

Structural Model of the Relationship Between Social Media Addiction in Students Based on Behavioral Brain Systems: The Mediating Role of Chronotype

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ABSTRACT

Purpose: The present study aimed to examine a structural model of social media addiction based on behavioral brain systems, with the mediating role of chronotype among university students.

Methods and Materials: The research design was descriptive-correlational using structural equation modeling. The statistical population included all students of the Islamic Azad University, Semnan Branch, during the 2023–2024 academic year. From this population, 326 participants were selected through convenience sampling. The research instruments included the Behavioral Inhibition System/Behavioral Activation System (BIS/BAS) scales developed by Charles S. Carver and Teri L. White, the Morningness–Eveningness Questionnaire (MEQ) by Jim Horne and Olov Östberg, and the Social Media Addiction Questionnaire developed by Khajehahmadi et al. Data analysis was conducted using SPSS-25 and Amos software.

Findings: The results indicated that social media addiction was positively associated with both the Behavioral Activation System (BAS) and the Behavioral Inhibition System (BIS), and negatively and significantly associated with morning chronotype. Structural equation modeling findings confirmed that the Behavioral Activation System had both a direct and an indirect effect—through a decrease in morningness score (i.e., a tendency toward eveningness)—on increasing social media addiction. However, the mediating role of chronotype in the relationship between the Behavioral Inhibition System and addiction was not supported.

Conclusion: The findings suggest that chronotype, as a physiological substrate, facilitates the pathway through which neural sensitivities—particularly the reward system—are translated into addictive behaviors. Accordingly, therapeutic and preventive interventions in the domain of emerging addictions should, in addition to psychological factors, focus on the regulation of circadian rhythms and the modification of students' temporal lifestyle patterns.

Keywords: Social media addiction, behavioral brain systems, chronotype, circadian rhythm, students.

1. Introduction

The rapid expansion of digital technologies and the pervasive integration of social media into daily life

have transformed patterns of human interaction, particularly among university students, who represent one of the most active and vulnerable user groups. While social media

platforms provide opportunities for communication, information exchange, and identity construction, excessive and uncontrolled use has led to the emergence of behavioral patterns conceptualized as social media addiction. This phenomenon has been associated with a range of adverse outcomes, including impaired academic functioning, emotional dysregulation, and reduced psychological well-being (Sarwar et al., 2025; Üstündağ et al., 2025; Yaqoob et al., 2025). Contemporary research increasingly conceptualizes social media addiction within broader frameworks of behavioral addictions, emphasizing the role of neuropsychological vulnerabilities, personality traits, and environmental reinforcements in its development and maintenance (Soraci et al., 2025; Totur et al., 2025). Accordingly, identifying underlying mechanisms that predispose individuals to such maladaptive patterns has become a central focus in psychological research.

One of the most influential theoretical frameworks for understanding individual differences in susceptibility to addictive behaviors is Gray's Reinforcement Sensitivity Theory, operationalized through the Behavioral Activation System (BAS) and the Behavioral Inhibition System (BIS). These systems represent neurobiological substrates that regulate responses to reward and punishment, respectively, and are closely linked to motivational and affective processes. Individuals with heightened BAS sensitivity tend to exhibit increased responsiveness to reward cues, impulsivity, and approach behaviors, which may predispose them to engage excessively in rewarding digital activities such as social media use (Lu et al., 2019; Shabtari et al., 2023). Conversely, the BIS is associated with sensitivity to punishment and avoidance behaviors, although its role in addictive behaviors appears more complex and context-dependent (Esmaeili, 2020). Empirical studies have demonstrated that both systems can significantly predict problematic internet and mobile phone use, highlighting the importance of neurobehavioral mechanisms in the etiology of digital addictions (Cheraghiani, 2020; Eynipour et al., 2021). More recent modeling approaches have further confirmed that behavioral brain systems can directly and indirectly influence addiction tendencies through various psychological mediators (Ghaderi & Moeinan, 2024; Pourmohseni Kalouei et al., 2023).

In parallel with neurobehavioral perspectives, chronotype has emerged as a critical biopsychological factor influencing behavioral regulation, emotional functioning, and health-related outcomes. Chronotype refers to individual differences in circadian preference, typically categorized

along a continuum from morningness to eveningness, reflecting variations in the timing of sleep-wake cycles and peak cognitive performance (Günel, 2023; Yangilar & Yilmaz, 2022). Research indicates that evening-type individuals are more likely to experience sleep disturbances, poorer lifestyle habits, and increased vulnerability to psychological distress compared to their morning-type counterparts (Bodur et al., 2021; Burek et al., 2022). These differences extend to cognitive and behavioral domains, where chronotype has been linked to executive functioning, self-regulation, and decision-making processes (Carlson et al., 2023; Owens et al., 2016). Furthermore, the COVID-19 pandemic has underscored the sensitivity of chronotype to environmental changes, revealing its dynamic interaction with lifestyle patterns and psychological well-being (Genta et al., 2021).

Importantly, growing evidence suggests that chronotype may play a mediating or moderating role in the relationship between psychological vulnerabilities and maladaptive behaviors. For instance, chronotype has been shown to influence emotional states, mental health symptoms, and quality of life through intermediary mechanisms such as sleep quality, anxiety, and resilience (Noh et al., 2021; Nowakowska-Domagala et al., 2023; Poon et al., 2024). Similarly, studies have demonstrated that eveningness is associated with increased engagement in risky and addictive behaviors, including problematic smartphone and internet use (Demirhan et al., 2017). This association can be explained by the misalignment between biological rhythms and social demands, which may impair self-regulation and increase susceptibility to immediate rewards offered by digital environments. Moreover, chronotype has been linked to social functioning and psychological adjustment, suggesting that it may serve as a key mechanism through which individual differences in neurobehavioral systems are translated into observable behaviors (Al-Rfooh & Khater, 2024; Luo et al., 2024).

Despite the growing body of research on behavioral brain systems and chronotype, limited studies have examined their integrated role in predicting social media addiction within a unified structural framework. Most existing research has either focused on direct relationships or has considered mediating variables in isolation, thereby overlooking the complex interplay between neurobiological sensitivities and circadian processes. Given that both behavioral brain systems and chronotype are rooted in biological regulation, their interaction may provide a more comprehensive understanding of how internal predispositions shape

behavioral outcomes. For example, individuals with high BAS sensitivity may be more prone to eveningness due to heightened reward-seeking tendencies, which in turn may increase their exposure to and engagement with social media platforms during late hours. This pathway highlights the potential of chronotype as a physiological conduit linking neural sensitivity to behavioral addiction.

Furthermore, recent advancements in digital behavior research emphasize the importance of contextual and psychological mediators in understanding the development of problematic social media use. Factors such as fear of missing out (FoMO), social comparison, and internalizing symptoms have been identified as significant contributors to addictive patterns, often interacting with individual differences in personality and biological rhythms (Soraci et al., 2025; Zhu et al., 2025). Additionally, the role of social media addiction in shaping academic resilience, interpersonal relationships, and emotional well-being has been widely documented, reinforcing the need for multidimensional explanatory models (Sarwar et al., 2025). In this context, integrating behavioral brain systems and chronotype into a structural model offers a theoretically grounded and empirically testable approach to understanding the mechanisms underlying social media addiction among students.

Given these considerations, the present study seeks to address existing gaps in the literature by examining the structural relationships between behavioral brain systems, chronotype, and social media addiction among university students. By adopting a structural equation modeling approach, this study aims to simultaneously assess direct and indirect pathways, thereby providing a nuanced understanding of how neurobiological and circadian factors interact to influence addictive behaviors. Such an approach not only contributes to the theoretical advancement of addiction research but also has practical implications for the development of targeted interventions that address both psychological and physiological dimensions of behavior. Therefore, the aim of this study is to investigate the structural model of social media addiction based on behavioral brain systems with the mediating role of chronotype among university students.

2. Methods and Materials

2.1. Study Design and Participants

Based on the defined objectives, the research method was descriptive-correlational with a structural analysis approach.

The statistical population of the present study consisted of all students enrolled at the Islamic Azad University, Semnan Branch, during the second semester of the 2023–2024 academic year. According to the Krejcie and Morgan table, a sample size of 361 participants was determined. Considering the nature of the research variables and the breadth of the population, a convenience sampling method was employed. For this purpose, electronic questionnaires were designed, and access links were distributed through virtual groups and widely followed student channels affiliated with Islamic Azad University of Semnan. Participants were asked to voluntarily participate and to respond carefully. Given the single-stage implementation of the study, the exclusion criterion was incomplete questionnaire responses.

2.2. Measures

Behavioral Activation/Inhibition Systems Scale (BIS/BAS): To assess individual differences in sensitivity to behavioral brain systems, the 24-item scale developed by Charles S. Carver and Teri L. White (1994) was used. This instrument evaluates two central dimensions of behavior: inhibition and activation. The scale consists of two main sections: the Behavioral Inhibition System (BIS) subscale, which includes 7 items, and the Behavioral Activation System (BAS) subscale, which comprises three components: Reward Responsiveness (5 items), Drive (4 items), and Fun Seeking (4 items). It should be noted that 4 items in this questionnaire are included as filler or distractor items and are not considered in the final scoring. Responses are rated on a four-point Likert scale ranging from 1 (completely false) to 4 (completely true). Regarding the psychometric properties of this instrument in Iran, the findings of Babapour, Dadashzadeh, and Tousi (2011) indicate satisfactory internal consistency; specifically, the internal consistency coefficient for the BIS subscale was reported as 0.73. Additionally, the internal consistency coefficients for the three BAS components (Reward Responsiveness, Drive, and Fun Seeking) were confirmed as 0.73, 0.76, and 0.66, respectively.

Morningness–Eveningness Questionnaire (MEQ): To assess circadian typology (morningness–eveningness), the Persian version of the Morningness–Eveningness Questionnaire developed by Jim Horne and Olov Östberg (1976) was used. This self-report instrument contains 19 items, each designed with heterogeneous response options and specific scoring criteria. The total score ranges from 16

to 86, with higher scores indicating morningness and lower scores indicating eveningness. Based on the obtained score, individuals are classified into five categories: definitely morning type (70–86), moderately morning type (59–69), intermediate type (42–58), moderately evening type (31–41), and definitely evening type (16–30). The construct validity of this questionnaire in the Iranian population has been confirmed through exploratory factor analysis, as well as through the assessment of convergent and divergent validity using the Beck Depression Inventory, Oxford Happiness Questionnaire, and General Health Questionnaire. Factor analysis identified three factors for the Persian version: wake-time preference, sleep preference, and optimal performance preference. The reliability of the instrument, assessed using Cronbach's alpha, was reported as 0.79 for the total scale and ranged from 0.58 to 0.73 for its subdimensions, indicating acceptable reliability for assessing circadian typology in related research.

Mobile-Based Social Media Addiction Questionnaire: The Mobile-Based Social Media Addiction Questionnaire was developed by Khajehahmadi et al. in 2016. This questionnaire consists of 23 items across four components: individual performance (items 1–9), time management (items 10–15), self-control (items 16–19), and social relationships (items 19–23). The items are rated on a five-

point Likert scale: strongly disagree (score 1), somewhat disagree (score 2), neutral (score 3), somewhat agree (score 4), and strongly agree (score 5). Therefore, the minimum total score is 23 and the maximum is 115, with higher scores indicating greater addiction to mobile-based social media. The internal reliability of the scale, calculated using Cronbach's alpha, was reported as 0.92.

2.3. Data Analysis

After excluding incomplete questionnaires, data obtained from 326 participants were statistically analyzed using Amos and SPSS version 25. Descriptive statistics were computed using mean and standard deviation indices, and inferential analysis was conducted using analysis of variance (ANOVA), correlation coefficients, and structural equation modeling.

3. Findings and Results

In the present study, data from 326 students aged 19 to 45 years (mean age = 24.65) were analyzed. Descriptive statistics, including means, standard deviations, and correlations among the research variables, are presented in Table 1.

Table 1

Descriptive Statistics and Correlations Among Research Variables

No.	Variables	1	2	3	4
1	Behavioral Activation System (BAS)	1			
2	Behavioral Inhibition System (BIS)	0.12	1		
3	Chronotype	-0.21**	0.08	1	
4	Social Media Addiction	0.32**	0.24**	-0.48**	1
	Mean	32.64	18.24	47.26	81.23
	Standard Deviation	9.04	6.32	8.53	17.65

The results in Table 1 indicate that participants, on average, exhibited an intermediate chronotype. Furthermore, the mean score for mobile-based social media addiction was relatively high. Examination of the Pearson correlation matrix shows that social media addiction has a positive and significant relationship with both the Behavioral Activation System (BAS) and the Behavioral Inhibition System (BIS), whereas its relationship with chronotype (morningness) is negative and strong. An important finding in this section is the significant negative relationship between the Behavioral

Activation System and chronotype, suggesting that individuals with a dominant behavioral activation system tend to exhibit greater eveningness (i.e., lower morningness scores), while the Behavioral Inhibition System did not show a significant relationship with students' biological clock.

Given that structural equation modeling (SEM) was used to analyze the data, the assumption of normality was first examined using the Kolmogorov–Smirnov (K–S) test and was confirmed. The results presented in Table 2 indicate a good fit of the proposed research model.

Table 2

Model Fit Indices

Index Type	CMIN/df	p	RMSEA	GFI	NFI	TLI	IFI	RFI	PCFI	PNFI
Desired Value	< 3	> .05	< .08	.90–1.00	1.00	> .90	> .90	> .60	> .60	> .60
Observed Value	3.34	.02	.08	.99	.98	.96	.99	.89	.68	.67

Based on the structural equation modeling findings using the bootstrap method, all direct paths from behavioral brain systems to social media addiction were positive and statistically significant. Regarding the mediating role, the findings confirmed that the Behavioral Activation System, in addition to its direct effect, increases social media

addiction indirectly through a reduction in morningness score (i.e., a tendency toward eveningness). However, the mediating role of chronotype in the relationship between the Behavioral Inhibition System and addiction was not supported due to the inclusion of zero within the confidence interval (see Figure 1 and Table 3).

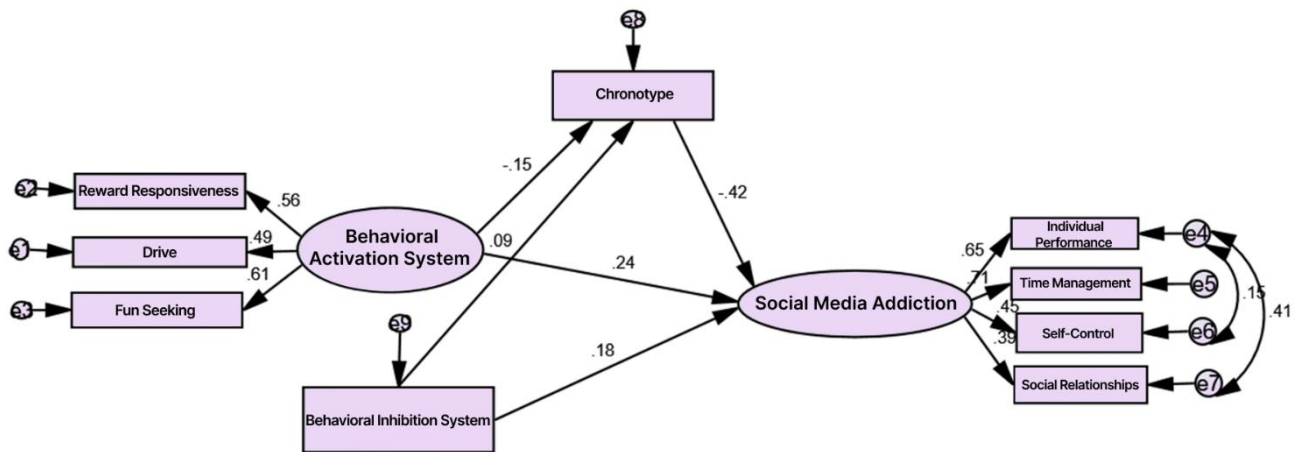
Table 3

Bootstrap Results for the Proposed Research Model

Pathway	Estimate	SE	Lower Bound	Upper Bound	p-value
Direct Effects					
BAS → Social Media Addiction	0.24	0.07	0.12	0.35	.001
BIS → Social Media Addiction	0.18	0.06	0.08	0.29	.011
BAS → Chronotype	-0.15	0.05	-0.24	-0.06	.024
BIS → Chronotype	0.09	0.08	-0.07	0.25	.140
Chronotype → Social Media Addiction	-0.42	0.12	-0.58	-0.27	.001
Indirect Effects (Mediated Paths)					
BAS → Chronotype → Social Media Addiction	0.06	0.02	0.02	0.11	.032
BIS → Chronotype → Social Media Addiction	-0.04	0.03	-0.09	0.01	.180

Figure 1

Model with Beta Coefficients



4. Discussion and Conclusion

The findings of the present study provided robust support for the proposed structural model linking behavioral brain

systems, chronotype, and social media addiction among university students. Specifically, the results demonstrated that both the Behavioral Activation System (BAS) and the Behavioral Inhibition System (BIS) had significant positive

direct effects on social media addiction, while chronotype (morningness–eveningness) showed a significant negative relationship with addictive behaviors. In addition, the mediating analysis revealed that chronotype partially mediated the relationship between BAS and social media addiction, whereas its mediating role in the relationship between BIS and addiction was not supported. These findings collectively underscore the importance of integrating neurobehavioral and circadian frameworks in understanding the etiology of emerging behavioral addictions.

The positive association between BAS and social media addiction observed in this study is consistent with theoretical expectations derived from reinforcement sensitivity theory, which posits that individuals with heightened sensitivity to reward are more likely to engage in behaviors that provide immediate gratification. Social media platforms, by offering continuous feedback, social validation, and novelty, function as potent reward systems that can reinforce repetitive usage patterns. This finding aligns with prior empirical research demonstrating that BAS is a significant predictor of problematic internet and smartphone use (Lu et al., 2019; Shabtari et al., 2023). Moreover, similar studies have shown that individuals with elevated reward responsiveness exhibit increased impulsivity and reduced capacity for delayed gratification, thereby increasing their vulnerability to digital addictions (Cheraghiani, 2020; Eynipour et al., 2021). The current findings extend this line of research by demonstrating that BAS not only exerts a direct influence on social media addiction but also operates indirectly through chronotype, suggesting a more complex, multi-layered mechanism of influence.

The significant positive relationship between BIS and social media addiction, although somewhat less pronounced than that of BAS, also provides important insights into the motivational dynamics underlying addictive behaviors. Traditionally, BIS has been associated with avoidance tendencies and sensitivity to punishment; however, recent research suggests that individuals with high BIS sensitivity may engage in maladaptive coping strategies, including excessive digital media use, to alleviate anxiety and negative affect. This interpretation is supported by studies indicating that BIS is linked to emotional distress and vulnerability to psychopathology, which in turn may drive individuals toward compensatory behaviors such as social media engagement (Esmaeili, 2020; Shabtari et al., 2023). Furthermore, the coexistence of high BAS and BIS sensitivity may create a dual-risk profile characterized by

both heightened reward-seeking and increased emotional reactivity, thereby amplifying susceptibility to addiction.

A central contribution of the present study lies in elucidating the role of chronotype as a mediating variable. The findings indicated that chronotype was negatively associated with social media addiction, meaning that individuals with a stronger morning orientation were less likely to exhibit addictive behaviors, whereas those with an evening orientation were at greater risk. This result is consistent with a substantial body of literature demonstrating that eveningness is associated with poorer self-regulation, increased impulsivity, and greater engagement in risky behaviors, including problematic digital media use (Bodur et al., 2021; Demirhan et al., 2017). Additionally, evening-type individuals often experience misalignment between their biological rhythms and social obligations, leading to sleep disturbances and cognitive fatigue, which may further impair decision-making and increase reliance on easily accessible rewards such as social media (Günel, 2023; Zhu et al., 2022). These findings reinforce the conceptualization of chronotype as a critical biopsychological factor influencing behavioral regulation.

The mediating role of chronotype in the relationship between BAS and social media addiction provides further theoretical and empirical insight. The results suggest that individuals with high BAS sensitivity are more likely to exhibit eveningness tendencies, which in turn increase their risk of social media addiction. This pathway can be interpreted through the lens of reward-driven behavioral patterns, where individuals with heightened sensitivity to reward may prefer late-night activities that offer greater opportunities for stimulation and reinforcement. Empirical evidence supports this interpretation, indicating that eveningness is associated with increased engagement in leisure and digital activities during nighttime hours, often at the expense of sleep and self-regulation (Carlson et al., 2023; Owens et al., 2016). Furthermore, chronotype has been shown to mediate the relationship between psychological traits and behavioral outcomes through mechanisms such as sleep quality, emotional regulation, and cognitive functioning (Nowakowska-Domagala et al., 2023; Poon et al., 2024). The present study adds to this literature by demonstrating that chronotype serves as a physiological conduit through which reward sensitivity is translated into addictive behavior.

In contrast, the mediating role of chronotype in the relationship between BIS and social media addiction was not supported, as indicated by the non-significant indirect effect.

This finding suggests that the influence of BIS on addiction operates through pathways other than circadian preference, potentially involving emotional or cognitive mediators such as anxiety, stress, or maladaptive coping strategies. Previous studies have highlighted the role of anxiety and social dysfunction as mediators in the relationship between chronotype and mental health outcomes, indicating that different mechanisms may underlie the effects of BIS (Nowakowska-Domagala et al., 2023). Additionally, research has shown that BIS-related behaviors are more closely linked to internalizing symptoms, which may lead individuals to seek relief through digital engagement independently of their circadian orientation (Esmaeili, 2020). Therefore, the absence of a mediating effect in this pathway highlights the need to consider alternative explanatory mechanisms in future research.

The overall pattern of findings in this study is also consistent with broader research on digital addiction, which emphasizes the interplay between individual predispositions and environmental affordances. Social media platforms are designed to maximize user engagement through algorithm-driven content delivery, intermittent reinforcement, and social comparison processes, all of which can interact with individual vulnerabilities to promote addictive behaviors (Soraci et al., 2025; Yaqoob et al., 2025). Furthermore, the impact of social media addiction on academic performance, emotional well-being, and interpersonal relationships has been widely documented, underscoring its significance as a public health concern among university students (Sarwar et al., 2025; Üstündağ et al., 2025). The integration of behavioral brain systems and chronotype into a unified model provides a more comprehensive framework for understanding these complex dynamics.

In addition, the findings of this study are in line with recent research highlighting the role of circadian and lifestyle factors in shaping health-related outcomes. Studies have shown that chronotype is associated with physical health, psychological well-being, and occupational functioning, suggesting that it represents a fundamental dimension of human behavior (Al-Rfooh & Khater, 2024; Noh et al., 2021). Moreover, lifestyle factors such as sleep quality, dietary habits, and physical activity have been found to interact with chronotype, further influencing behavioral outcomes (Burek et al., 2022; Yanglar & Yilmaz, 2022). These findings support the notion that interventions targeting chronotype and circadian regulation may have broad benefits for both mental health and behavioral outcomes, including the reduction of social media addiction.

Despite its contributions, the present study is subject to several limitations that should be considered when interpreting the findings. First, the use of a cross-sectional design limits the ability to draw causal inferences regarding the relationships among variables. Although structural equation modeling provides a powerful analytical framework, longitudinal studies are needed to establish temporal precedence and causal pathways. Second, the reliance on self-report measures may introduce biases such as social desirability and recall errors, potentially affecting the accuracy of the data. Third, the use of convenience sampling restricts the generalizability of the findings to broader populations, as the sample may not be representative of all university students. Additionally, cultural and contextual factors specific to the study setting may influence the observed relationships, limiting the applicability of the results to other contexts.

Future research should address these limitations by employing longitudinal and experimental designs to examine the causal mechanisms underlying the relationships identified in this study. Investigating additional mediating and moderating variables, such as sleep quality, emotional regulation, and cognitive flexibility, may provide a more comprehensive understanding of the pathways linking behavioral brain systems to social media addiction. Furthermore, expanding the scope of research to include diverse populations and cultural contexts would enhance the generalizability of the findings. The use of objective measures, such as digital usage tracking and physiological assessments, could also improve the accuracy and reliability of data. Finally, integrating multidisciplinary perspectives, including neuroscience, chronobiology, and behavioral psychology, may facilitate the development of more sophisticated theoretical models.

From a practical standpoint, the findings of this study have important implications for the prevention and treatment of social media addiction among university students. Interventions should adopt a holistic approach that addresses both psychological and physiological dimensions of behavior. For example, programs aimed at enhancing self-regulation and reducing reward sensitivity may help mitigate the impact of behavioral activation tendencies. At the same time, strategies for regulating circadian rhythms, such as promoting consistent sleep schedules and reducing nighttime screen exposure, may be effective in reducing eveningness and its associated risks. Educational initiatives that raise awareness about the impact of chronotype and digital habits on mental health could also play a crucial role

in prevention. Moreover, integrating these approaches into university counseling services and health promotion programs may enhance their effectiveness and accessibility.

Authors' Contributions

All authors significantly contributed to this study.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

Data are available for research purposes upon reasonable request to the corresponding author.

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Declaration of Interest

The authors report no conflict of interest.

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Ethical Considerations

In this study, to observe ethical considerations, participants were informed about the goals and importance of the research before the start of the study and participated in the research with informed consent.

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