointestinal problems</i>			
	Single child	0.539	0.351	0.744
	Non-single child	0.083	0.687	0.583
	Moodiness			
	Single child	0.432	0.004	0.309
	Non-single child	0.727	0.485	0.043
	Anxiety			
	Single child	0.333	0.018	0.848
	Non-single child	0.937	0.876	0.457
	<i>Difficulty in concentrating</i>			
	Single child	0.339	0.063	0.728
	Non-single child	0.523	0.622	0.201

comparison to the control group, the sleep duration of the intervention group increased after the intervention. Using ordered logistic regression, we found that the intervention group had 2.088 times higher odds of longer sleep duration post-intervention (OR = 2.088, 95% CI: 1.048–4.162). Full regression results are shown in Table 6. However, there was no statistically significant difference in

sleep duration between the two groups before the intervention ($P>0.05$).

Table 6 Ordered logistic regression analysis of sleep duration and sleep quality at different time

Intervention time point	Factors	β	OR	P	OR 95%CI
Sleep duration					
Post-intervention	Intervention Group	0.736	2.088	0.036	1.048-4.162
	Control Group	-	1.000	-	-
Pre-intervention	Intervention Group	-0.437	0.646	0.110	0.378-1.105
	Control Group	-	1.000	-	-
Sleep quality					
Post-intervention	Intervention Group	0.252	1.287	0.355	0.754-2.197
	Control Group		1.000	-	-
Pre-intervention	Intervention Group	-0.743	0.476	0.009	0.272-0.831
	Control Group	-	1.000	-	-

3.3.3 Sleep Quality

Using the generalized estimating equation model, we investigated the effects of group factors (intervention group, control group) and time factors (pre-intervention, post-intervention) on the sleep quality of college students with PSU. The results indicated the presence of an interaction effect between group and time factors ($P<0.05$), as shown in Table 2.

Ordered logistic regression analysis was conducted on sleep quality at different time points, and the assumption of parallelism was satisfied for the ordered logistic regression models of sleep quality both before and after intervention (pre-intervention $P=0.153>0.05$; post-intervention $P=0.754>0.05$). The results of the ordered logistic regression analysis revealed a difference in sleep quality between the two groups prior to the intervention ($OR=0.476$, 95% CI: 0.272, 0.831). Compared with the control group, the likelihood of better sleep quality in the intervention group was 0.476 times that of the control group. However, there was no statistically significant difference in sleep quality between the two groups after intervention ($P>0.05$), as shown in Table 4.

3.3.4 Somatic, psychological symptoms

Utilizing a generalized estimating equation model, we examined the effects of group factors (intervention group, control group) and time factors (pre-intervention, post-intervention) on the

occurrence of sleep problems, fatigue, dizziness, eye discomfort, neck problems, and gastrointestinal problems among college students with PSU. The results showed that only the occurrence rate of neck problems differed between the groups, with a higher occurrence rate observed in the intervention group compared to the control group. The occurrence rate of neck problems in the intervention group was 1.759 times that of the control group ($P=0.02$, 95% *CI*: 1.091, 2.836). There were no interaction effects observed for other somatic, psychological symptoms such as dizziness, vision problems, sleep problems, gastrointestinal problems, depression, anxiety, and difficulty concentrating ($P>0.05$). Refer to Table 2 for details.

4. Discussion

In recent years, numerous studies have confirmed the efficacy and feasibility of WeChat-based interventions in reducing substance use (Chen, Qian, Sun, Lin, & Tang, 2019; Liao, Wang, Liu, McNeill, & Tang, 2021; T. Luo, Li, Williams, Fritz, Beiter, Phillippi, Yu, Kantrow, Chen, et al., 2022). However, the WeChat platform has not yet been used for intervention studies on behavioral addictions. Therefore, this study conducted a research project based on the WeChat platform to intervene in PSU. In order to ensure the efficacy of the intervention program's basic structure, a prudent approach is to ground the intervention method in a thoroughly researched theoretical treatment framework, thereby providing theoretical support for explaining the intervention effects (Lam & Lam, 2016). The theoretical basis provides key factors foundation identifies key factors involved in the intervention process and their interactions, thus helping to explain the mechanism of intervention trials, facilitating in-depth research and evaluation of intervention plan components and steps, determining which intervention factors are key and effective, and making necessary adjustments and improvements in practice. Opportunely, the IMB model has been widely used to predict changes in health behaviors across diverse populations (Chang et al., 2018), and it has been proven to be an effective model for improving health practices (Charles Shapu, Ismail, Ahmad, Ying, & Abubakar Njodi, 2020). Therefore, this research conducted a randomized controlled trial based on the IMB model using WeChat public accounts to intervene in PSU.

Our findings demonstrate that participants who received the WeChat official-account intervention exhibited significantly lower smartphone-addiction scale scores and shorter daily screen time than controls, indicating that a brief, theory-driven, mobile-delivered program can effectively reduce PSU levels among university students. With respect to the IMB components, information scores increased over time in both groups, with no significant between-group difference post-intervention. This pattern likely reflects the ubiquitous availability of online health material, which enables students to acquire similar knowledge independently (Stellefson et al., 2011). Consequently, information provision alone appears insufficient to elicit behavioral change in the context of PSU.

By contrast, significant group $\times$ time interactions emerged for both motivation and behavioral skills. Post-intervention motivation scores were significantly higher in the intervention group, supporting previous evidence that motivation to change is a key precursor of reduced smartphone use (Jin, Jiang, Xiong, & Zhao, 2023). The intervention adopted a participant-centered approach,

using real-life narratives and peer support to enhance intrinsic and extrinsic motivation for limiting smartphone use.

Additionally, the intervention group demonstrated higher addiction cessation skill scale scores compared to the control group after the intervention, indicating the efficacy of WeChat intervention in enabling participants to acquire more addiction cessation skills. Behavioral skills refer to individuals' objective skills and perceptual abilities to implement healthy behaviors (Bakır, Çavuşoğlu, & Mengen, 2021). In this study, we provided the research subjects with several addiction cessation skills in the form of videos, texts, images, etc., including setting limits on smartphone usage time, replacing smartphone usage with other activities (such as talking with family or friends, exercising, or reading), improving cognitive perception of smartphone usage, and alleviating social psychological symptoms. These cessation skills have been proven effective in reducing PSU tendencies in previous studies. For example, Jay A Olson et al. implemented several interventions (modulating the brightness of the phone to grayscale, turning off unnecessary notification alerts, muting the phone and placing it out of reach during sleep, etc.), and the results showed that compared to the control group, the intervention group reduced problematic phone usage and decreased screen time (Olson, Sandra, Chmoulevitch, Raz, & Veissière, 2022). Additionally, reading and moderate-intensity aerobic exercise can improve self-control ability in smartphone-addicted college students, with reading potentially even more effective than short bouts of moderate-intensity aerobic exercise (J. Zhou & Wang, 2022). Although the addiction levels of the research subjects decreased, it is unclear which specific behavioral skills were effective, or if it was a combination of several behavioral skills. Further in-depth research may be needed in the future to determine this. In summary, providing the research subjects with a series of behavioral skills to master addiction cessation techniques can help them break free from PSU.

Among secondary outcomes, sleep duration was significantly longer in the intervention group post-intervention, whereas sleep quality did not differ between groups. This discrepancy underscores that sleep quality is multifactorial—influenced by habits, environment, sleep latency, and psychological status beyond mere screen-time reduction (Zhang et al., 2024). Incorporating sleep-hygiene or stress-management modules may enhance future interventions.

Regarding somatic symptoms, only neck problems differed significantly between groups, with higher baseline incidence in the intervention arm (49.5 % vs. 36.2 %). Both groups exhibited parallel reductions post-intervention (≈ 6.6 %). Because cervical discomfort is often chronic, a six-week timeframe may be insufficient to detect clinically meaningful improvement. Longer-term trials are needed to evaluate somatic benefits.

Despite these promising findings, several limitations should be acknowledged. First, the sample was recruited from a single university, which may limit generalizability to broader populations. Second, the use of a passive control group introduces the possibility of placebo or demand effects. Future studies should include active control conditions to enhance internal validity. Third, the intervention duration was relatively short (6 weeks) and no long-term follow-up was conducted.

Thus, the sustainability of the observed effects remains unknown. Finally, while improvements in motivation and behavioral skills were observed, mediation analysis was not performed. Future research should employ structural equation modeling to formally test the IMB pathway.

5. Conclusions

This study provides empirical support for the feasibility and effectiveness of a WeChat-based intervention, grounded in the IMB model, for reducing problematic smartphone use among Chinese college students. The intervention not only reduced PSU levels, but also enhanced motivation and behavioral skills, which are key determinants of sustained behavior change. These findings contribute to the growing body of evidence on digital health interventions and offer a scalable, low-cost approach to addressing PSU in university settings. Further research is needed to confirm long-term efficacy, test mediation mechanisms, and evaluate generalizability across diverse populations.

Declarations of interest

None.

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Figure 1 CONSORT Flow Diagram. CONSORT: consolidated standards of reporting trials

Figure 2 Comparison of SAS-SV score, Smartphone usage time, Motivation, and Behavioural skills scale scores before and after intervention in the two groups. SAS-SV: Smartphone Addiction Scale-Short Version.



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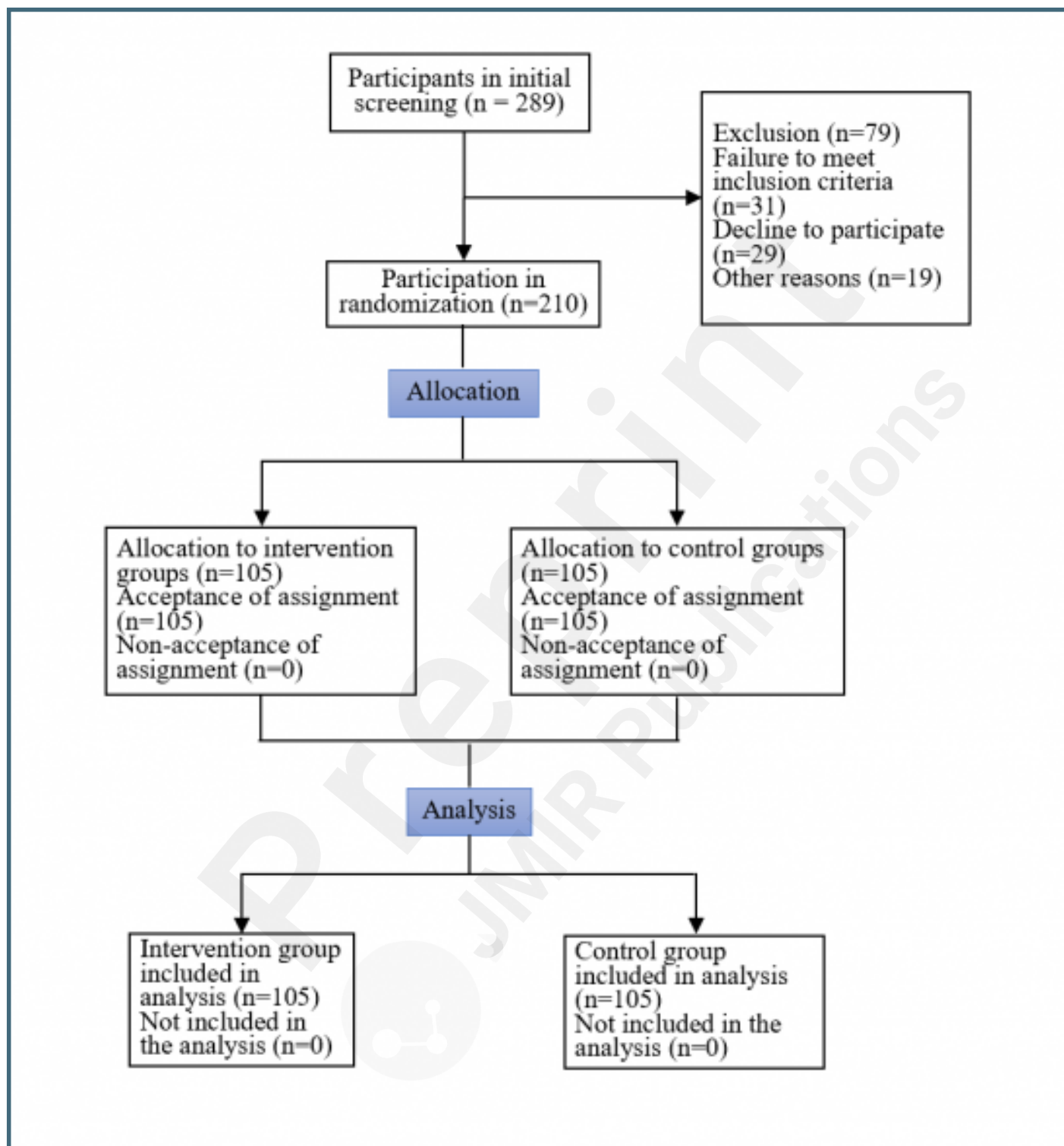
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Supplementary Files

Figures

CONSORT flow diagram.



The scores of the smartphone addiction scale.

