

The effectiveness of WeChat public account intervention based on the IMB model among college students with internet addiction: a randomized controlled trial

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Abstract

Background: Over the years, domestic and foreign scholars in different fields have carried out a large number of studies on the intervention methods of Internet addiction, mainly including Group counseling, Cognitive Behavioral Therapy, psychological health education, sports therapy, acupuncture, pharmacotherapy, and comprehensive intervention. However, these interventions face significant challenges in scalability and accessibility due to constraints posed by time, space, participant numbers, cost, and privacy concerns.

Objective: This study examines the effect of WeChat public accounts intervention based on the Information-Motivation-Behavioral Skills Model (IMB) model to improve internet addiction in college students as well as the potential mechanism of action that causes changes in addictive behaviors.

Methods: We recruited 226 internet-addicted college students, randomly assigning them to an intervention (n=113) or control group (n=113), with gender as the stratification factor. The intervention group underwent a structured, six-week program leveraging WeChat public accounts intervention, while the control group continued their regular routines without intervention. Pre-intervention data were subjected to statistical comparison using independent samples t-test, Mann-Whitney U test, and chi-square (2) test. To evaluate the intervention's effects and identify pre- to post-intervention changes, we utilized Generalized Linear Mixed Models (GLMM) and Generalized Estimating Equations (GEE) for analysis with SPSS 23.0, considering statistical significance at $\alpha = 0.05$.

Results: The intervention group showed significant improvement in internet addiction ($2=14.154$, $P<0.001$). GLMM analysis confirmed a substantial reduction in addiction levels post-intervention compared to the control group (adjusted mean change: -4.531 , 95%CI: -7.281 to -1.781 , $P=0.001$), with no significant differences in internet usage time. GEE analysis revealed a significant interaction effect of time and group on sleep duration ($P<0.001$) with the intervention group showing a significant increase post-intervention (OR=2.186, 95%CI: 1.142 to 4.183, $P=0.018$). No significant differences were observed between the groups in sleep quality and somatic-psychological symptoms.

The intervention group showed increased motivation (adjusted mean change: 4.283, 95%CI: 0.804 to 7.763, $P=0.016$) and behavioral skills (adjusted mean change: 3.407, 95%CI: 1.771 to 5.043, $P<0.001$) post-intervention.

Conclusions: The WeChat public accounts intervention based on the IMB mode can significantly reduce the level of internet addiction in college students and simultaneously have a positive effect on increasing sleep duration.

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Abstract

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Methods

We recruited 226 internet-addicted college students, randomly assigning them to an intervention (n=113) or control group (n=113), with gender as the stratification factor. The intervention group underwent a structured, six-week program leveraging WeChat public accounts intervention, while the control group continued their regular routines without intervention. Pre-intervention data were subjected to statistical comparison using independent samples *t*-test, Mann-Whitney *U* test, and chi-square (χ^2) test. To evaluate the intervention's effects and identify pre- to post-intervention changes, we utilized Generalized Linear Mixed Models (GLMM) and Generalized Estimating Equations (GEE) for analysis with SPSS 23.0, considering statistical significance at $\alpha = 0.05$.

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The intervention group showed significant improvement in internet addiction ($\chi^2=14.154$, $P<0.001$). GLMM analysis confirmed a substantial reduction in addiction levels post-intervention compared to the control group (adjusted mean change: -4.531, 95%CI: -7.281 to -1.781, $P=0.001$), with no significant differences in internet usage time. GEE analysis revealed a significant interaction effect of time and group on sleep duration ($P<0.001$) with the intervention group showing a significant increase post-intervention ($OR=2.186$, 95%CI: 1.142 to 4.183, $P=0.018$). No significant differences were observed between the groups in sleep quality and somatic-psychological symptoms.

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Conclusion

The WeChat public accounts intervention based on the IMB mode can significantly reduce the level of internet addiction in college students and simultaneously have a positive effect on increasing sleep duration.

Keywords: IMB model; Internet addiction; WeChat public accounts; Randomized controlled trial; Intervention

1 Introduction

The extensive and pervasive adoption of the Internet across various societal sectors has resulted in a significant increase in the global number of internet users. According to the 53rd China Statistical Report on Internet Development released by China Internet Network Information Center¹, by December 2023, China boasted an internet user population of 1.092 billion, with a penetration rate of 77.5%. Remarkably, users spend an average of 26.1 hours online weekly, with 99.9% accessing the internet through mobile devices. This digital revolution has, however, introduced a significant societal challenge: Internet Addiction (IA), which is particularly concerning among adolescents and young adults.² College students, who rely heavily on the internet for education, entertainment, and communication, are especially susceptible to its allure. Their increased independence, coupled with often insufficient self-control and a quest for self-expression, makes them particularly vulnerable to the negative effects of digital media^{3,4}. Consequently, many college students find themselves exhibiting symptoms of IA, which can inflict detrimental impacts on their physical, mental, and social well-being.⁵⁻⁸ Studies worldwide confirm these concerns, with high IA prevalence rates among college students. For instance, Salarvand et al.⁹ found a 31.51% addiction rate among 16,585 Iranian college students. A meta-analysis involving 22 studies in seven countries showed that the prevalence of Internet addiction among middle school students and college students in Africa was 32.2% and 42.0%¹⁰. Within China, Cai et al.¹¹ conducted a study among 1070 medical students from five universities, discovering a prevalence range of 20.7% to 25.8% for IA, with senior students being more prone to this addiction than their junior counterparts. Given these alarming statistics and the profound implications of IA on college students' lives, it is imperative that we take proactive measures to prevent and mitigate its onset.

Over the years, domestic and foreign scholars in different fields have carried out a large number of studies on the intervention methods of Internet addiction, mainly including Group counseling¹²,

Cognitive Behavioral Therapy¹³, psychological health education^{14,15}, sports therapy¹⁶, acupuncture¹⁷, pharmacotherapy¹⁸, and comprehensive intervention^{19,20}. However, these interventions face significant challenges in scalability and accessibility due to constraints posed by time, space, participant numbers, cost, and privacy concerns. The emergence of online interventions for Internet Addiction (IA) represents a groundbreaking approach, harmoniously blending psychological insights with internet-based information and communication technologies. This innovative model offers distinct advantages over conventional methods, including cost-effectiveness and broader accessibility, thus reaching a wider audience. It also overcomes barriers related to time, scheduling, location, and participant limits, promoting greater inclusivity.²¹ In comparison to conventional face-to-face interventions, online interventions offer a unique advantage in mitigating the negative psychosocial impacts associated with stigma and social anxiety. They encourage individuals afflicted with IA to embrace help-seeking behavior, fueling social engagement and motivation.^{22,23} Based on WeChat's social influence and huge user scale, it is of great practical significance to carry out science popularization and information transmission through WeChat public accounts. Previous studies have shown that WeChat intervention has achieved certain effects in reducing tobacco²⁴ and alcohol overuse²⁵. Although research directly addressing IA through WeChat public account interventions is yet to be reported, mounting evidence from psychology and neurobiology underscores similarities between IA and other forms of substance and behavioral addictions²⁶. This underlines the plausibility of online intervention as a viable and potentially impactful approach to ameliorate IA among college students.

The Information-Motivation-Behavioral Skills Model (IMB) is mainly used to predict preventive health behaviors and implement health education. This model introduces the concepts of "motivation" and "self-efficacy" from rational behavior theory²⁷ and social cognition theory²⁸ respectively, and divides the factors affecting individual behavior transformation into three components: information, motivation and behavioral skills. By employing these three core

components, the IMB endeavors to elucidate the intricate process of behavior change, elucidating both the direct and indirect relationships among behavioral determinants, their strengths, and the directionality of these associations. Ultimately, this approach facilitates a deeper understanding and prediction of behaviors, guiding the exploration of optimal intervention strategies. Notably, information, motivation, behavior, and skills not only function as independent variables that directly shape individual behavior but also interactively influence behavior through their intricate interplay.²⁹ When individuals attain a threshold level of proficiency in these areas, they are poised to embark on behavioral shifts that ultimately contribute to health promotion goals. As a systematic and scientific theoretical model of behavioral transformation, IMB has been widely used in behavioral intervention studies of various diseases such as diabetes³⁰, AIDS³¹ and cardiovascular disease³². Compared with other theories, IMB model is easier to implement intervention practice from theoretical research, which can provide theoretical support for better prevention and control of IA.

Therefore, this study selected college students with internet addiction as research objects and conducted a six-week randomized controlled trial to evaluate the effect of WeChat public account intervention based on IMB model on improving internet addiction among college students, and attempted to explore the potential mechanism of addictive behavior change from the perspectives of information, motivation and behavioral skills. In order to explore a new model of online treatment of Internet addiction, it provides a new idea for the intervention research of internet addiction in college students.

2 Methods

This study followed the reporting guidelines which were established by Consolidated Standards of Reporting Trials (CONSORT 2010).³³ We are registered with ClinicalTrials.gov, registration number NCT06704984. The recruitment of participants for this study commenced on March 1, 2023, and concluded on April 1, 2023. By recruiting college students with internet addiction who

voluntarily participated in this study, we obtained their informed consent. Following this, participants who met the criteria were selected and randomly divided into the intervention group and the control group. The study design received ethical clearance from the University's Ethics Committee (approval number: 20190495), ensuring that all research activities adhered to ethical principles and that participants' information remained strictly confidential, solely for scientific purposes and without any risk of disclosure.

2.1 Participant inclusion/exclusion criteria

Inclusion criteria: (1) College students diagnosed with Internet addiction, as evidenced by an IAT scale score of 40 or above; (2) Age range between 18 and 24 years; (3) Use WeChat software; (4) Good physical health, capable of completing the whole process of the study; (5) Voluntary participation with a signed Informed Consent form.

Exclusion criteria: (1) Presence of any mental illness or cognitive impairment; (2) Current or impending receipt of psychological or pharmacological treatment for a mental health condition; (3) Circumstances that would hinder participation, such as internships, suspensions, or other reasons for absence from school; (4) Refusal to participate in the study.

2.2 Randomization

Haiyan Shi, a researcher, utilized stratified randomization to generate the random allocation sequence for participants. Guifang Jin was responsible for recruiting these participants, while Wenzhuo Xu assigned them to their respective intervention or control groups according to the randomized sequence. Once enrolled, participants were not permitted to switch groups, maintaining the integrity of the study design. Due to the specific nature of the intervention, it was not possible to blind the study participants. The statistical analysis of the data ensured the separation of study participants, intervention implementers and data collectors, and the statistical analyses were carried out by separate staff.

2.3 Sample size calculation

This study was designed as a randomized controlled trial, with sample size determination grounded in internet addiction scores. Utilizing a bilateral test with $\alpha=0.05$ and $1-\beta=0.90$, a 1:1 ratio was established between the intervention and control groups. Given the novelty of the WeChat public account intervention for internet addiction, a preliminary trial involving 60 college students with the condition was conducted to inform sample size calculations. Participants were randomly assigned to either the intervention group ($n=30$) or the control group ($n=30$), yielding TAT scale scores of 50.27 ± 12.28 in the intervention group and 56.43 ± 12.64 in the control group. Based on these findings, a total sample size of 170 individuals was determined, with an allowance for 10% attrition due to ineligibility, non-compliance, or loss to follow-up, resulting in a requirement for 187 participants. Ultimately, 226 participants were recruited, with 113 assigned to each group.

2.4. Interventions

Intervention group: A six-week intervention leveraging an online WeChat public account was implemented, integrating the IMB model into its design. Drawing from literature analysis, the intervention plan was structured into three distinct modules: information, motivation, and behavioral skills. The comprehensive intervention encompassed disseminating knowledge on Internet addiction, identifying and avoiding triggers, fostering withdrawal motivation, imparting coping strategies for cravings and challenging situations, enhancing self-efficacy, and facilitating access to personal and social support. Participants who followed the WeChat public account received automated push notifications containing articles or videos every two days. Throughout the intervention period, engagement was monitored by tracking the readership of the sent content through the WeChat public account's backend data. The intervention plan of WeChat public account based on IMB model is shown in Supplementary table 1 for details.

Control group: without any intervention, maintain normal life and study state.

To mitigate potential contamination between the intervention and control groups, participants were instructed to refrain from sharing group-specific information with others during the intervention period. Furthermore, the WeChat public account was configured with search restrictions, ensuring that non-intervention participants could not access its content. Additionally, the researchers employed the WeChat public account platform to monitor and confirm that only those in the intervention group were following the account, thereby facilitating the seamless execution of the intervention experiment.

2.5 Data collection and outcomes

The researchers adopted a comprehensive approach to data collection, utilizing paper questionnaires to gather both baseline demographic information and various indicators from participants before and one week post-intervention.

(1) Main indicators: Internet addiction. The 20-item IAT scale prepared by Young³⁴ was used to investigate the Internet addiction of the participants. This scale employed a 5-point Likert scale, ranging from a total score of 20 to 100. Scores were interpreted as follows: 20-39 indicated no Internet addiction, 40-69 mild Internet addiction, and ≥ 70 moderate to severe Internet addiction. Notably, the scale demonstrated robust reliability, with Cronbach's α coefficients of 0.81 and 0.87 pre- and post-intervention, respectively, and a retest reliability of 0.88.

(2) Secondary indicators: The participants' Internet time, sleep duration, sleep quality and somatic-psychological symptoms in the past month were collected.

(3) Other indicators:

Knowledge related to Internet addiction (Information): To assess participants' knowledge regarding Internet addiction, a self-designed questionnaire was employed, tailored from the comprehensive "Knowledge and Attitude of Internet Addiction" questionnaire by Huang Yurong et al.³⁵ This instrument comprises 10 judgment questions, ensuring a balanced assessment. A scoring system was implemented, awarding one point for each correct answer and zero for incorrect or

unclear responses, with specific items (3, 4, 7, and 9) utilizing reverse scoring to minimize bias. The total score ranges from 0 to 10, reflecting a higher level of mastery over Internet addiction-related knowledge with an increased score. Notably, the questionnaire's retest reliability of 0.84 underscores its high stability and reliability.

Internet addiction improves motivation situation (Motivation): To gauge participants' motivation towards improving their Internet addiction, the Treatment Self-Regulation Questionnaire (TSRQ) was utilized, drawing upon the Chinese version adapted by Zhou Chenxi et al.³⁶ in collaboration with foreign scholars. This 15-item questionnaire adopts a 7-point Likert scale, yielding a total score that spans from 15 to 105. Higher scores indicative of a stronger willingness to engage in treatment for Internet addiction demonstrate the instrument's sensitivity to individual motivation levels. The questionnaire's Cronbach's α coefficient, both pre- and post-intervention, stood at 0.81, while its retest reliability reached 0.82, reinforcing its internal consistency and reliability.

Internet Control Self-efficacy (Behavioral skills) : To evaluate participants' behavioral skills in managing their Internet addiction, the Internet Control Self-efficacy Questionnaire (ICSQ) compiled by Luo et al.³⁷ was administered. This questionnaire encapsulates 12 items, focusing on crucial aspects such as time management, task control, and clarity of purpose. Each item is scored on a 4-point Likert scale, resulting in a total score that varies from 12 to 48. The higher the score, the higher the network control self-efficacy. In this study, the Cronbach's α coefficient of the scale before and after intervention were 0.90 and 0.93, respectively, and the retest reliability was 0.80.

2.6 Statistics analysis

For the continuous variables, a comprehensive assessment of the changes in IAT scale scores, time spent online, and IMB scores between the intervention and control groups, both pre- and post-intervention, was conducted using Generalized Linear Mixed Models (GLMMs). This approach allowed us to account for potential variability within and between subjects, enhancing the robustness of our findings. Specifically, the model was constructed with fixed effects comprising group factors

(distinguishing between the intervention and control groups), time factors (indicating pre- and post-intervention periods), and their interaction (group $\times$ time), providing insights into how the intervention impacted these outcomes over time. Holm-Bonferroni correction was used to compare the differences between groups at different time points on the basis of corrected baseline data. For categorical variables, the differences in sleep duration, sleep quality and somatic-psychological symptoms between the two groups before and after intervention were analyzed by Generalized Estimated Equation (GEE). Group factors, time factors, group $\times$ time interaction terms were incorporated into the model to compare the differences between groups. When the outcome variables were ordered multiple categorical variables (sleep duration, sleep quality), the difference between the groups at different time points was analyzed by ordered Logistic regression. Bilateral test, $\alpha=0.05$.

3 Results

3.1 Demographic characteristics of the participants

A total of 226 participants, who fulfilled the inclusion criteria, were chosen from a pool of 312 college students. Stratified by gender, they were randomly assigned to either the intervention group (n=113) or the control group (n=113), as depicted in the CONSORT flowchart in Figure 1. The mean age of the participants was 20.75 ± 0.93 years, with a gender distribution of 48.7% males and 51.3% females. A detailed comparison of demographic characteristics between the intervention and control groups is provided in Table 1. No statistically significant differences were observed in terms of age, gender, family residence, or the status of being an only child ($P > 0.05$), ensuring the baseline comparability of the two groups.

Table 1 Demographic characteristics of the participants in the two groups

Variables	Total sample size	Intervention	Control	t/χ^2	P
		group	group		
	n=226	n=113	n=113		

Age (years, $\bar{x} \pm s$)	20.75 $\pm$ 0.93	20.79 $\pm$ 1.02	20.71 $\pm$ 0.82	-	0.519
				0.646	
Gender N (%)				<0.00	>0.99
male	110 $\square$ 48.7 $\square$	55 $\square$ 48.7 $\square$	55 $\square$ 48.7 $\square$	1	9
female	116 $\square$ 51.3 $\square$	58 $\square$ 51.3 $\square$	58 $\square$ 51.3 $\square$		
Family place of residence N (%)				1.220	0.748
village	79 $\square$ 35.0 $\square$	38 $\square$ 33.6 $\square$	41 $\square$ 36.3 $\square$		
township	38 $\square$ 16.8 $\square$	17 $\square$ 15.0 $\square$	21 $\square$ 18.6 $\square$		
county	54 $\square$ 23.9 $\square$	30 $\square$ 26.5 $\square$	24 $\square$ 21.2 $\square$		
city	55 $\square$ 24.3 $\square$	28 $\square$ 24.8 $\square$	27 $\square$ 23.9 $\square$		
The one-child N (%)				2.304	0.129
yes	83 $\square$ 36.7 $\square$	47 $\square$ 41.6 $\square$	36 $\square$ 31.9 $\square$		
no	143 $\square$ 63.3 $\square$	66 $\square$ 58.4 $\square$	77 $\square$ 68.1 $\square$		
Education level of father N (%)				1.441	0.837
Primary and below	39 $\square$ 17.3 $\square$	22 $\square$ 19.5 $\square$	17 $\square$ 15.0 $\square$		
Junior high school	87 $\square$ 38.5 $\square$	40 $\square$ 35.4 $\square$	47 $\square$ 41.6 $\square$		
Senior high school	24 $\square$ 10.6 $\square$	13 $\square$ 11.5 $\square$	11 $\square$ 9.7 $\square$		
Technical/technical school	19 $\square$ 8.4 $\square$	9 $\square$ 8.0 $\square$	10 $\square$ 8.8 $\square$		
College or above	57 $\square$ 25.2 $\square$	29 $\square$ 25.7 $\square$	28 $\square$ 24.8 $\square$		
Education level of mother N (%)				3.930	0.416
Primary and below	81 $\square$ 35.8 $\square$	37 $\square$ 32.7 $\square$	44 (38.9)		
Junior high school	62 $\square$ 27.4 $\square$	33 $\square$ 29.2 $\square$	29 (25.7)		
Senior high school	24 $\square$ 10.6 $\square$	9 $\square$ 8.0 $\square$	15 (13.3)		
Technical/technical school	24 $\square$ 10.6 $\square$	13 $\square$ 11.5 $\square$	11 (9.7)		
College or above	35 $\square$ 15.5 $\square$	21 $\square$ 18.6 $\square$	14 (12.4)		
Annual household income per capita N (%)				6.891	0.142

< 10,000 yuan	38□16.8□	13□11.5□	25□22.1□		
10,000 to 19,900 yuan	49□21.7□	27□23.9□	22□19.5□		
20,000 to 29,900 yuan	40□17.7□	25□22.1□	15□13.3□		
30,000 to 39,900 yuan	31□13.7□	15□13.3□	16□14.2□		
≥ 40,000 yuan	68□30.1□	33□29.2□	35□31.0□		
Academic performance N (%)				0.852	0.653
Lower middle class/Lower class	53□23.5□	29□25.7□	24□21.2□		
intermediate	75□33.2□	38□33.6□	37□32.7□		
Medium/Fine	98□43.4□	46□40.7□	52□46.0□		

3.2 Baseline Comparison of Outcome Measures

At the outset of the study, participants exhibited an average Internet Addiction Test (IAT) score of 53.43 ± 9.99 , and the mean daily internet usage over the past month was 7.76 ± 2.54 hours. A thorough statistical comparison of key outcome indicators—including IAT scores, internet usage time, sleep duration, sleep quality, and the presence of somatic and psychological symptoms, as well as IMB scores—between the intervention and control groups showed no significant discrepancies ($P > 0.05$). This indicates that the groups were equivalent at baseline, providing a robust foundation for the analysis of the intervention's impact. (Table 2)

Table 2 Comparison of baseline outcome indicators between the two groups

Variables	Total sample size □n=226□	Intervention group □n=113□	Control group □n=113□	$t/\chi^2/Z$	P
IAT Scale□ $\bar{x} \pm s$ □	53.43±9.99	53.66±11.03	53.20±8.88	- 0.346	0.73 0
Internet usage time□ $\bar{x} \pm s$ □	7.76±2.54	8.01±2.50	7.52±2.57	- 1.461	0.14 5
Sleep time N (%)				5.34	0.06

≤6h	25□11.1□	13□11.5□	12□10.6□		9
6.01~8.00h	129□57.1□	72□63.7□	57□50.4□		
>8h	72□31.9□	28□24.8□	44□38.9□		
Sleep quality N (%)				1.309	0.52
preferably	65□28.8□	30□26.5□	35□31.0□		0
normal	142□62.8□	75□66.4□	67□59.3□		
poor	19□8.4□	8□7.1□	11□9.7□		
Somatopsychological symptoms					
N (%)					
Dizziness (yes)	43□19.0□	23□20.4□	20□17.7□	0.258	0.61
					1
Eye discomfort (Yes)	95□42.0□	45□39.8□	50□44.2□	0.454	0.50
					0
Gastrointestinal problems (Yes)	57□25.2□	32□28.3□	25□22.1□	1.150	0.28
					4
Depressed mood (yes)	49□21.7□	28□24.8□	21□18.6□	1.277	0.25
					8
Anxiety (yes)	67□29.6□	38□33.6□	29□25.7□	1.718	0.19
					0
Difficulty concentrating (yes)	61□27.0□	37□32.7□	24□21.2□	3.795	0.05
					1
IMB score					
Information M□P25, P75□	10.00□9.00,	10.00□9.00,	10.00□9.00,	-	0.92
	10.00□	10.00□	10.00□	0.091	7
Motivation□ $\bar{x}$ ±s□	69.27±14.11	68.67±13.65	69.88±14.59	-	0.52
				0.640	3
Behavior Skills□ $\bar{x}$ ±s□	29.40±5.94	29.40±5.80	29.41±6.10	0.011	0.99
					1

3.3 WeChat public account intervention

Throughout the intervention phase, participants received two posts every two days on the WeChat public account, with an additional post on weekends during the second to fifth weeks, totaling 46 interventions. These interventions were categorized into 11 focused on information, 19 on motivation, and 16 on behavioral skills. The intervention format included video, pictures and text. During the intervention period, the average number of times the intervention content was read was recorded through the WeChat public number background data, as shown in Figure 2.

3.4 Intervention effect of WeChat public account on internet addiction of college students

3.4.1 Main Indicators

The main outcome indicator of this study was IAT scale score. To meticulously assess the differences between the intervention and control groups, we employed both dichotomous and continuous variables as our outcome metrics. Specifically, we categorized the variations in IAT scores before and after the intervention into two distinct groups: a reduction of ≥ 12 points in the IAT score was deemed indicative of a significant improvement in internet addiction symptoms, whereas any lesser decrease was considered as no substantial improvement. Notably, the Chi-square test yielded compelling results, revealing a statistically significant divergence in the intervention effects between the two groups ($\chi^2=14.154$, $P<0.001$), as tabulated in Table 3.

Table 3 Comparison of internet addiction intervention effectiveness between groups

Groups	Improved N (%)	Not improved N (%)	χ^2	P
Intervention group	32□28.3□	81□71.7□	14.154	<0.001
Control group	10□8.8□	103□91.2□		

To gain a deeper understanding of these dynamics, we further utilized the generalized linear mixed effects model to scrutinize the pre- and post-intervention IAT scores of both groups. Our

analysis unveiled a marked intergroup interaction effect on the IAT scores, achieving statistical significance ($P < 0.001$). Importantly, both groups experienced a decline in their IAT scores post-intervention, with the intervention group exhibiting a notably more pronounced reduction compared to the control group. (Table 4) IAT scores at different time points between groups were further analyzed, and the results were shown in Table 5. Intergroup comparisons after adjusting for baseline showed a statistically significant decrease in IAT scores in the intervention group compared with the control group (adjusted mean change: -4.531, 95%CI: -7.281~-1.781, $P = 0.001$).

Table 4 Results of the generalized linear mixed effects model analysis

Group	N	$M(P_{25}, P_{75})/\bar{x} \pm s$		P		
		Baseline	Postintervention	Interaction term	Group effect	Time effect
IAT scores						
Intervention group	113	53.66±11.03	47.88±11.16	<0.001	0.104	<0.001
Control group	113	53.20±8.88	52.41±10.85			
Internet usage time						
Intervention group	113	8.01±2.50	6.36±2.60	0.008	0.898	<0.001
Control group	113	7.52±2.57	6.93±2.76			
MB scores						
Information				0.276	0.759	0.015
Intervention group	113	10.00□9.00, 10.00□	10.00□9.00, 10.00□	0.001	0.331	<0.001
Control group	113	10.00□9.00, 10.00□	10.00□9.00, 10.00□			
Motivation						1
Intervention group	113	68.67±13.65	74.65±12.22	<0.001	0.019	<0.001
Control group	113	69.88±14.59	70.36±12.65			
Behavioral skills						1
Intervention group	113	29.40±5.80	32.82±6.90	<0.001	0.019	<0.001
Control group	113	29.41±6.10	29.42±6.17			

3.4.2 Secondary indicators

(1) Changes in Internet usage time

The generalized linear mixed effects model was used to analyze the effects of group factors and time factors on the online time of college students with Internet addiction. The results showed that there was a significant interaction effect between groups ($P=0.008$). Notably, post-intervention, both the intervention and control groups exhibited a reduction in their internet usage time. However, the decrease observed within the intervention group was notably more pronounced compared to the control group. (Table 4) When comparing groups after adjusting the baseline, no significant difference between groups was observed ($P=0.104$), as shown in table 5.

Table 5 Mean change from baseline in IAT scores, internet usage time and IMB scores

Groups	Post-test	
	Mean change (95%CI)	P^a
IAT scores		
Intervention group VS Control group	-4.531[-7.281, -1.781]	0.001
internet usage time		
Intervention group VS Control group	-0.565[-1.247, 0.117]	0.104
IMB scores		
Motivation		
Intervention group VS Control group	4.283[0.804, 7.763]	0.016
Behavioral skills		
Intervention group VS Control group	3.407[1.771, 5.043]	<0.001

a) P value after Holm-Bonferroni correction.

(2) Changes in sleep duration

The sleep duration of orderly and multi-classification was taken as the dependent variable ($1 \leq 6h$, $2 = 6 \sim 8h$, $3 > 8h$). Employing the generalized estimation equation model, we systematically explored the influence of group factors and temporal dynamics on the sleep patterns of college

students with internet addiction. Our findings revealed a statistically significant interaction effect between the groups ($P < 0.001$). (Table 6)

Table 6 Results of the generalized estimating equation model analysis

Group	N	n(%)		Interaction term	P				
		Baseline	Postintervention		Group effect	Time effect			
sleep duration									
≤6h									
Intervention group	11	13(11.5%)	8(7.1%)	<0.001	0.934	<0.001			
	3								
Control group	11	12(10.6%)	14(12.4%)						
	3								
6.01~8.00h									
Intervention group	11	72(63.7%)	85(75.2%)						
	3								
Control group	11	57(50.4%)	90(79.6%)						
	3								
>8h									
Intervention group	11	28(24.8%)	20(17.7%)						
	3								
Control group	11	44(38.9%)	9(8.0%)						
	3								
sleep quality									
Preferably									
Intervention group	11	30(26.5%)	24(21.2%)	0.276	0.759	0.015			
	3								
Control group	11	35(31.0%)	20(17.7%)						
	3								
Normal									
Intervention group	11	75(66.4%)	81(71.7%)						

	3					
Control group	11	67	59.3	82	72.6	
Poor	3					
Intervention group	11	8	7.1	8	7.1	
	3					
Control group	11	11	9.7	11	9.7	
	3					
somatic-psychological symptoms						
Dizziness (yes)				0.328	0.932	0.679
Intervention group	11	23	20.4	21	18.6	
	3					
Control group	11	20	17.7	25	22.1	
	3					
Eye discomfort (Yes)				0.556	0.222	0.729
Intervention group	11	45	39.8	44	38.9	
	3					
Control group	11	50	44.2	54	47.8	
	3					
Gastrointestinal problems (Yes)				0.669	0.302	0.503
Intervention group	11	32	28.3	33	29.2	
	3					
Control group	11	25	22.1	29	25.7	
	3					
Low mood (yes)				0.905	0.176	0.184
Intervention group	11	28	24.8	33	29.2	
	3					
Control group	11	21	18.6	26	23.0	
	3					
Anxiety (yes)				0.651	0.204	0.471

Intervention group	11	38□33.6□	33□29.2□			
	3					
Control group	11	29□25.7□	28□24.8□			
	3					
Difficulty concentrating (yes)				0.205	0.119	0.083
Intervention group	113	37□32.7□	39□34.5□			
Control group	113	24□21.2□	35□31.0□			

To delve deeper into the pre- and post-intervention changes, we conducted an Ordered Logistic regression analysis. Prior to the intervention, the comparison between groups failed to yield a statistically significant difference in sleep duration ($P=0.052$). However, post-intervention, a marked statistical difference emerged ($P=0.018$), with an odds ratio (OR) of 2.186 and a 95% confidence interval (CI) ranging from 1.142 to 4.183. This suggests that, compared to the control group, the intervention group experienced a notably longer sleep duration after the intervention. In other words, the intervention group had a 2.186 times higher likelihood of sleeping longer than the control group, as detailed in Table 7.

Table 7 Results of ordered logistic regression analyses of sleep duration

Time	Groups	β	OR	95% CI	P
Baseline	Intervention group	-0.512	0.599	0.357~1.005	0.052
	Control group		1.000		
Postintervention	Intervention group	0.782	2.186	1.142~4.183	0.018
	Controlgroup		1.000		

(3) Sleep quality

The generalized estimating equation model analysis showed that there was no significant interaction effect between groups in the difference of sleep quality. (Table 6)

(4) Somatic-psychological symptoms

Figure 3 provides a visual representation of the pre- and post-intervention changes in the reported somatic-psychological symptoms among the two groups of participants. Notably, the number of individuals reporting dizziness, eye discomfort, and anxiety symptoms decreased following the intervention. Conversely, an increase in the number of participants reporting other symptoms was observed.

To gain a deeper understanding of the intervention's impact on these diverse somatic-psychological symptoms, we employed the generalized estimation equation model. By treating the binary classification of somatic-psychological symptoms as the dependent variable and incorporating the interaction term of group factor, time factor, and group $\times$ time as predictor variables, we analyzed the intervention effects. The results showed that no significant interaction term effect was observed for various somatic-psychological symptoms, and the difference between groups was not significant. (Table 6)

3.4.3 Other indicators

The generalized linear mixed effects model was employed to meticulously examine the influence of group and time factors on Information-Motivation-Behavioral Skills (IMB) scores. The results revealed significant intergroup interaction effects for both motivation score ($P=0.001$) and behavioral skill score ($P<0.001$). Specifically, post-intervention, the intervention group exhibited notable enhancements in both motivation and behavioral skills compared to their pre-intervention levels, as indicated in Table 4.

Upon further intergroup comparison, adjustments were made to account for baseline variations. The adjusted findings highlighted a statistically significant increase in the motivation score of the intervention group post-intervention, with a marked difference from the control group (adjusted mean change: 4.283, 95%CI: 0.804~7.763, $P=0.016$). Similarly, the behavioral skill scores of the intervention group surpassed those of the control group post-intervention, with the disparity reaching statistical significance (adjusted mean change: 3.407, 95%CI: 1.771~5.043, $P<0.001$). (Table 5)

4 Discussion

This randomized controlled trial investigates the efficacy of IIMB model-based WeChat public account intervention in reducing internet addiction among college students and its impact on sleep duration. The study indicates that while the intervention significantly decreases internet addiction levels and positively affects sleep duration, it does not reduce internet usage time, improve sleep quality, or alleviate somatic-psychological symptoms of Internet addicted college students. The World Health Organization (WHO) advocates for Electronic Health (eHealth) services, highlighting the role of information and communication technologies in enhancing healthcare quality and efficiency, and expanding access to health education and preventive measures. With the progression of mobile technology, eHealth and Mobile Health (mHealth) have become essential in mental health promotion, offering innovative methods to tackle internet addiction. While the concept of online intervention for Internet addiction may initially seem paradoxical, given its reliance on the Internet itself, recent research has vindicated its efficacy. A systematic review published in 2022 by Park et al.³⁸ showed that Internet-based treatments can effectively diminish addiction symptoms, curtail the duration and frequency of online addictive behaviors in the short term, aligning with the findings of our study. At present, online intervention for Internet addiction is still in the early stage of development. In order to ensure the effectiveness of the basic structure of intervention programs, it is prudent to establish online intervention on the basis of a well-researched theoretical treatment framework to provide theoretical support for the explanation of intervention effects³⁹. The theoretical basis provides the key factors involved in the intervention process and their interaction, which can help to explain the mechanism of action of the intervention test, facilitate in-depth research and evaluation of the components and steps of the intervention plan to determine which intervention factors are critical and effective, and can make necessary adjustments and improvements in practice. Recognizing this, the present study embraced the IMB model as a conceptual lens, endeavoring to delve into the intricate workings of WeChat public account-based interventions in ameliorating

Internet addiction, examining it from the tripartite dimensions of information, motivation, and behavioral skills.

Our study demonstrated that following the intervention, no significant differences were observed in information scores between the intervention group and the control group. Participants in both groups exhibited equivalent levels of knowledge regarding Internet addiction. This suggests that merely acquiring information about the withdrawal from Internet addiction is not sufficient to directly reduce the severity of Internet addiction. Individual behavior change is a multifaceted process influenced by a variety of factors. According to the IMB model, individuals are more likely to achieve behavior change and meet their desired goals by creating an environment that fosters the transformation of personal attitudes, enhancing motivation for behavior change, and providing specific behavioral skills, particularly by improving self-efficacy.⁴⁰ Intervention research based on this model has addressed the traditional imbalance of "emphasizing awareness while neglecting behavior," placing greater emphasis on enhancing motivation and improving behavioral skills, which ultimately enhances the effectiveness of interventions.⁴¹ Specifically, the marked increase in motivation scores observed within the intervention group, both intra-group and when compared to the control group, indicating that the intervention of WeChat public account enhanced the motivation of the study participants to improve Internet addiction. This is also supported by the findings of Bottel et al.⁴² that online intervention can significantly reduce the severity of Internet addiction and duration of Internet use by increasing the motivation to abstain from Internet use behavior. Similarly, Niemann et al.⁴³ conducted an intervention study involving 169 participants, showing that an online-based incentive intervention program can effectively promote motivation to change behavior, thereby reducing problematic Internet use and preventing its progression to Internet addiction. These results align with our study, highlighting the critical role of motivation in improving Internet addiction.

The IMB model categorizes improvement motivation into two distinct aspects: individual motivation and social motivation. In terms of individual motivation, enhancing individuals' attitudes,

beliefs, and perceived benefits associated with quitting Internet addiction can effectively stimulate their drive to actively pursue change, thereby facilitating the goal of improving Internet addiction. The efficacy of motivational enhancement therapy, which revolves around eliciting ambivalence towards cessation (withdrawal motivation) and impeding maintenance tendencies (approach motivation), has garnered significant attention within the research community. Its application across diverse addiction disorders, including Internet addiction, gambling, alcoholism, and smoking, has demonstrated remarkable interventional outcomes.^{44,45} In terms of social motivation, the social support obtained by encouraging individuals to quit Internet addiction may help reduce the level of Internet addiction.⁴⁶ According to the cognitive behavioral model proposed by Davis, when there is a lack of adequate social support in real life, individuals may turn to the Internet to find dynamic social support to meet their psychological needs⁴⁷. Enter the WeChat public account intervention, an innovative, user-centered approach rooted in the IMB model and tailored specifically for individuals struggling with Internet addiction. This strategy harmoniously integrates the dual objectives of enhancing individual motivation for change and fostering social support, aligning with the principles of Motivational Interviewing as conceptualized by Miller and Rollnick. Motivational Interviewing is a collaborative conversational technique designed to amplify an individual's intrinsic motivation and commitment towards positive change⁴⁸. Building on this foundation, this study leverages the WeChat platform to integrate the motivation to improve Internet addiction into the intervention plan. The entire intervention process is non-coercive and voluntary, making it particularly suitable for those who are reluctant or ambivalent about actively quitting Internet addiction due to feelings of shame.

In terms of behavioral skills, the results of this study reveal that following the intervention, the behavioral skills score of participants in the intervention group was significantly higher than that of the control group. This indicates that the intervention delivered via WeChat public account can effectively enhance the self-efficacy of individuals with Internet addiction. A randomized controlled trial conducted by Dieris-Hirche et al.⁴⁹ showed that online intervention can reduce symptoms of

Internet addiction while increasing participants' motivation to change and self-efficacy, which is consistent with the findings of this study. Relevant studies have pointed out that conventional health education still relies on passive supervision and spoon-feeding. In this mode, patients have a low level of self-efficacy, lack the autonomy to understand knowledge, and are prone to negative emotions, which makes the intervention effect unsatisfactory.⁵⁰ The health education intervention mode of WeChat public account based on IMB model carried out in this study can provide continuous health information and induce self-efficacy of Internet addicts from the aspect of personal motivation. Studies have found that the application of reading therapy can effectively reduce the low degree of Internet addiction among college students.⁵¹ Therefore, we also used videos, text, pictures and other forms to push the study participants to get rid of Internet addiction techniques, including increasing outdoor activities, physical exercise, finding alternative hobbies, downloading mobile phone management software, etc., to assist the study participants to improve the symptoms of Internet addiction. Secondly, motivational intervention based on the IMB model makes Internet addicts realize that unhealthy behaviors or non-compliance with the intervention may bring serious consequences, which can promote the change of treatment attitude of the study participants, thus strengthening self-efficacy. Through the typical case sharing function of the platform, the persuasion of health education information can be enhanced in the form of presentation, and peer effects can be generated to further improve the intervention effect.

Despite the lack of significant differences in internet usage time between the groups, this finding may be explained by the unique nature of the intervention delivered through WeChat public accounts. Participants were required to access the internet to obtain intervention tools, receive intervention content, and engage in online communications with researchers. This necessity likely sustained their overall online presence. Consequently, although the intervention may have enhanced participants' attitudes towards reducing Internet addiction, the immediate reduction in online time may not be readily apparent. This aligns with previous findings in online intervention studies.⁵²

Academic pressure may be a contributing factor to the lack of significant change in internet usage time. Research participants may need to use the internet to consult materials, prepare class notes, and participate in online learning. Although they continue to use electronic devices, the purpose and nature of their internet use have shifted. The internet is now primarily utilized for self-improvement and to meet academic needs, thereby reducing academic pressure.

Excessive Internet usage poses a multifaceted threat to both physical and mental wellbeing, encompassing issues like compromised sleep quality, dizziness, ocular strain, unhealthy dietary habits, as well as symptoms of depression and anxiety.^{53,54} Prolonged sleep deprivation among adolescents significantly impairs their emotional regulation capabilities, manifesting in heightened depression, apathy, anxiety, and fatigue.⁵⁵ Furthermore, the blue light emitted by electronic screens is believed to disrupt sleep patterns, with cumulative effects that can hinder the normal production of melatonin, delaying sleep onset and subsequently deteriorating sleep quality among Internet addicts.⁵⁶ These findings suggest the potential benefits of preventing and controlling Internet addiction for the healthy development of college students. Regarding sleep conditions, the intervention outcomes of this study reveal a noteworthy improvement. Specifically, participants in the intervention group, who received the WeChat public account-based IMB model intervention, experienced significantly longer sleep durations compared to the control group, indicating a positive influence on enhancing sleep duration. However, no discernible differences were observed in sleep quality between the two groups. This lack of significant change in sleep quality could stem from several factors. Firstly, individual sleep issues often stem from long-standing lifestyle habits, and the relatively brief 6-week intervention period in this study might not be sufficient to effect substantial improvements in sleep quality, suggesting that a longer-term intervention may be necessary to achieve optimal results. Secondly, the duration of sleep alone does not necessarily equate to its quality, as factors such as personal routines, sleep environments, sleep latency, and mental health status can significantly impact sleep quality.^{57,58} In delving into the somatic-psychological

symptomatology, the current study failed to detect significant differences between the groups, which may be attributed to the intervention's temporal scope. Given that somatic-psychological symptoms often emerge as a consequence of prolonged processes, their resolution necessitates a comprehensive examination of various factors, including individual traits, the depth of addiction, and the severity of symptoms. Consequently, a short-term intervention might not suffice to significantly mitigate these symptoms. In the future, it is necessary to further explore the long-term effect of WeChat public account intervention in improving the somatic-psychological symptoms of Internet addicts.

5 Limitation

The current study is undeniably constrained by several limitations that merit attention. Firstly, the sampling framework is inherently limited, as participants were exclusively drawn from a single school, resulting in a potentially underrepresented. Future research should aim to broaden the participant pool to include a more diverse range of individuals, thereby enhancing the robustness and applicability of the results. Secondly, the intervention duration in this study was restricted to a mere 6 weeks. Such a short timeframe may not be sufficient to fully capture the nuanced effects of the WeChat public account intervention. To address these limitations, future endeavors should prioritize the implementation of longer-term intervention trials, accompanied by rigorous follow-up assessments. This approach will help validate the intervention's effectiveness and explore its durability over time.

6 Conclusion

WeChat public account intervention based on IMB model can significantly reduce the level of Internet addiction among college students, and has a certain positive effect on improving sleep duration. The effectiveness of WeChat public account intervention based on the IMB model in reducing the amount of time spent online and improving sleep quality and somatic-psychological

symptoms in internet-addicted college students has not been found. In summary, the findings of this study can be used as a supplement to the existing research evidence of online intervention for Internet addiction, and provide a reference for the intervention research of new Internet addiction.

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Supplementary table 1The intervention scheme of WeChat public accounts based on the IMB model

Intervention topic	Specific content
Information	Disease knowledge introduction: including the prevalence of Internet addiction, common types, symptoms and risk factors that may aggravate addiction symptoms.
	News dynamic: Update the latest news about Internet addiction in real time.
	Real stories and experience sharing: Real cases of successful withdrawal from Internet addiction.
	Treatment methods: Common treatment methods for Internet addiction are introduced, including psychological therapy, drug therapy, exercise intervention, music therapy, reading therapy and other intervention methods as well as treatment precautions, and the importance of compliance is emphasized.
Motivation	Self-monitoring: Dynamic assessment and recording of IAT scale scores to assess addiction levels in a timely manner.
	Emotional management: Give psychological support to the research object, listen patiently, encourage the research object to express their ideas, communicate with them more, and objectively analyze the advantages and problems existing in the research object. Encourage research subjects and share success stories to build their confidence.
	Information management: Provide guidance to the research subjects on corresponding addiction information, answer their doubts about Internet addiction information, inform the research subjects to pay more attention to the official information, and improve their ability to identify information.
	Social support: The communication between subjects and staff and between subjects can resonate and increase their motivation to improve Internet addiction, thereby changing addictive behaviors. The staff provides individualized advice based on the main problems of the research subjects, discusses strategies to overcome the problems, and gives appropriate suggestions and feedback. By giving positive reinforcement to the subjects, the confidence of the subjects

	was effectively improved.
Behavior skills	Internet addiction prevention methods and healthy lifestyle: set goals, reasonable time management, find alternative hobbies, actively participate in outdoor activities, regular physical exercise, etc.
	Targeted health education: The study subjects are guided according to the initial assessment to help the study subjects get rid of the addiction state.
	Self-efficacy: According to the scale of self-assessment, actively participate in background messages, enhance self-efficacy.
	Enhanced behavior: Feedback on the effects of the intervention, exchange of views with staff or study subjects.
Information-motivation-behavioral skills	Problem solving: re-evaluate the information, motivation and behavioral skills of the research subjects through exchange feedback, and push relevant content according to the existing problems of the research subjects.

Author contributions

All authors have made substantial contributions to the conception, design, execution, and/or interpretation of the study. All authors have participated sufficiently in the work to take public responsibility for appropriate portions of the content.

Data Availability Statement

The datasets generated and analyzed during the current study are available in the Supplementary Information files submitted with this manuscript. All relevant data supporting the findings of this study are included within the article and its supplementary materials. Additional information can be obtained from the corresponding author upon reasonable request.

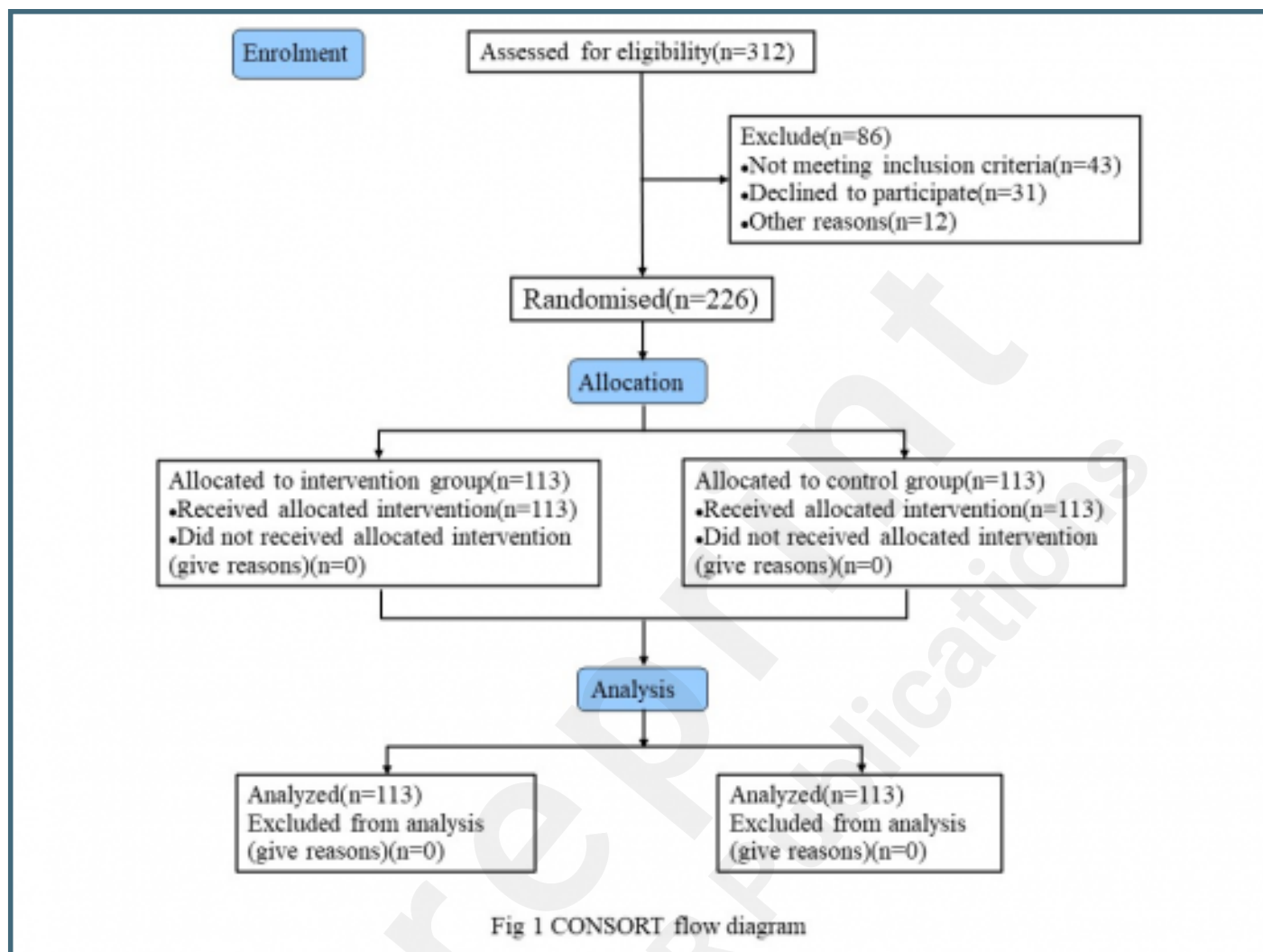
Conflict of Interest Statement

The authors certify that they have no affiliations with or involvement in any organization or entity with a financial or non-financial interest in the subject matter or materials discussed in this manuscript. There are no conflicts of interest to declare.

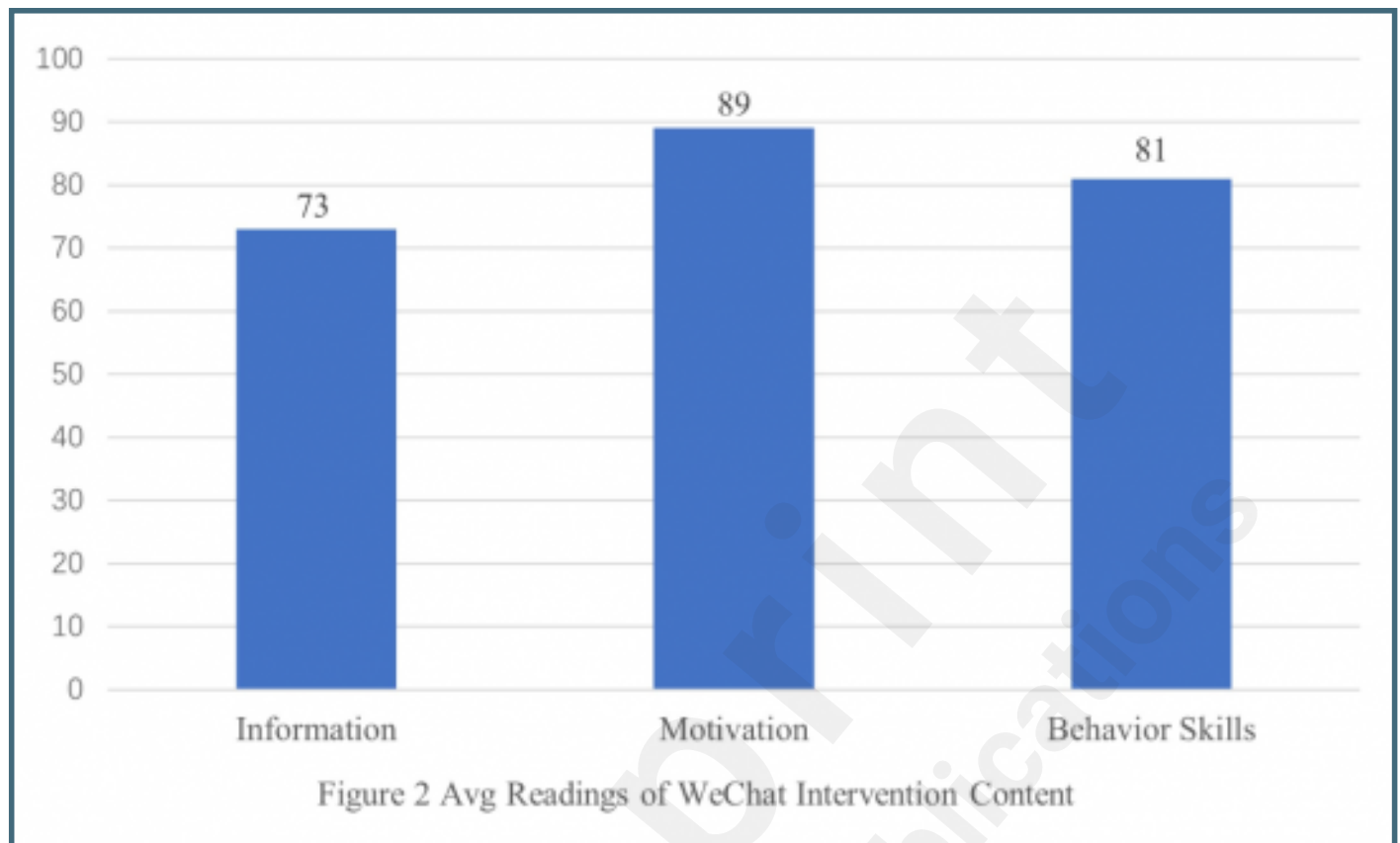
Supplementary Files

Figures

CONSORT flow diagram.



Avg Readings of WeChat Intervention Content.



Somatic-Psychological Symptoms Pre-Post Intervention.

