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ORIGINAL RESEARCH

Lifestyle Mediates the Associations of Social Media and Smartphone Use Addiction with Sleep Quality and Mental Health Problems in Adults: An Exploratory Study

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Background: Excessive time spent on social media and smartphones, as well as inappropriate use, has raised concerns about their potential impact on mental health. Many studies have shown that social media addiction and smartphone addiction are associated with poor sleep quality and increased risk of depression and anxiety. This study examined the mediating role of lifestyle on the relationship between social media and smartphone use addictions with poor sleep quality, anxiety, and depression.

Methods: A cross-sectional study was conducted among 1324 undergraduate and graduate students aged 20–40 years. Participants completed validated self-report measures assessing social media addiction, smartphone addiction, sleep quality, anxiety symptoms, depressive symptoms, and lifestyle behaviors, including smoking, alcohol consumption, eating behaviors, and physical activity.

Results: The mean scores for sleep quality, anxiety, and depressive symptoms were 6.9 ± 3.4, 6.7 ± 5.4, and 8.6 ± 5.8, respectively. In this cross-sectional study, mediation analysis indicated statistically significant indirect associations through lifestyle between social media addiction and poor sleep quality (the indirect effects: unstandardized coefficient [B] = 0.006, 95% confidence interval [CI] [0.002–0.014]), anxiety symptoms (B = 0.007, 95% CI [0.001–0.016]), and depressive symptoms (B = 0.013, 95% CI [0.006–0.025]). Similarly, lifestyle was observed to mediate the association between smartphone use addiction and poor sleep quality (the indirect effects: B = 0.005, 95% CI [0.002–0.010]), anxiety symptoms (B = 0.006, 95% CI [0.001–0.015]), and depressive symptoms (B = 0.012, 95% CI [0.005–0.020]). Although the indirect effects were statistically significant, their magnitude was small, indicating that lifestyle accounted for a limited proportion of the associations between technology-related addictions and sleep quality and mental health problems.

Conclusion: Lifestyle behaviors statistically mediated the associations of social media or smartphone use addiction with poor sleep quality, anxiety, and depression. Although causal inferences cannot be made, these findings suggest that lifestyle practices may be important in understanding and addressing the mental health challenges associated with excessive technology use.

Keywords: anxiety symptoms, depression symptoms, lifestyle, social media addiction, smartphone use addiction, sleep quality

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Introduction

Digital technology has profoundly transformed daily life, especially with the ubiquitous adoption of social media and smartphones. Digital technology serves as a powerful tool for fostering connections among individuals,[1] opportunities for self-directed learning,[2,3] supporting adherence to preventive measures and treatment regimens,[4] and satisfying human needs.[5] It is estimated that in 2024, approximately 60.42% of people own at least one smartphone,[6] and about 62.3% of people worldwide use social media.[7] Undoubtedly, social media and smartphones positively affect and benefit modern life. However, excessive and inappropriate use of social media and smartphones impacts health outcomes.[8,9] It has negative impacts on health and daily life and is considered a behavioral addiction.[10] A systematic review and meta-analysis encompassing 51 studies and 35,520 university students revealed that the global prevalence of social network addiction among this population was estimated at 18.4%, with a notably higher prevalence of 22.8% reported in Asia.[11] In Taiwan, more than two-thirds of young people are enrolled in universities each year (Net Enrollment Rate: 70.55% in 2019).[12] Previous research on young adults has also commonly included students aged 20–40 years enrolled in bachelor's, master's, and PhD programs.[13] Given that university students and recent graduates represent a large proportion of adults in Taiwan and are at heightened risk of problematic social media and smartphone use, they provide a relevant and accessible population for investigating the associations with lifestyle and mental health outcomes. The 20–40 age group has one of the highest rates of social media addiction, estimated at around 37%.[14] However, most existing research has primarily focused on adolescents and younger adults aged 18–29,[15] leaving this slightly older age range comparatively underexplored.

Social media addiction (SMA) and smartphone use addiction (SUA) have been linked to anxiety and depression, and poor sleep quality. High-intensity social media use often leads to late-night usage, reduced sleep duration, difficulty falling asleep, and increased sleep disturbances, disrupting overall sleep quality.[16–18] Excessive social media and smartphone use can impair attention and social interaction, fostering feelings of envy, social comparison, and anxiety about missing out on experiences.[19,20] Additionally, individuals with SMA or SUA are frequently exposed to negative content, cyberbullying, harassment, and a negative self-image, which contribute to isolation, low self-esteem, and negative emotions.[21–23] Physiologically, the blue light from smartphone screens interferes with the natural sleep-wake cycle because it suppresses melatonin production.[24] Prolonged smartphone use has also been linked to physical health issues, such as muscle pain, headaches, and cognitive impairment, which further exacerbate poor sleep quality.[25] Moreover, SUA has been associated with increased feelings of loneliness, stress, and reduced psychological well-being.[26]

Lifestyle is a modifiable factor that promotes overall physical and mental health, prevents non-communicable diseases, and reduces the risk of major illnesses.[27] A healthy lifestyle encompasses regular physical activity, balanced nutrition, moderate alcohol consumption (or abstinence), and non-smoking.[28] A healthy lifestyle has been consistently linked to improved mental well-being and reduced risks of depression and anxiety.[29,30] Physical activity, in particular, has been shown to lower the risk of depressive and anxiety disorders significantly,[31,32] while a diet balanced in micro- and macronutrients supports both physical health and stress reduction.[33] Smoking, aside from its well-documented physical health risks, contributes to psychological distress.[34] A study with 242,952 people from 48 low- and middle-income countries revealed that there was a consistent correlation between depression and high levels of smoking behaviors.[35] Similarly, heavy alcohol consumption contributes to sleep disturbances by reducing slow-wave sleep and increasing rapid-eye-movement (REM) sleep.[36]

On the other hand, the Interaction of Person–Affect–Cognition–Execution (I-PACE) model proposes that problematic technology use develops through dynamic interactions among individual characteristics, affective and cognitive responses, and executive functioning, which may progressively impair self-regulation and reinforce maladaptive behavioral patterns.[37] These behavioral changes may include health-related behaviors, such as physical activity, dietary habits, smoking, and alcohol consumption, which are closely associated with sleep quality and mental health. Consistent with the I-PACE model, previous mediating studies have suggested that the associations between technology addiction and mental health problems could be explained indirectly through psychosocial and behavioral pathways. For example, self-esteem[38] and social capital and mindfulness[39] have been identified as mediators linking SMA with mental health problems. Physical activity has also been found to mediate these associations.[40] In addition, adolescents who exhibited SMA were at heightened risk of engaging in unhealthy behaviors, such as smoking, excessive alcohol consumption,

eating unhealthy diets (fewer fruits and vegetables, skipping breakfast), and low physical activity.[41–43] Exposure to phone screens and spending more time on social networks reduces interpersonal interaction and physical activity.[44] Moreover, social media content, such as advertisements, user-generated posts, and movies, can influence young people's dietary choices and substance use behaviors.[45–48] Most previous studies have examined lifestyle behaviors as mediators by focusing on single domains, such as physical activity or diet. However, in reality, smoking, alcohol use, dietary habits, and physical activity often co-occur and collectively influence health. Therefore, rather than examining a single lifestyle behavior, the present study constructed a composite lifestyle index capturing these four behaviors to test whether it mediates the associations of social media and smartphone addiction with sleep quality, anxiety, and depression.

In epidemiological and behavioral research, relying on psychometrically sound self-report instruments that are culturally adapted is essential for accurately capturing subjective constructs such as mental health and health-related quality of life.[49,50] Adhering to established psychometric validation standards ensures that the measures reliably reflect the targeted health behaviors within specific population contexts.

This study aimed to examine the mediating effects of lifestyle in the relationship between SMA, SUA, and mental health outcomes, including anxiety, depression, and sleep quality. The findings may inform evidence-based strategies to improve mental health in the digital age by identifying modifiable factors contributing to these associations. We hypothesize that a composite lifestyle index, reflecting multiple health-related behaviors, would statistically mediate the associations between social media addiction or smartphone addiction and sleep quality, anxiety, and depression.

Materials and Methods

Study Design and Population Sampling

A cross-sectional study using a convenience sampling approach was conducted from November 2022 to December 2023. Students aged 20–40 years studying in year 3 or above or in master's and Ph.D. programs, and the general public were voluntarily recruited for the online survey distributed across 47 universities in Taiwan (20 universities in the north, 14 universities in the centre, 9 universities in the south, 3 universities in the east, and 1 university in the outlying island). This study was part of a larger project conducted within our research network of universities in Taiwan, which is carrying out an ongoing online survey on COVID-19 health literacy.[51] Therefore, no a priori sample size calculation was performed specifically for the present study. Instead, all eligible participants who completed the survey during the study period were included in the analysis. Participants were excluded if they self-reported a diagnosed psychiatric disorder, a severe visual impairment (eg, refractive disorder), or any other health condition that prevented them from reading, understanding, or completing the online questionnaire at the time of the survey.

Data Collection Procedure

Participants received a QR code containing a Google Forms link. Every university had a contact person (an employee or teacher) who sent a QR code to students and the public through the school's mailing system, social networks, media sites, student clubs/associations, and personal social media/network emails. Participants must fill in their survey email to ensure the data is accurate. The reminder posts/messages/emails were posted/sent out within 1 week and 2 weeks apart to increase the response rate. It took about 20 minutes to complete the questionnaires. All participants were asked if they were willing to participate voluntarily. If they agreed to participate, they must sign the consent form and move on to the following pages. The mandatory field was applied to all survey questions. The principal investigator exported all the responses into Google Sheets and saved/stored them on Google Drive with a secure password. Finally, researchers confidentially coded, cleaned, and analyzed the data.

Measurements

Social Media Addiction

The Bergen Social Media Addiction Scale (BSMAS) is an instrument to be used widely to screen the level of addictive social media use.[52] Participants reported their experiences using social media in the past year. This self-reported instrument has six items, and each item was scored ranging from 1 = very rarely to 2 = rarely, 3 = occasionally, 4 =

frequently, and 5 = very often. The sum score of six items ranges from 6 to 30. Higher scores reflect a higher level of addictive social media use.

Smartphone Use Addiction

To assess the level of smartphone addiction, we utilized the Smartphone Application-Based Addiction Scale (SABAS).[53] Participants reported their smartphone use habits (e.g, My smartphone is the most important thing in my life) on a 6-point Likert scale ranging from 1 = strongly disagree to 2 = disagree, 3 = slightly disagree, 4 = slightly agree, 5 = agree, 6 = strongly agree. Sum scores range from 6 to 36. A higher sum score indicates a greater level of addictive smartphone application use.

BSMAS and SABAS were used in the Taiwanese population.[54] The Cronbach's alpha index of the two scales was 0.84.

Lifestyle

- Lifestyle included smoking, alcohol consumption, healthy eating behaviors, and physical activity.
- Smoking behaviors: individuals reported their smoking status: current smoker, former smoker (used but stopped), or never smoker.
- Alcohol consumption: participants answered, "In the last 30 days, how many times did you drink any alcoholic beverages?". We classified it into three groups: none, moderate (drink 1–4 times/month on average), and heavy (daily or at least twice weekly).
- Healthy eating behavior was measured using the 5-item healthy eating score (HES-5) developed by military researchers.[55] The HES-5 is similar to the 2015 Healthy Eating Index for measuring how healthy someone's diet is overall.[55] Participants described how often they ate fruits, vegetables, whole grains, dairy products, and fish in the past month. They rated each item from 0 (rarely or never) to 5 (3 or more times a day) to show how frequently they consumed each item. The total HES scores range from 0 to 25. In this study, we divided HES-5 scores into three categories based on tertiles: low (HES-5 < 10), moderate ($10 \leq$ HES-5 < 14), and high (HES-5 ≥ 14).
- Physical activity: A short version of the International Physical Activity Questionnaire (IPAQ) was employed to assess participants' physical activity.[56] This questionnaire provided the number of minutes per day and days per week over the past seven days that participants spent at different intensities (vigorous, moderate, walking, and sitting). The metabolic equivalent task minutes per week (MET-min/wk) represented the physical activity level.[57] To calculate the MET-min/wk, the total of minutes per week for each intensity of physical activity, including vigorous, moderate, walking, and sitting, is multiplied by 8, 4, 3.3, and 1, respectively. The physical activity levels were classified into 3 groups: low (tertile 1 MET < 975), moderate ($975 \leq$ tertile 2 MET < 1872), and high (tertile 3 MET ≥ 1872). The IPAQ was validated and used in the Taiwanese population.[58]

To assess lifestyle, we constructed a composite index based on four behaviors: smoking, alcohol consumption, eating behaviors, and physical activity. Each component was categorized into three levels reflecting different levels of health-related behavior and assigned scores of 0, 1, or 2 (Supplementary Table 1). Scores were then summed to generate a composite index ranging from 0 to 8, with higher values representing a healthier behavioral profile (Supplementary Table 1). This approach follows previous epidemiological studies that have combined multiple health behaviors into an unweighted cumulative index to examine their overall association with health outcomes.[59–61] Equal weighting was applied because there is currently no universally accepted approach for assigning differential weights across heterogeneous health behaviors. Previous methodological studies have suggested that simple cumulative indices may provide comparable predictive performance to more complex weighted approaches while maintaining interpretability, reproducibility, and comparability across studies.[62,63] Although composite lifestyle indices have often been applied in longitudinal cohorts to predict health outcomes, the same approach can be applied in cross-sectional settings to examine associations with mental health and sleep.

Sleep Quality

The Pittsburgh Sleep Quality Index (PSQI), a widely used and validated self-report questionnaire, was applied to assess sleep quality and disturbances over one month.[64] The PSQI consists of 19 items generating seven components: subjective sleep quality, sleep latency (the time it takes to fall asleep), sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medications, and daytime dysfunction. Each component score ranges from 0 to 3. Seven component scores are then summed as a global PSQI score. The global PSQI score ranges from 0 (good sleep quality) to 21 (poor sleep quality). This scale has been used among university students in Taiwan.[65] The reliability of PSQI was 0.82–0.83 for all subjects.[66]

Anxiety Symptoms

The 7-item Generalized Anxiety Disorder (GAD-7) was developed by Spitzer et al and was applied to measure anxiety symptoms.[67] This scale was validated in the Chinese version and used in the Taiwanese population.[68,69] The GAD-7 consists of 7 items to assess the frequency of common anxiety symptoms over the last two weeks. Respondents were asked to rate each item on a 4-point scale: 0 = "not at all", 1 = "several days", 2 = "more than half the days", and 3 = "nearly every day". The scores of all 7 items range from 0 to 21. Higher scores imply more severe anxiety symptoms. In this study, the GAD-7 has a Cronbach's alpha index of 0.94.

Depressive Symptoms

We utilized the Center for Epidemiological Studies Depression (CESD-10) to screen depressive symptoms over the last week.[70] It was applied to the Taiwanese.[71] The CESD-10 is a 10-item scale designed to evaluate symptoms of depression, including feelings of worthlessness, depressed mood, diminished interest in activities, and changes in sleep and appetite. Responses for each item are scored on a 4-point scale from 0 (rarely or none) to 3 (most or all of the time). Items 4 ("I was happy") and 7 ("I enjoyed life") are reverse-scored. The total score ranges from 0 to 30, with higher scores reflecting greater severity of depressive symptoms. This scale demonstrated strong internal consistency, with a Cronbach's alpha of 0.87.

Covariates

Sociodemographic information was collected, including age, gender (women vs men), marital status (never married vs ever married), education (undergraduate vs graduate), working status (studying/unemployed vs employed), living status (alone, with a friend, with a partner, and with family), and ability to pay for medication (difficult vs easy). Participants provided their height, weight, and chronic disease (ie, diseases or health problems that last at least six months) (no vs yes). Body mass index (BMI) was calculated with the formula: BMI (kg/m^2) = weight (kg)/height (m^2) and was divided into under/normal weight (BMI < 24), overweight (BMI: 24 to <27), and obesity (BMI ≥ 27) according to the definition of the Ministry of Health and Welfare of Taiwan (2018).

Statistical Analysis

We evaluated the normality assumption of the PSQI, GAD-7, and CESD-10 scores by examining their skewness and kurtosis. Both metrics fell within the range of −2 to +2, which is generally considered acceptable for approximating a normal distribution in large sample sizes.[72] Descriptive statistics were used to analyze participants' characteristics and measure scores, including means and standard deviations (SD) for continuous variables and frequencies (percentages) for categorized variables. *T*-tests and one-way analysis of variance (ANOVA) were used to compare the means of subgroups for outcome variables. Linear regression was performed to examine the factors associated with each dependent variable (Supplementary Table 2). We ran Spearman correlation between independent variables with a p-value less than 0.05 from simple linear regression. To avoid multicollinearity, we selected a representative variable from variable pairs with high or moderate correlations. Age had a moderate correlation with marital status (rho = 0.333) and educational level (rho = 0.637); we excluded age from the mediation model (Supplementary Table 3). Mediation analysis was run to explore the potential mediating effect of lifestyle in the association between SMA or SUA with sleep quality (after adjusting for the ability to pay for medication, chronic diseases), anxiety symptoms (after adjusting for gender, marital status, ability to pay for medication, chronic diseases), and depressive symptoms (after adjusting for marital status, education, ability to pay for medication, chronic diseases). We performed mediation analyses on cross-sectional data to investigate potential

indirect pathways. This method offers initial insight into whether lifestyle behaviors explain a portion of the observed associations. All analyses were performed using IBM SPSS 25.0 software and PROCESS model 4 for mediation analysis for SPSS.[73] The indirect effect can be considered statistically significant if the confidence intervals do not include zero.

Results

The Participants' Characteristics

The mean age of study subjects was 24.3 ± 4.7 years. Of 1324 participants, the mean scores of sleep quality, anxiety, and depression were 6.9 ± 3.4, 6.7 ± 5.4, and 8.6 ± 5.8, respectively. Regarding demographic characteristics, 69.9% were women, 91.5% were unmarried, 47.8% had lived with a family member, 72.4% were college students, 56.1% had a job, and 66.2% had the ability to pay for medication. In addition, 72.7% had a BMI <24 kg/m2, and 20.8% reported at least

Table 1 The Participants' Characteristics

		PSQI Scores 6.9 ± 3.4		**GAD-7 Scores 6.7 ± 5.4**		**CESD-10 Scores 8.6 ± 5.8**	
		Mean ± SD	**p**	**Mean ± SD**	**p**	**Mean ± SD**	**p**
Age (years)							
	24.3 ± 4.7						
Gender			0.198		< 0.001		0.508
Female	925 (69.9)	7.0 ± 3.4		7.1 ± 5.4		8.7 ± 5.8	
Male	399 (30.2)	6.7 ± 3.3		5.6 ± 5.1		8.5 ± 5.8	
Married status			0.597		0.014		0.027
Never married	1212 (91.5)	6.9 ± 3.4		6.8 ± 5.4		8.7 ± 5.8	
Ever married	112 (8.5)	7.1 ± 3.7		5.6 ± 4.7		7.5 ± 5.6	
Living status			0.111		0.551		0.404
Alone	341 (25.8)	7.0 ± 3.4		6.7 ± 5.5		8.9 ± 5.8	
With friend	243 (18.4)	7.2 ± 3.5		7.1 ± 5.5		8.9 ± 5.6	
With a partner	106 (8.0)	7.3 ± 3.2		6.4 ± 5.7		8.0 ± 6.1	
With family	634 (47.8)	6.7 ± 3.3		6.5 ± 5.2		8.5 ± 5.9	
Education			0.591		0.24		0.002
Undergraduate	961 (72.6)	6.0 ± 3.4		6.8 ± 5.4		8.9 ± 5.8	
Graduate	363 (27.4)	6.8 ± 3.4		6.4 ± 5.3		7.8 ± 5.8	
Working status			0.115		0.791		0.838
Studying/unemployed	581 (43.9)	6.8 ± 3.4		6.6 ± 5.3		8.6 ± 5.6	
Part-time/full-time work	743 (56.1)	7.1 ± 3.4		6.7 ± 5.4		8.7 ± 6.0	
Ability to pay for medication			< 0.001		< 0.001		< 0.001
Difficult	448 (33.8)	7.6 ± 3.5		7.8 ± 5.7		9.8 ± 6.2	
Easy	876 (66.2)	6.6 ± 3.3		6.1 ± 5.1		8.0 ± 5.5	

(*Continued*)

Table 1 (Continued).

		PSQI Scores 6.9 ± 3.4		GAD-7 Scores 6.7 ± 5.4		CESD-10 Scores 8.6 ± 5.8	
		Mean ± SD	**p**	**Mean ± SD**	**p**	**Mean ± SD**	**p**
Body mass index (BMI kg/m^2)			0.149		0.099		0.794
Under/normal weight (BMI < 24)	962 (72.7)	6.8 ± 3.3		6.8 ± 5.4		8.7 ± 5.7	
Overweight (24 ≤ BMI < 27)	186 (14.0)	7.2 ± 3.6		6.8 ± 5.7		8.6 ± 6.3	
Obesity (BMI ≥ 27)	176 (13.3)	7.2 ± 3.7		5.9 ± 5.1		8.4 ± 6.1	
Chronic diseases			< 0.001		< 0.001		< 0.001
No	1048 (79.2)	6.6 ± 3.2		6.2 ± 5.2		8.1 ± 5.6	
Yes	276 (20.8)	8.3 ± 3.6		8.5 ± 5.7		10.5 ± 6.4	
Lifestyle							
	4.2 ± 1.2						
BSMAS scores							
	14.8 ± 4.8						
SABAS scores							
	19.7 ± 6.1						

Note: Data are presented as number (percentage) or mean ± standard deviation (SD).
Abbreviations: PSQI, the Pittsburgh sleep quality index; GAD-7, the 7-item generalized anxiety disorder; CESD, the 10-item Center for epidemiologic studies depression; BSMAS, Bergen social media addiction scale; SAMAS, smartphone application-based addiction scale; BMI, body mass index.

one chronic disease. Mean scores of lifestyle, social media addiction, and smartphone use addiction were 4.2 ± 1.2, 14.8 ± 4.8, and 19.7 ± 6.1, respectively. There were significant correlations between SMA, SUA, lifestyle, sleep quality, anxiety symptoms, and depressive symptoms (Table 1).

The Correlation of Social Media Addiction, Smartphone Use Addiction, Lifestyle, Sleep Quality, Anxiety Symptoms, and Depressive Symptoms

The correlation analysis reveals significant relationships among the variables ($p < 0.01$). Social media addiction and smartphone use addiction showed weak positive correlations with the outcomes of sleep quality, anxiety, and depression. Lifestyle exhibited weak negative correlations with these outcomes, indicating that a healthier lifestyle was associated with better sleep quality and lower levels of anxiety symptoms and depressive symptoms (Table 2).

The Mediating Role of Lifestyle

The mediation analysis results are depicted in Figure 1A–F and Table 3. As shown in Table 3, the indirect effects demonstrated 95% confidence intervals (CI) that did not include zero, indicating evidence of partial mediation by lifestyle behaviors in the associations between SMA and SUA with poor sleep quality, anxiety symptoms, and depressive symptoms.

In the SMA mediation model, significant indirect associations through lifestyle behaviors were observed between SMA and poor sleep quality (unstandardized coefficient (B) = 0.006; 95% CI [0.002–0.014]), anxiety symptoms (B = 0.007; 95% CI [0.001–0.016]), and depressive symptoms (B = 0.013; 95% CI [0.006–0.025]). SMA and SUA were negatively associated with lifestyle (all pathways significant). After adjusting for SMA and covariates, lifestyles were negatively related to PSQI scores, indicating better sleep quality (B = −0.221; 95% CI [−0.361, −0.083]), anxiety

Table 2 The Correlation Between Social Media Addiction, Smartphone Use Addiction, Lifestyle, Sleep Quality, Anxiety, and Depression

	Social Media Addiction	Smartphone Use Addiction	Lifestyle	Sleep Quality	Anxiety
Smartphone use addiction	0.537**				
Lifestyle	−0.098**	−0.104**			
Sleep quality	0.113**	0.126**	−0.110**		
Anxiety	0.222**	0.163**	−0.093**	0.406**	
Depression	0.267**	0.221**	−0.138**	0.477**	0.792**

Notes: Pearson correlation coefficients are presented. **, p-value was less than 0.01.

symptoms (B = −0.242; 95% CI [−0.470, −0.035]), and depressive symptoms (B = −0.440; 95% CI [−0.654, −0.194]). Regarding direct effects, SMA demonstrated significant positive associations with poor sleep quality (B = 0.066; 95% CI [0.024, 0.109]), anxiety symptoms (B = 0.227; 95% CI [0.169, 0.286]), and depressive symptoms (B = 0.288; 95% CI [0.223, 0.358]).

In the SUA mediation model, significant indirect associations through lifestyles were also observed for poor sleep quality (B = 0.005; 95% CI [0.002–0.010]), anxiety symptoms (B = 0.006; 95% CI [0.001–0.015]), and depressive symptoms (B = 0.012; 95% CI [0.005–0.020]). Adjusting for SUA and covariates, healthier lifestyles were significantly

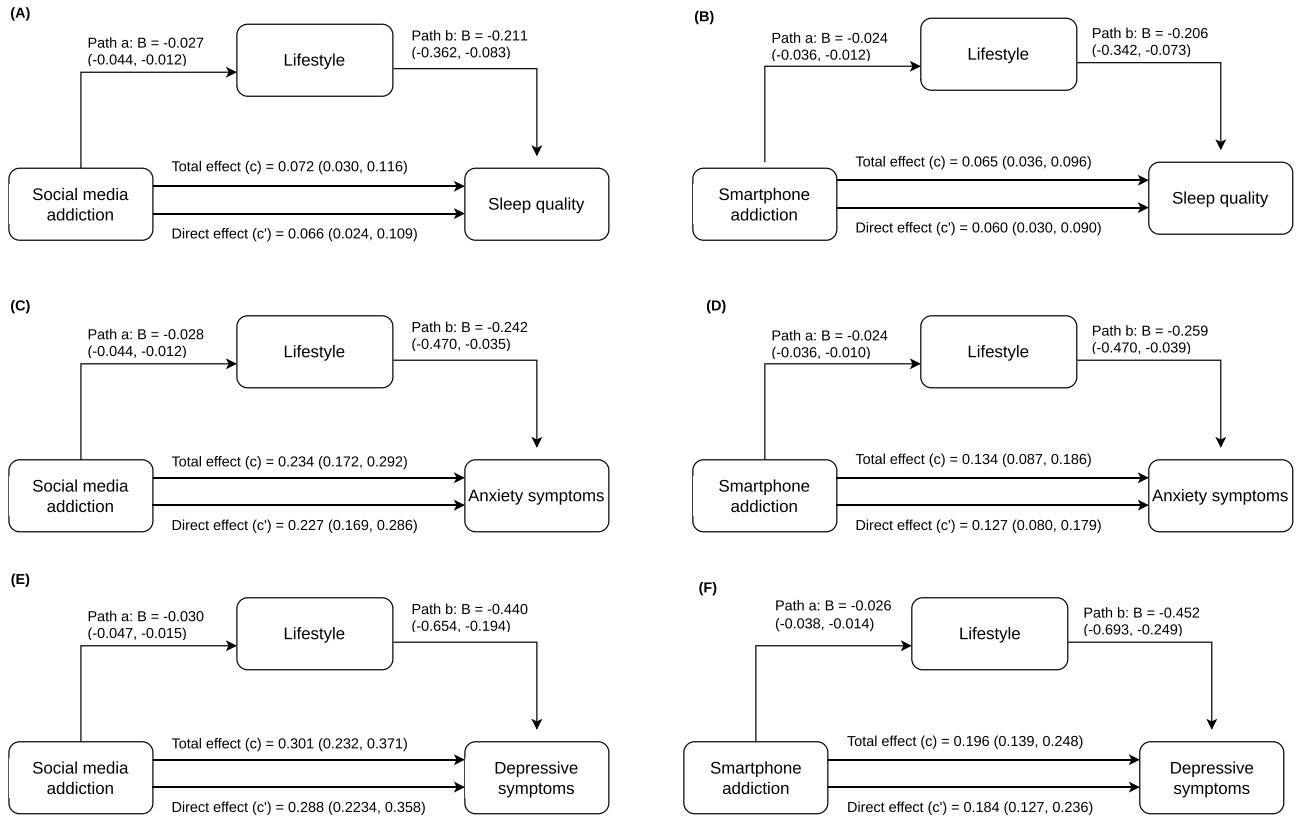

Figure 1 Mediation models examining the potential mediating role of lifestyle in the associations between social media addiction, smartphone addiction and sleep quality, anxiety symptoms, and depressive symptoms. (**A**) Social media addiction and sleep quality. (**B**) Smartphone addiction and sleep quality. (**C**) Social media addiction and anxiety symptoms. (**D**) Smartphone addiction and anxiety symptoms. (**E**) Social media addiction and depressive symptoms. (**F**) Smartphone addiction and depressive symptoms. Values represent unstandardized regression coefficients (**B**) with 95% confidence intervals. Path a denotes the association between the exposure and lifestyle; path b denotes the association between lifestyle and the outcome; c represents the total effect; and c′ represents the direct effect. Standardized indirect effects are reported in Table 3.

Table 3 The Indirect Effects of Lifestyle Mediate the Association Between SMA, SUA, Sleep Quality, Anxiety, and Depression

Association	Indirect Effect, B (95% CI)	Completely Standardized Indirect Effect, β (95% CI)
BSMAS → sleep quality index	0.006 (0.002, 0.014)	0.008 (0.002, 0.017)
BSMAS → anxiety symptoms	0.007 (0.001, 0.016)	0,005 (0.001, 0.012)
BSMAS → depressive symptoms	0.013 (0.006, 0.025)	0.010 (0.003, 0.019)
SABAS → sleep quality index	0.005 (0.002, 0.010)	0.007 (0.001, 0.015)
SABAS → anxiety symptoms	0.006 (0.001, 0.015)	0.006 (0.001, 0.014)
SABAS → depressive symptoms	0.012 (0.005, 0.020)	0.012 (0.004, 0.021)

Notes: Indirect effects were estimated using PROCESS 4.2 with 95% confidence intervals based on 5000 bootstrap samples. An indirect effect was considered statistically significant when the 95% confidence interval did not include zero.

Abbreviations: B, unstandardized indirect effect; β, completely standardized indirect effect; CI, confidence interval; BSMAS, Bergen social media addiction scale; SAMAS, smartphone application-based addiction scale.

associated with better sleep quality (B = −0.206; 95% CI [−0.342, −0.073]), anxiety symptoms (B = −0.259; 95% CI [−0.470, −0.039]), and depressive symptoms (B = −0.452; 95% CI [−0.693, −0.249]). Additionally, the direct effects of SUA were significant and positively associated with sleep quality (B = 0.060; 95% CI [0.030, 0.090]), anxiety symptoms (B = 0.127; 95% CI [0.080, 0.179]), and depressive symptoms (B = 0.184; 95% CI [0.127, 0.236]).

In Table 3, we found that the completely standardized indirect effects ranged from 0.005 to 0.012, indicating that although the mediation effects were statistically significant, their magnitudes were small.

Discussion

Our findings suggest that lifestyle behaviors may partially explain the observed associations of SMA and SUA with poor sleep quality, anxiety symptoms, and depressive symptoms. Given the relatively small magnitude of the indirect associations and the cross-sectional design, these findings should be interpreted with caution and should not be interpreted as evidence of causal pathways.

The addictive use of social media and smartphone applications disrupts sleep quality and increases the severity of anxiety symptoms and depressive symptoms. These results align with previous studies.[74–76] For example, a randomized, crossover experimental study conducted over 14 days showed that using electronic screens before bedtime reduced melatonin, delayed the body's biological clock, reduced sleep quality, and reduced alertness the next day.[77] Similarly, a meta-analysis of 20 studies provided similar findings about the relationship between media use and sleep quality at bedtime.[78] Besides, Du et al found that SMA correlated to four types of anxiety, including generalized anxiety, social anxiety, attachment anxiety, and fear of missing out.[79] Although the causal association between SMA or SUA and depression and anxiety is not fully understood, the findings from a longitudinal study found that SMA is positively associated with depressive symptoms over time.[80] Although our cross-sectional design could not give causal inference, these findings reinforce that digital overuse is consistently linked to adverse mental health outcomes.

One of the main contributions of this study is the examination of a composite lifestyle index as a potential mediator. Specifically, we combined four lifestyle domains—smoking, alcohol consumption, dietary behaviors, and physical activity—into a single index to better reflect the co-occurrence of health-related behaviors in everyday life. This broader approach offers a more comprehensive view of how digital addiction may intersect with multiple aspects of daily health behavior. Ardesch et al also reported similar findings that people with SMA have more alcohol consumption, smoking, and an unhealthy diet.[81] A 10-year systematic review revealed that the relationship between social media use and alcohol consumption was positive.[82] Social media users were more likely to use e-cigarettes,[83] and e-cigarette users experienced a high risk of depression.[84] On the other hand, healthy behaviors, including frequent physical activity, low alcohol consumption, no smoking, and a healthy diet, were associated with better sleep quality.[85,86] Individuals with healthier

behaviors are less likely to experience depression and anxiety and tend to have higher overall well-being.[30,87] Biological research also provides evidence that individuals adhering to healthy lifestyles show reduced depression risk through brain, immunometabolic, and genetic mechanisms.[88] Our findings converge with this literature but extend it by testing lifestyle as a multifaceted mediator, rather than isolating individual health behaviors. On the other hand, we observed small effect sizes. Thus, the results should be interpreted with caution. Longitudinal and intervention studies are needed to confirm the temporal order and assess whether promoting healthier behaviors can indeed mitigate the negative effects of excessive social media and smartphone use.

Our study investigated the potential mediating role of lifestyle behaviors in the associations between social media addiction, smartphone addiction, and depression, anxiety, and poor sleep quality. While cyberbullying is another important risk factor associated with social media use and can have mental health consequences comparable to offline bullying, it was not assessed in our study. However, prior research has shown that healthy lifestyle behaviors, such as regular physical activity, sufficient sleep, and reduced alcohol use, can strengthen resilience and lower the risk of suicidal thoughts among adolescents exposed to cyberbullying.[89] Therefore, encouraging offline activities, especially those involving group participation and social interaction, outdoor physical activity, and less alcohol consumption, may not only promote healthier lifestyles but also reduce time spent online and potential exposure to risks, such as cyberbullying.

Although the indirect effects were statistically significant, the completely standardized indirect effects ($\beta = 0.005$–0.012) were consistently small, indicating that lifestyle explained a modest proportion of the associations between technology-related addictions and sleep quality, anxiety, and depressive symptoms. These findings suggest that lifestyle may represent one potential behavioral pathway linking problematic technology use with mental health outcomes. Therefore, although promoting a healthy lifestyle may complement strategies aimed at reducing problematic social media and smartphone use, the practical implications of these findings should be interpreted cautiously given the modest magnitude of the mediation effects.

Beyond identifying these associations, future research should evaluate technology-assisted interventions to promote healthier lifestyle behaviors and improve mental health among young adults. Recent evidence suggests that artificial intelligence–enabled digital health tools may facilitate early identification of individuals at risk, personalized behavioral support, and continuous monitoring of mental health symptoms.[90,91] However, further studies are needed to establish the clinical effectiveness, safety, confidentiality, and ethical implementation of digital health in real-world healthcare settings.

Despite these contributions, several limitations should be acknowledged. First, the cross-sectional design prevents determination of temporal relationships among social media addiction, lifestyle behaviors, sleep quality, and psychological outcomes. Reverse or bidirectional associations are possible; for example, individuals experiencing psychological distress or sleep problems may be more likely to engage in excessive social media use as a coping strategy, while problematic social media use may also contribute to adverse psychological and behavioral outcomes. Second, all variables were assessed using self-reported questionnaires, which may be subject to recall bias and social desirability bias. In addition, the use of self-reported measures collected within the same survey may introduce common method bias, potentially affecting the magnitude of observed associations. Third, the lifestyle index used in this study represents a pragmatic composite behavioral indicator rather than a psychometric scale measuring a single latent lifestyle construct. Although combining multiple health behaviors into an unweighted cumulative index is a commonly used epidemiological approach, assigning equal weights to smoking, alcohol consumption, dietary behaviors, and physical activity may not fully reflect their differential contributions to health outcomes. Furthermore, the tertile-based categorization of the index was dependent on the distribution of the current sample, which may limit comparability across populations. Future research should consider developing and validating standardized lifestyle indices or applying data-driven approaches to determine the relative contribution of individual behaviors. Finally, although participants were recruited from universities across different regions of Taiwan, the voluntary convenience sampling approach may have introduced selection bias. Therefore, caution is needed when generalizing these findings to other populations or settings.

Conclusion

Our study provides preliminary evidence that lifestyle factors may partially explain the associations of social media and smartphone addiction with sleep quality, anxiety, and depression. Although the indirect effects were statistically

significant, their small magnitude suggests that lifestyle accounts for a modest proportion of these associations. Therefore, the practical implications of these findings should be interpreted with caution. Future longitudinal research is needed to establish temporal and causal relationships and to evaluate the practical significance of intervention targeting lifestyle behaviors.

Abbreviation

CESD-10, Center for Epidemiological Studies Depression; BSMAS, Bergen Social Media Addiction Scale; GAD-7, 7-item Generalized Anxiety Disorder; HES-5, 5-item healthy eating score; MET min/wk, Metabolic equivalent task minutes per week; PSQI, Pittsburgh Sleep Quality Index; SUA, Smartphone use addiction; SMA, Social media addiction; SABAS, Smartphone Application-Based Addiction Scale.

Data Sharing Statement

The data supporting this study's findings are available from the corresponding author upon reasonable request.

Ethical Approval and Consent to Participate

The study was reviewed and approved by the Taipei Medical University-Joint Institutional Review Board (TMU-JIRB No.: N202201099). All participants were fully informed about the study's objectives, procedures, confidentiality measures, and their right to withdraw at any time. Written informed consent was obtained from each participant before completing the questionnaire. All research procedures were performed in accordance with the ethical standards of the Declaration of Helsinki (1980 revision).

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Author Contributions

All authors made a significant contribution to the work reported, whether in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors declare that they have no conflict of interest.

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