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Dynamic within-person associations between problematic social media use and sleep quality among university students: The mediating role of nomophobia and the moderating role of trait rumination

Honglei Gu¹ | Yuhang Hu² | Qi Zhong³ |
Yufang Cheng¹ | Jie Fang⁴

¹Department of Psychology, Cognition and Human Behavior Key Laboratory of Hunan Province, Hunan Normal University, Changsha, China

²School of Management, Huazhong University of Science and Technology, Wuhan, China

³Mental Health Education Guidance Center for Primary and Secondary Schools of Dongxing District, Neijiang, China

⁴Institute of New Development, Guangdong University of Finance and Economics, Guangzhou, China

Correspondence

Honglei Gu, Department of Psychology, Cognition and Human Behavior Key Laboratory of Hunan Province, Hunan Normal University, Changsha, 410081, China.
Email: ghl@hunnu.edu.cn

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Abstract

Problematic social media use (PSMU) and poor sleep quality are prevalent among university students. Although previous research has documented associations between PSMU and sleep problems, less is known about the short-term dynamic mechanisms underlying this relationship and the individual differences that may shape vulnerability. Drawing on intensive longitudinal data and dynamic structural equation modeling, this study examined a moderated mediation model in which nomophobia (i.e. anxiety or distress arising from being unable to access or use one's mobile phone) mediated the association between PSMU and poor sleep quality, with trait rumination examined as a moderator of this indirect association. A 21-day daily diary study was conducted with 228 Chinese university students. At the between-person level, higher PSMU was associated with greater nomophobia and poorer sleep quality. At the within-person level, increases in PSMU were

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prospectively associated with greater nomophobia, which subsequently predicted poorer sleep quality, supporting an indirect association through nomophobia. This indirect association was more pronounced among students with higher levels of trait rumination. By capturing dynamic day-to-day processes, these findings extend current understanding of how PSMU may contribute to poorer sleep during emerging adulthood and highlight nomophobia and rumination as potential targets for interventions aimed at promoting healthier digital habits and sleep.

KEYWORDS

nomophobia, problematic social media use, rumination, sleep quality

INTRODUCTION

Sleep is a fundamental human need, and sleep quality is closely linked to both physical and psychological well-being. In contemporary information societies, poor sleep quality has become increasingly prevalent alongside the rapid digitalization of everyday life and communication, emerging as an important public health concern (Ren et al., 2026). Sleep quality refers to individuals' subjective evaluation of their sleep experience, including sleep onset, maintenance, depth, and perceived restoration upon awakening (Kline, 2013). Accumulating evidence indicates that poor sleep quality is associated with impaired cognitive performance and increased negative affect (Wang et al., 2025; Xanidis & Brignell, 2016).

University students are particularly vulnerable to sleep problems (Garett et al., 2018). This developmental period is characterized by heightened academic demands, increasing autonomy in daily routines, and the salience of social belonging. In an era of ubiquitous information access and continuous connectivity, these developmental demands often co-occur with irregular schedules and extensive media use, which may disrupt sleep patterns (Garett et al., 2018). In China, these challenges may be further intensified by strong social expectations and intense competition. For instance, a large-scale study of 6284 Chinese university students found that 31 per cent reported poor sleep quality (Li et al., 2020), underscoring the prevalence of sleep-related problems in this population. Given the critical role of sleep in academic functioning and well-being, identifying modifiable risk factors for poor sleep quality among Chinese university students is therefore of substantial practical importance.

Among the factors associated with sleep quality, problematic social media use (PSMU) has received increasing attention. Previous research has consistently documented associations between PSMU and sleep problems (e.g. Ahmed et al., 2025). However, much of this evidence has relied on cross-sectional designs or longitudinal panel studies, which primarily capture stable between-person differences or relatively long-term associations. Such approaches are less suited to determining whether day-to-day elevations in PSMU within the same individual are followed by subsequent changes in sleep quality. This distinction is important because both

PSMU and sleep quality may fluctuate across days and contexts (Musetti et al., 2026; Wang et al., 2025). Intensive longitudinal approaches are therefore needed to distinguish these within-person dynamics from stable between-person differences and to clarify how the association unfolds over time in everyday life.

Beyond establishing these day-to-day associations, it is important to understand the proximal psychological processes through which PSMU may become associated with subsequent sleep problems. One potentially relevant mechanism is nomophobia, defined as the fear, anxiety, or distress associated with being unable to access or use one's mobile phone (Yildirim & Correia, 2015). Rather than treating nomophobia simply as another correlate of PSMU, the current study conceptualizes it as a time-varying psychological state that may change from day to day and help explain how elevated PSMU is followed by poorer sleep. Individual differences in trait rumination may further shape this process. Rumination refers to a maladaptive cognitive response style characterized by repetitive and passive focus on negative emotions and experiences (Nolen-Hoeksema et al., 2008) and may increase individuals' susceptibility to the adverse psychological consequences of PSMU. Examining nomophobia and rumination within an intensive longitudinal framework, therefore, allows us to move beyond static associations and investigate how behavioral, psychological, and cognitive processes are temporally connected within individuals in daily life.

Moreover, most existing evidence comes from Western cultural contexts, limiting its generalizability to Eastern collectivistic societies. Meta-analytic findings suggest that the adverse association between media use and sleep quality may be stronger in Eastern cultures (Han et al., 2024), where social connectedness and interpersonal harmony are highly valued (Stump & Gong, 2020). In such contexts, the importance attached to maintaining social connections and remaining responsive to others may make disengagement from social media or smartphones more difficult, potentially heightening vulnerability to PSMU, nomophobia, and subsequent sleep problems. Collectively, these gaps highlight the need for culturally grounded, intensive longitudinal research examining how PSMU, nomophobia, and subsequent sleep are dynamically connected among Chinese university students.

Problematic social media use and poor sleep quality

Social media refers to a broad range of platforms and applications that facilitate social interaction (Kingsbury et al., 2021). In contemporary society, social media use is pervasive among university students, for whom it serves as a primary channel for communication, self-expression, and social connection (Kingsbury et al., 2021). However, some individuals may experience PSMU, characterized by dysregulated engagement, difficulty controlling use, and associated distress or functional impairment (Franchina et al., 2018). Accumulating evidence suggests that PSMU is associated with a range of adverse outcomes, including poor sleep quality (Ahmed et al., 2025).

According to the sleep displacement hypothesis, PSMU—an unstructured leisure activity without clear start–end boundaries or time constraints—may displace time that would otherwise be devoted to sleep, thereby undermining sleep quality (Exelmans & Van den Bulck, 2017). University students often spend substantial time before bedtime browsing content, interacting with others, or engaging in online entertainment, which may delay sleep onset and consequently reduce sleep duration and overall sleep quality (Ren et al., 2026; Said et al., 2026). Supporting this association, a three-wave study of 1696 adolescents showed that PSMU at baseline predicted sleep problems 6 months later (Ren et al., 2026).

From a temporal perspective, subsequent rather than same-day sleep quality provides a clearer test of the proposed direction of association. In the present diary design, PSMU was assessed with reference to experiences occurring during the current day, whereas sleep quality reported on that same assessment day referred to the preceding night. Thus, same-day sleep quality had largely occurred before that day's media experiences and therefore could not be interpreted as a subsequent outcome of PSMU. By contrast, sleep quality reported on the following day reflected the sleep episode occurring after the preceding day's PSMU, thereby preserving the prospective temporal ordering between PSMU and subsequent sleep.

The mediating role of nomophobia

As noted earlier, nomophobia refers to the fear, anxiety, or distress associated with being unable to access or use one's smartphone (Yildirim & Correia, 2015). Although nomophobia is related to fear of missing out (FoMO), the two constructs are conceptually distinct (Gu et al., 2026). FoMO primarily reflects concern about missing rewarding social experiences about others (Przybylski et al., 2013), whereas nomophobia centers more specifically on distress arising from restricted access to the smartphone itself and its communication and informational functions (Yildirim & Correia, 2015). This distinction is important because the current study focuses specifically on smartphone-access-related anxiety as a proximal psychological mechanism linking PSMU to poor sleep quality.

PSMU may represent an important antecedent of nomophobia (Berdida et al., 2026). According to self-determination theory (SDT), autonomy, competence, and relatedness constitute three basic psychological needs that shape motivation and sustained engagement when supported by the social environment (Deci & Ryan, 2000). For university students, social media platforms may facilitate social connection (relatedness), foster communication skills (competence), and enable self-presentation aligned with personal preferences (autonomy), thereby fulfilling these needs (Skeggs & Orben, 2025). The fulfilment of these needs, in turn, promotes continued engagement (Deci & Ryan, 2000), which may increase reliance on smartphones and social media as primary avenues for meeting psychological needs. Consequently, being separated from one's phone may be perceived as threatening continued need fulfillment, eliciting heightened nomophobia. Consistent with this framework, a study involving 585 nursing students reported a positive association between social media use and nomophobia (Berdida et al., 2026).

Nomophobia may, in turn, contribute to poor sleep quality. From an SDT perspective, the frustration or deprivation of basic psychological needs can undermine psychological functioning (Deci & Ryan, 2000). Nomophobia may represent a fear state driven by anticipated disruptions in need fulfillment, particularly concerns about being unable to communicate or access information (Wen et al., 2023). Individuals high in nomophobia may worry about missing social interactions (relatedness) or losing access to information (competence), leading to repetitive checking behaviors, increased bedtime phone use, and difficulty disengaging from devices—processes that interfere with sleep initiation. Furthermore, heightened nomophobia may cause individuals to wake during the night to check messages because of concerns about missed communications or online activity, disrupting sleep maintenance and reducing sleep depth (Jahrami et al., 2022). Supporting this association, a study of 419 medical students found that nomophobia was significantly associated with poor sleep quality (Sadeghi et al., 2025). Taken together, these theoretical arguments and empirical findings suggest that nomophobia may function as a proximal psychological mechanism linking PSMU to sleep quality.

The moderating role of rumination

Although PSMU is related to greater nomophobia, the strength of this association may vary across individuals. Rumination is a maladaptive cognitive response style characterized by repetitive and passive attention to negative emotions and experiences, including their perceived causes and consequences, rather than active problem solving (Nolen-Hoeksema et al., 2008). As a relatively stable cognitive tendency, trait rumination reflects difficulty disengaging from persistent negative thoughts and emotions (Luo et al., 2025).

According to response styles theory, rumination intensifies maladaptive cognitions, prolongs negative affect, and interferes with effective problem solving (Nolen-Hoeksema et al., 2008). Individuals high in trait rumination may therefore be more likely to dwell on negative or ambiguous social media experiences, such as unanswered messages or perceived social disconnection, rather than disengaging from these experiences or responding adaptively (Luo et al., 2025). Such repetitive cognitive processing may magnify the psychological salience of social media interactions and strengthen reliance on smartphones as a means of maintaining connection, reassurance, and access to social information. Consequently, when PSMU increases, individuals high in trait rumination may experience greater anxiety and distress about losing access to their smartphones, resulting in stronger nomophobic responses. By contrast, individuals low in trait rumination may be better able to disengage from negative online experiences and use more adaptive coping strategies, thereby weakening the extent to which PSMU translates into nomophobia. Thus, trait rumination is expected to strengthen the positive association between PSMU and nomophobia.

The current study

To date, research on PSMU and sleep quality has largely overlooked the dynamic, day-to-day processes through which these experiences unfold within individuals, as well as the proximal psychological mechanisms and individual differences that may shape these temporal associations. In particular, relatively little is known about whether day-to-day elevations in PSMU are followed by changes in nomophobia and, subsequently, poorer sleep, or whether trait rumination shapes this within-person process. Moreover, evidence from Chinese cultural contexts remains limited, despite growing interest in how social and cultural contexts may influence technology-related experiences and their implications for sleep.

To address these gaps, the current study employed a 21-day daily diary design and dynamic structural equation modeling (DSEM) to examine the temporal associations among PSMU, nomophobia, and poor sleep quality at the within-person level among Chinese university students. By capturing experiences close to when they occur, the daily diary design reduces retrospective recall bias and enhances ecological validity, whereas DSEM enables the separation of within-person fluctuations from stable between-person differences and the examination of temporal dependencies across repeated daily assessments. The contribution of this study therefore lies less in introducing another combination of correlates of sleep and more in examining whether a theoretically specified psychological process unfolds dynamically within individuals over time. Specifically, the study contributes to the literature in three ways. First, it moves beyond predominantly cross-sectional and between-person approaches by examining day-to-day within-person temporal associations between PSMU and subsequent sleep quality. Second, it integrates PSMU, nomophobia, and trait rumination within a unified dynamic framework to

examine a proximal psychological mechanism and an individual-difference factor that may shape this temporal process. Third, it provides intensive longitudinal evidence from Chinese university students, extending research on technology-related sleep experiences to a cultural context that remains underrepresented.

From a temporal perspective, we conceptualized the proposed mediation process as unfolding prospectively across consecutive daily assessments. For clarity, the temporal notation used throughout the study refers to assessment days. Day t denotes the current assessment day, Day $t - 1$ the immediately preceding assessment day, and Day $t - 2$ two assessment days earlier. PSMU and nomophobia reported on a given day refer to experiences occurring during that day, whereas sleep quality reported on Day t refers to the preceding night's sleep (i.e. the sleep episode occurring between Day $t - 1$ and Day t). Daily PSMU may heighten concerns about access to one's smartphone, thereby increasing nomophobia on the following day; elevated nomophobia may, in turn, interfere with subsequent sleep quality. Accordingly, the mediation model was specified such that PSMU on Day $t - 2$ predicted nomophobia on Day $t - 1$, which in turn predicted poor sleep quality reported on Day t .

The $t - 2 \rightarrow t - 1 \rightarrow t$ specification should not be interpreted as implying that the hypothesized effects necessarily require three calendar days to unfold or that more proximal effects are implausible. Rather, it operationalizes the proposed mediation process as two consecutive one-day lagged transitions, such that the predictor precedes the mediator and the mediator, in turn, precedes the subsequent sleep episode. This prospective specification therefore provides clearer temporal ordering than a contemporaneous model, in which the direction of the associations would be more ambiguous.

Accordingly, the study tested the following hypotheses:

Hypothesis 1. Higher PSMU on Day $t - 2$ will predict poorer sleep quality reported on Day t .

Hypothesis 2. Nomophobia on Day $t - 1$ will mediate the temporal association between PSMU on Day $t - 2$ and poor sleep quality reported on Day t .

Hypothesis 3. Trait rumination will moderate the indirect association between PSMU on Day $t - 2$ and poor sleep quality reported on Day t via nomophobia on Day $t - 1$, such that the indirect association will be stronger among individuals with higher levels of trait rumination.

METHODS

Participants and procedure

This study employed a 21-day daily diary design. Using cluster sampling, intact classes were recruited from a university in China. Prior to the diary phase, participants completed a baseline questionnaire assessing demographic characteristics (e.g. gender and age) and trait rumination. After providing informed consent, the participants entered the 21-day daily assessment period.

Each day at 19:00, a survey link was distributed through the participating classes' WeChat groups. The participants reported their PSMU and nomophobia experienced during that day, as well as their sleep quality during the previous night. Thus, sleep quality reported on Day

t referred to the night immediately preceding the Day t assessment, whereas PSMU and nomophobia reported on Day t referred to experiences occurring during that day. Accordingly, sleep quality reported on the same assessment day temporally preceded most of that day's social media experiences and was therefore not treated as a prospective outcome of those experiences. Each daily survey took approximately 1 min to complete, and responses were accepted until 24:00 on the same day. To minimize potential order effects, the presentation order of the daily items was randomized at each assessment.

The study was not preregistered. The study protocol was reviewed and approved by the Research Ethics Committee of the first author's institution (Approval No. 2023472). Data collection was conducted from May 7 to May 28, 2024. Participation was voluntary, and all participants were informed that they could withdraw from the study at any time without penalty. Research assistants screened the submitted surveys for completeness and response validity. The participants received an online incentive of RMB 20 upon completion of the study. Importantly, the dataset analyzed in the current study has not been used in any previous publication, and the current study is not a secondary analysis of previously published data.

The final sample comprised 228 university students ($M_{\text{age}} = 18.38$ years, $SD = 0.89$, range = 17–23), of whom 83.3 per cent were female. Across the 21-day diary period, 4788 daily observations were theoretically possible, of which 4581 valid daily surveys were completed, yielding an overall compliance rate of 95.7 per cent. Day-specific completion rates remained high throughout the study period, ranging from 92.1 to 98.7 per cent (see Table S1 for completion rates for each of the 21 diary days). The number of completed daily surveys per participant ranged from 16 to 21, with an average of 20.09 surveys per participant.

No formal a priori power analysis was conducted before data collection. The sample size was determined with consideration of the intensive longitudinal design and the need for sufficient information at both the within-person and between-person levels. To evaluate the statistical sensitivity of the achieved design, we conducted a Monte Carlo simulation based on the multilevel DSEM structure and the estimated model parameters. The simulation reflected the study design of 228 participants assessed across 21 daily occasions and incorporated the autoregressive, lagged, random-effect, and cross-level parameters specified in the primary model. Statistical power exceeded 0.80 for most focal parameters, indicating adequate sensitivity for detecting the principal temporal effects under the specified model.

Measures

Daily problematic social media use

To minimize participant burden in the daily diary design while retaining sensitivity to day-to-day fluctuations, three items were adapted from the Problematic Social Media Use Scale (Franchina et al., 2018). The original items were modified to assess participants' daily experiences of PSMU. The participants responded to the following items: "Today, I find it difficult to quit using social media," "Today, I use social media because I feel unhappy," and "Today, I feel restless, frustrated, or irritated when I can't access social media." Responses were rated on a 5-point scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*), with higher scores indicating greater daily PSMU. In this study, internal consistency of the sample across items and time points (i.e. R_{KF} ; Cranford et al., 2006; Revelle & Wilt, 2019) was 0.97.

Daily sleep quality

Daily sleep quality was assessed using three items adapted from the Pittsburgh Sleep Quality Index (PSQI; Buysse et al., 1989). To minimize participant burden in the daily diary design while capturing day-to-day variation in sleep, the items were selected to reflect three key aspects of daily sleep quality: difficulty initiating sleep, subjective sleep quality, and non-restorative sleep. The participants responded to the following items: “I had some difficulty falling asleep last night,” “My sleep quality was not good last night,” and “I felt tired even after waking up this morning.” Items were rated on a 5-point Likert scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*), with higher scores indicating poorer daily sleep quality. Internal consistency of the sample across items and time points (R_{KF}) was 0.99.

Daily nomophobia

Daily nomophobia was assessed using four items adapted from the Nomophobia Questionnaire (NMP-Q; Yildirim & Correia, 2015). The original NMP-Q comprises four dimensions: not being able to communicate, losing connectedness, not being able to access information, and giving up convenience. To minimize participant burden in the daily diary design while retaining coverage of the multidimensional nature of nomophobia, we selected one item with the highest factor loading from each of the four dimensions reported by Yildirim and Correia (2015). The selected items were then adapted to reflect participants' daily experiences. The participants responded to the following items: “If I tried to check my messages on my smartphone right now but couldn't, I would be very angry,” “If I couldn't use my smartphone right now, I'd be afraid of falling into a difficult situation,” “If I don't have my phone with me today, I'll feel very anxious because I could not instantly communicate with my family and/or friends,” and “If I could not have my smartphone with me right now, I would feel very anxious because I could not stay up-to-date with social media and online networks.” Items were rated on a 5-point Likert scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*), with higher scores indicating greater daily nomophobia. In this study, internal consistency of the sample across items and time points (R_{KF}) was 0.98.

Trait rumination

Trait rumination was measured using the Ruminative Responses Scale (Treynor et al., 2003), which consists of 10 items (e.g. “Think about a recent situation, wishing it had gone better”). Items were rated on a 4-point Likert scale ranging from 1 (*almost never*) to 4 (*almost always*), with higher average scores indicating greater trait rumination. In the current study, Cronbach's α was 0.78.

Data analysis

Data analyses were conducted using SPSS 26.0 and Mplus 8.6. Given that daily observations were nested within individuals, the data had a two-level structure, with time at Level 1 (within-person) and individuals at Level 2 (between-person). First, an unconditional (null) model

without predictors was estimated to obtain variable means, within- and between-person variances, correlations, and intraclass correlation coefficients (ICCs). ICC values indicate the proportion of total variance attributable to between-person differences, with values above .059 suggesting that multilevel modeling is warranted (Cohen, 1983).

Second, DSEM was used to examine temporal associations between PSMU and sleep quality. Third, a DSEM-based mediation model was specified (Fang et al., 2024), in which PSMU, nomophobia, and sleep quality were modeled within a multilevel time-series framework. This approach decomposes observed scores into latent within-person and between-person components. At the within-person level, autoregressive and cross-lagged paths among the three variables were specified to test the dynamic mediating role of nomophobia in the association between PSMU and sleep quality. To preserve the temporal ordering among the predictor, mediator, and outcome, the primary mediation model was specified as $X_{t-2} \rightarrow M_{t-1} \rightarrow Y_t$. Given the timing of the daily assessments, this specification represents two consecutive 1-day transitions: PSMU on Day $t - 2$ predicts nomophobia on Day $t - 1$, which in turn predicts sleep quality during the subsequent night, reported on Day t . The specification was therefore intended to establish temporal precedence rather than to imply that the underlying process necessarily requires 3 days to unfold. Finally, a moderated mediation model was tested, incorporating trait rumination at the between-person level as a moderator of the within-person association between PSMU and nomophobia (Fang et al., 2025).

DSEM integrates multilevel modeling, time-series analysis, and structural equation modeling, making it particularly suitable for examining within-person dynamics in intensive longitudinal data (McNeish & Hamaker, 2020). By explicitly incorporating temporal dependencies and separating within-person from between-person variation, DSEM provides advantages over conventional multilevel approaches for modeling dynamic processes that unfold over time. The model was estimated within a Bayesian framework using Markov chain Monte Carlo (MCMC) algorithms. Parameter estimates were evaluated based on their 95 per cent Bayesian credible intervals (CrIs), with an effect considered supported when the corresponding CrI did not include zero. To accommodate intermittent missing diary observations and the resulting unequal spacing between observed assessments, the TINTERVAL option in Mplus was specified with an interval of 1, corresponding to a 1-day lag between adjacent measurement occasions. Missing observations were accommodated within the state-space estimation framework using Kalman filtering, which uses available observations to estimate unobserved states. This approach allowed participants with intermittent missing diary observations to be retained in the analysis rather than excluded through listwise deletion (McNeish & Hamaker, 2020). The Mplus analytic code is provided in the Supporting Information to enhance transparency and facilitate reproducibility.

RESULTS

Descriptive statistics and correlations

Table 1 presents the means; within-person and between-person variance estimates; and ICCs for PSMU, nomophobia, and poor sleep quality. The table also reports within-person and between-person correlations among the variables. The ICCs for PSMU, nomophobia, and poor sleep quality were 0.56, 0.66, and 0.38, respectively, indicating that 44 per cent of the variance in PSMU, 34 per cent of the variance in nomophobia, and 62 per cent of the variance in poor sleep quality were attributable to within-person fluctuations across the 21-day period.

TABLE 1 Descriptive statistics and correlations.

Variable	Mean	Variance		ICC	Correlations		
		Within	Between		1	2	3
1. Problematic social media use	3.01	0.29	0.37	0.56	—	.90***	.55***
2. Nomophobia	3.07	0.26	0.50	0.66	.47***	—	.52***
3. Poor sleep quality	2.88	0.59	0.37	0.38	.21***	.20***	—
4. Trait rumination	2.43	—	0.20	—	—	—	—

Note: ICC = intraclass correlation coefficients. The upper triangle presents between-person correlations; the lower triangle presents within-person correlations.

*** $p < 0.001$.

At the within-person level, PSMU was positively associated with both nomophobia ($r = 0.47$) and poor sleep quality ($r = 0.21$), suggesting that on days when participants showed greater PSMU, they also reported higher levels of nomophobia and poorer sleep quality. At the between-person level, PSMU was positively correlated with both nomophobia ($r = 0.90$) and poor sleep quality ($r = 0.55$), indicating that individuals with higher PSMU tended to experience greater nomophobia and poorer sleep quality.

Results of the DSEM analyses

The analyses were conducted sequentially to evaluate the proposed model. We first examined the temporal within-person associations among daily PSMU, nomophobia, and poor sleep quality, including the indirect association between PSMU and poor sleep quality through nomophobia. We then examined whether this indirect association varied as a function of trait rumination. Accordingly, the analyses reported below represent progressively more comprehensive tests of the same theoretical model rather than separate, unrelated models.

Temporal associations and the mediating role of nomophobia

We first examined the temporal association between PSMU and poor sleep quality to establish the basic prospective relationship underlying the proposed mediation process. As shown in Figure 1, PSMU ($\beta = 0.268$, 95% CrI [0.236, 0.302]) and poor sleep quality ($\beta = 0.215$, 95% CrI [0.181, 0.249]) both showed positive autoregressive effects, indicating temporal stability in these daily experiences. Importantly, PSMU on Day $t - 2$ positively predicted poor sleep quality on Day t ($c = 0.034$, 95% CrI [0.002, 0.067]), providing initial evidence that elevations in PSMU prospectively preceded poorer subsequent sleep quality.

We next extended this temporal model by introducing nomophobia as the proposed within-person mediator. As shown in Figure 2, PSMU ($\beta = 0.277$, 95% CrI [0.230, 0.320]), nomophobia ($\beta = 0.292$, 95% CrI [0.244, 0.341]), and poor sleep quality ($\beta = 0.194$, 95% CrI [0.155, 0.233]) all showed positive autoregressive effects. The autoregressive coefficient for poor sleep quality was numerically smaller than those for PSMU and nomophobia.

Consistent with the proposed temporal mediation process, higher-than-usual PSMU on Day $t - 2$ predicted higher nomophobia on Day $t - 1$ ($a = 0.071$, 95% CrI [0.036, 0.103]), which, in

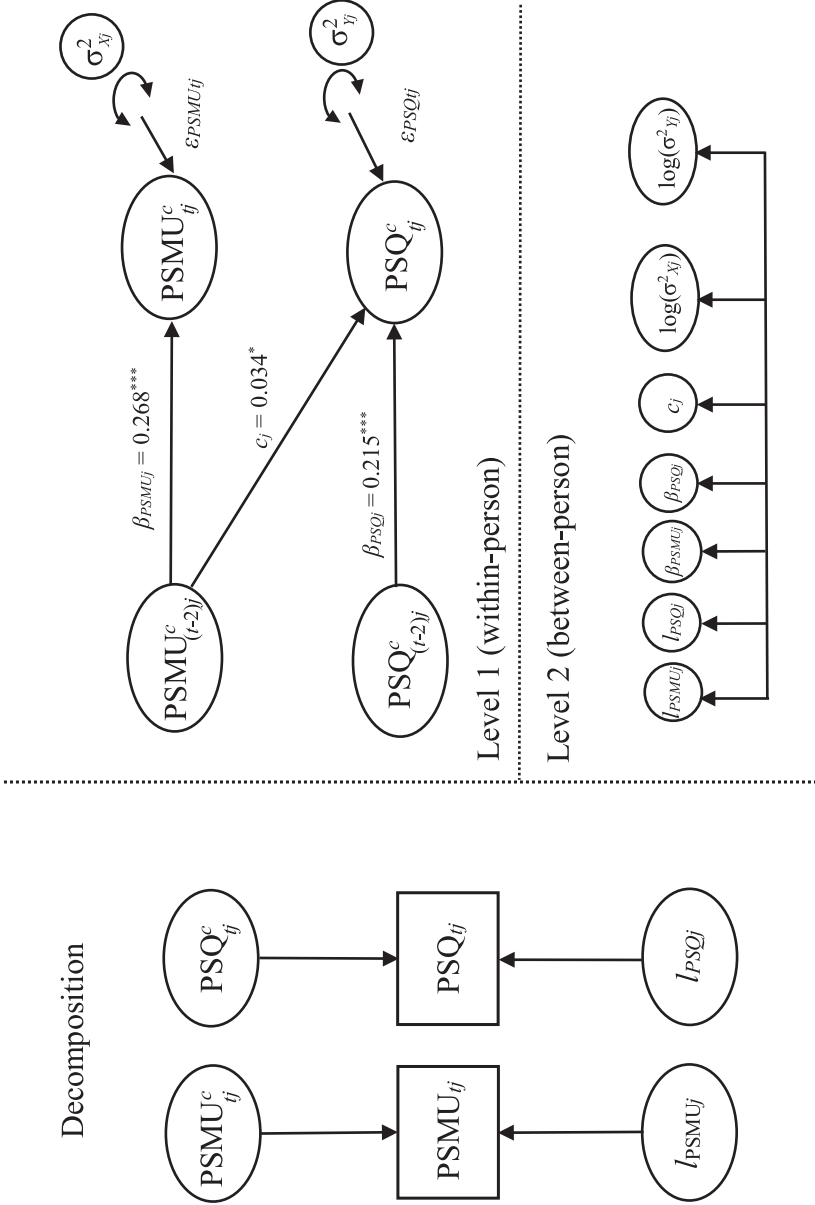


FIGURE 1 The dynamic relationship between problematic social media use and poor sleep quality. Note. PSMU = problematic social media use; PSQ = poor sleep quality. β denotes autoregressive effects, whereas c represents the total effect of problematic social media use on sleep quality. The subscript t denotes the current assessment day, and $t - 2$ denotes two assessment days earlier. Problematic social media use reported on a given day refers to participants' experiences of problematic social media engagement during that day, whereas sleep quality reported on Day t refers to the preceding night's sleep (i.e. the sleep episode occurring between Day $t - 1$ and Day t). * $p < .05$, *** $p < .001$.

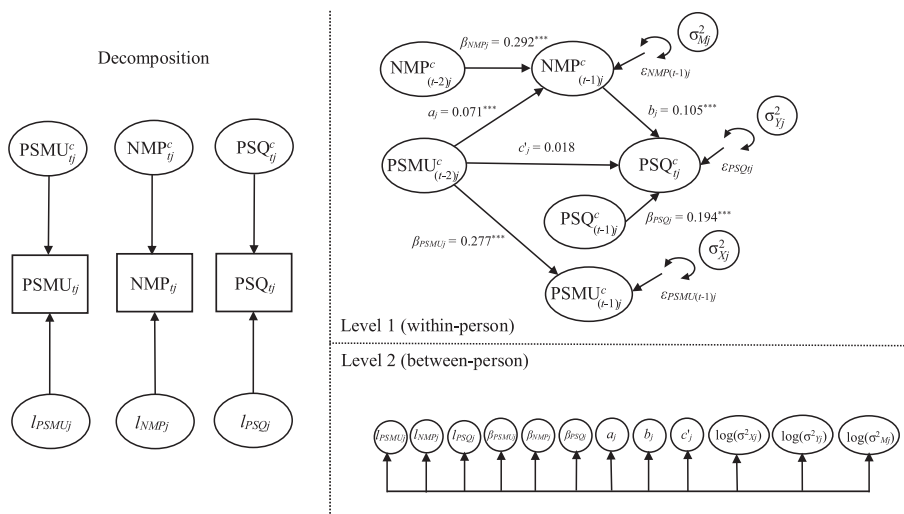
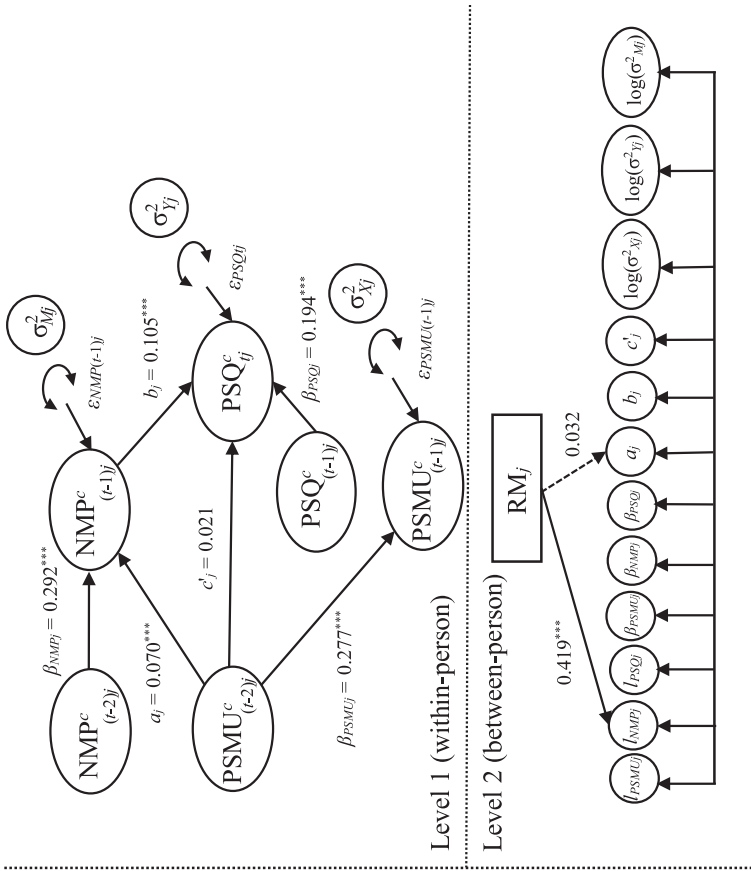


FIGURE 2 The dynamic mediating role of nomophobia in the relationship between problematic social media use and sleep quality. *Note.* PSMU = problematic social media use; NMP = nomophobia; PSQ = poor sleep quality. β denotes autoregressive effects, whereas a , b , and c' represent the first-stage path, second-stage path, and direct effect of the mediation, respectively. The subscript t denotes the current assessment day, $t - 1$ the immediately preceding assessment day, and $t - 2$ two assessment days earlier. Problematic social media use and nomophobia reported on a given day refer to experiences occurring during that day, whereas sleep quality reported on Day t refers to the preceding night's sleep (i.e. the sleep episode occurring between Day $t - 1$ and Day t). *** $p < .001$.

turn, predicted poorer sleep quality on Day t ($b = 0.105$, 95% CrI [0.052, 0.158]). The within-person indirect effect of PSMU on poor sleep quality through nomophobia was 0.011 (95% CrI [0.001, 0.022]). Because the 95 per cent CrI excluded zero, the results supported the hypothesized indirect effect. Taken together, these findings extend the initial prospective association by identifying nomophobia as a within-person mechanism linking daily PSMU to poorer subsequent sleep quality.

Trait rumination as a moderator of the indirect effect

We extended the mediation model by incorporating trait rumination as a between-person moderator to examine whether the within-person indirect association between PSMU and poor sleep quality via nomophobia varied as a function of individual differences in rumination. As shown in Figure 3, PSMU on Day $t - 2$ predicted PSMU on Day $t - 1$ ($\beta = 0.277$, 95% CrI [0.233, 0.323]) and positively predicted nomophobia on Day $t - 1$ ($a = 0.070$, 95% CrI [0.036, 0.103]). Nomophobia likewise showed temporal stability, with nomophobia on Day $t - 2$ predicting nomophobia on Day $t - 1$ ($\beta = 0.292$, 95% CrI [0.243, 0.341]). In turn, nomophobia on Day $t - 1$ positively predicted poor sleep quality on Day t ($b = 0.105$, 95% CrI [0.053, 0.156]). At the between-person level, trait rumination was positively associated with nomophobia ($\beta = 0.419$, 95% CrI [0.216, 0.623]). The cross-level interaction between daily PSMU and trait rumination in predicting nomophobia was positive, although its 95 per cent CrI included zero ($\beta = 0.032$, 95% CrI [-0.032, 0.102]).



Decomposition

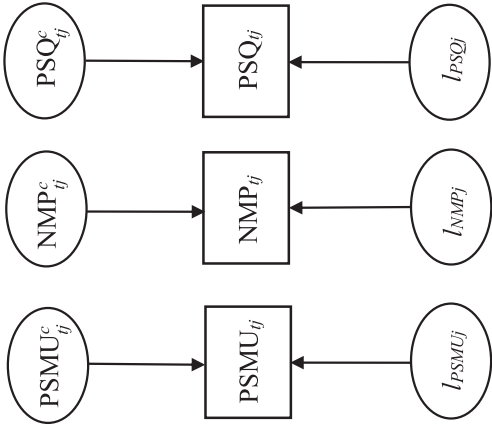


FIGURE 3 DSEM moderated mediation model of problematic social media use, nomophobia, poor sleep quality, and trait rumination. *Note.* $PSMU$ = problematic social media use; NMP = nomophobia; PSQ = poor sleep quality; RM = rumination. β denotes autoregressive effects, whereas a , b , and c' represent the first-stage path, second-stage path, and direct effect of the mediation, respectively. The subscript t denotes the current assessment day, $t - 1$ the immediately preceding assessment day, and $t - 2$ two assessment days earlier. Problematic social media use and nomophobia reported on a given day refer to experiences occurring during that day, whereas sleep quality reported on Day t refers to the preceding night's sleep (i.e. the sleep episode occurring between Day $t - 1$ and Day t). *** $p < .001$.

Notably, a nonsignificant interaction on an individual component path does not necessarily preclude variation in the overall indirect effect across levels of the moderator (Edwards & Lambert, 2007). Because the magnitude of an indirect effect may vary as a function of the moderator, we further used the Johnson–Neyman technique to probe the conditional indirect effect across the observed range of trait rumination. As illustrated in Figure 4, when trait rumination exceeded 0.06 units above the sample mean, the conditional indirect effect of PSMU on poor sleep quality via nomophobia was positive and its 95 per cent CrI excluded zero. The magnitude of this indirect effect increased as trait rumination increased. At or below this threshold, the corresponding 95 per cent CrI included zero. Taken together, these findings suggest that the within-person indirect association between PSMU and sleep quality via nomophobia was more pronounced among students with higher levels of trait rumination.

Finally, we conducted sensitivity analyses to examine whether the observed pattern depended on the specific temporal specification used in the primary analyses. We re-estimated the model using first-order lagged associations, with PSMU on Day $t - 1$ predicting nomophobia on Day t and nomophobia on Day $t - 1$ predicting poor sleep quality on Day t . The results were substantively consistent with those of the primary analyses. Specifically, the Johnson–Neyman analysis indicated that when trait rumination exceeded 0.79 units above the sample mean, the conditional indirect effect was positive and its 95 per cent CrI excluded zero. The magnitude of the indirect effect also increased as trait rumination increased. These findings suggest that the substantive pattern did not appear to be contingent on the $t - 2 \rightarrow t - 1 \rightarrow t$ temporal specification.

DISCUSSION

Drawing on 21 consecutive days of intensive longitudinal data and DSEM, this study examined nomophobia as a within-person mechanism linking PSMU to poor sleep quality and investigated whether this indirect association varied as a function of trait rumination. The results

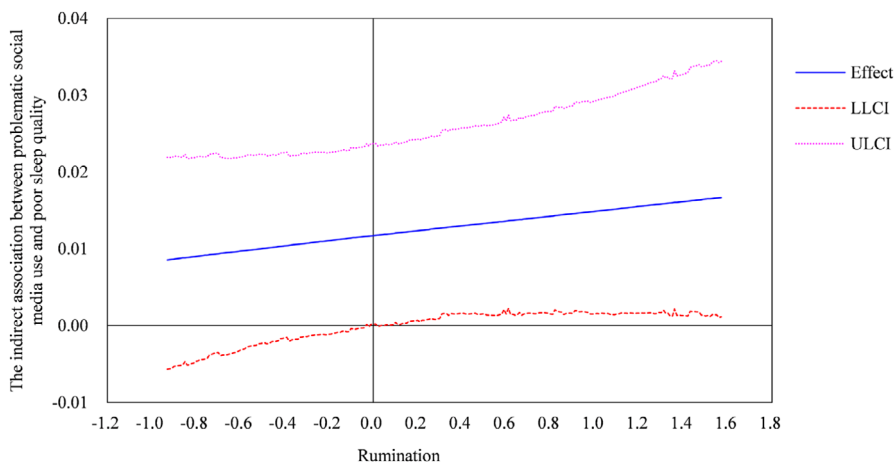


FIGURE 4 The moderating effect of rumination on the indirect association between problematic social media use and poor sleep quality. *Note.* Rumination was grand-mean centered. The effect represents the point estimate of the indirect effect, whereas LLCI and ULCI denote the lower and upper bounds, respectively, of the 95 per cent credible interval.

showed that higher PSMU prospectively predicted poorer sleep quality and that this association operated, in part, through subsequent increases in nomophobia. The conditional indirect association was also more pronounced among individuals with higher levels of trait rumination. By integrating daily diary assessments with DSEM, the current study extends prior research by illustrating how PSMU, nomophobia, and sleep quality may be dynamically connected within individuals over time.

Consistent with prior research (Ahmed et al., 2025; Ren et al., 2026), higher PSMU prospectively predicted poorer subsequent sleep quality. This finding extends previous evidence by demonstrating that the association is observable not only between individuals but also as a temporal within-person process across consecutive daily assessments. In other words, periods characterized by elevated PSMU were followed by poorer subsequent sleep experiences within the same individuals.

This pattern is broadly consistent with the sleep displacement hypothesis, which proposes that difficulty regulating engagement in digital activities may interfere with routines and behaviors that support healthy sleep (Exelmans & Van den Bulck, 2017). Although this study did not directly assess bedtime social media use or sleep displacement, elevated PSMU may reflect difficulty disengaging from social media and regulating digital activity in ways that are compatible with healthy sleep routines. Such dysregulated engagement may also contribute to irregular routines and reinforce patterns of digital behavior that compete with sleep-related self-regulation (Perlis et al., 2011). These processes may be particularly relevant for university students, who face substantial academic demands, strong social motivations, and increasing autonomy over their daily routines, potentially making effective regulation of social media use and sleep-related behaviors more challenging.

The findings further indicated that nomophobia served as a temporal within-person mechanism linking PSMU to subsequent poor sleep quality. Specifically, greater PSMU was followed by higher nomophobia, which in turn predicted poorer subsequent sleep quality. This finding highlights nomophobia as a proximal psychological process that may help explain how PSMU becomes associated with later sleep difficulties. From the perspective of SDT, social media provides opportunities for self-expression, social interaction, and access to socially relevant information that may fulfil needs for autonomy, relatedness, and competence (Skeggs & Orben, 2025). When social media becomes an important means of accessing these valued functions, repeated problematic engagement may strengthen psychological reliance on smartphone-mediated connectivity, making restricted access to the smartphone more distressing and thereby increasing nomophobia (Berdida et al., 2026).

Greater nomophobia may subsequently interfere with sleep by sustaining psychological arousal, preoccupation with connectivity, and difficulty disengaging from smartphone-related concerns. Previous research suggests that individuals high in nomophobia may engage in behaviors such as repeated checking or prolonged smartphone use around bedtime, which may interfere with sleep initiation and continuity (Jahrami et al., 2022). These behaviors were not directly measured in the current study and should therefore be regarded as possible explanatory mechanisms rather than processes directly demonstrated by our data. In the Chinese context, where maintaining interpersonal responsiveness may be especially salient, concerns about losing access to messages or ongoing group interactions could further intensify smartphone-related anxiety (Gu et al., 2026). Future research should directly assess these behavioral and psychological processes to determine how they contribute to the observed temporal association between nomophobia and sleep.

The conditional indirect association between PSMU and poor sleep quality through nomophobia was more pronounced at higher levels of trait rumination. This finding is consistent with response styles theory, which characterizes rumination as a maladaptive cognitive tendency involving repetitive and passive focus on negative emotions and experiences (Nolen-Hoeksema et al., 2008). Persistent rumination may make it more difficult for individuals to disengage cognitively from negative or unresolved social experiences and may prolong emotional distress (Luo et al., 2025). In the context of PSMU, individuals higher in trait rumination may therefore be more likely to dwell on ambiguous or negative online experiences, such as unanswered messages or perceived social disconnection. Such repetitive processing could increase the psychological salience of maintaining access to social media and smartphone-mediated communication, thereby increasing nomophobia, which in turn exacerbates poor sleep quality.

This interpretation should nevertheless be considered cautiously. Although the conditional indirect effect became more evident at higher levels of trait rumination, the cross-level interaction between PSMU and trait rumination in predicting nomophobia had a 95 per cent CrI that included zero. These findings therefore provide stronger evidence for variation in the conditional indirect pattern than for a robust moderation effect on the individual first-stage pathway. Future studies with greater measurement precision and independent replication are needed to establish the robustness of trait rumination as a moderator of this dynamic process.

Several limitations warrant consideration. First, the exclusive use of self-report measures represents an important measurement limitation. Daily PSMU, nomophobia, and sleep quality were assessed using the same general method and similar response formats, which may have introduced common method variance and shared response tendencies. For example, global negative evaluations or mood-congruent reporting could have influenced participants' ratings across multiple constructs and may therefore have contributed to or inflated some of the observed temporal associations. Although the lagged design established temporal separation among the focal variables, such separation does not eliminate shared method variance. Accordingly, the observed associations should not be interpreted as definitive evidence of a specific behavioral mechanism unfolding over time. In addition, some overlap in the content of the self-report measures of PSMU and nomophobia may have reduced the empirical distinctiveness of the two constructs and contributed, at least in part, to their observed associations. Future research should incorporate multimethod assessments, including objective smartphone and social media use records, passive sensing, and actigraphy-based measures of sleep, alongside self-report measures to better distinguish subjective experiences from behavioral patterns and provide a more stringent test of the proposed temporal process.

Second, circadian rhythms and individual differences in circadian preference were not directly assessed. These factors may be associated with both sleep patterns and psychological experiences (Vitale et al., 2015) and could therefore have influenced the observed associations. In addition, because participants were permitted to complete the daily survey between 19:00 and 24:00, variation in completion time may have reflected differences in daily schedules or circadian preference, although survey timing should not be interpreted as a direct measure of chronotype. Future research should incorporate validated measures of chronotype or circadian preference and explicitly model assessment timing as a potential time-varying covariate to determine whether the observed temporal associations remain after accounting for these factors.

Third, the current study did not distinguish between device use and the specific activities undertaken on social media. Social media is inherently social and encompasses multiple forms

of engagement, such as interacting with others, viewing content, and maintaining social connections, which may have distinct implications for psychological experiences and sleep. Future research should therefore adopt more fine-grained and activity-specific measures of social media use to identify which forms of engagement are most strongly associated with nomophobia and poor sleep quality.

Finally, the sample consisted exclusively of Chinese university students, which may limit the generalizability. The observed associations may partly reflect educational or cultural characteristics specific to this population. Replication across more diverse educational settings and cultural contexts is needed to determine the extent to which the proposed dynamic processes generalize to young people in both Eastern and Western societies.

Despite these limitations, the current study advances theoretical understanding of how problematic media use relates to sleep in daily life. By integrating PSMU, nomophobia, and rumination within a unified dynamic framework, the study moves beyond static associations and highlights the importance of temporal psychological processes underlying technology-related health outcomes. In particular, it underscores nomophobia as a proximal psychological mechanism through which problematic social media engagement may influence sleep, while also highlighting rumination as a cognitive vulnerability shaping susceptibility to technology-related sleep disturbances. More broadly, the findings support an integrative perspective that considers behavioral, psychological, and cognitive processes simultaneously in explaining technology-related health risks.

Practically, the temporal association between PSMU and sleep quality emphasizes the importance of monitoring media and smartphone habits. Interventions should aim to foster balanced usage patterns, such as disabling nonessential notifications, avoiding social media in the hour before bedtime, and substituting some online interactions with offline social activities (Gu et al., 2025). The mediating role of nomophobia suggests that programs targeting smartphone-related anxiety, such as school-based digital literacy initiatives, may be beneficial. Finally, the moderated mediation via rumination highlights the value of addressing behavioral, psychological, and cognitive processes simultaneously. Cognitive-behavioral approaches can help students identify and modify maladaptive thought patterns, reduce ruminative thinking, and mitigate its negative impact on sleep (Luo et al., 2025).

CONFLICT OF INTEREST STATEMENT

The authors have no competing interests to declare that are relevant to the content of this article.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request. Some data may not be publicly available because they contain sensitive participant information and cannot be openly shared for privacy considerations.

ETHICS STATEMENT

The study was approved by the Research Ethics Committee of Hunan Normal University (Approval No. 2023472).

CONSENT TO PARTICIPATE

Informed consent was obtained from all individual participants included in the study.

ORCID

Honglei Gu  <https://orcid.org/0000-0001-9630-9042>

Yuhang Hu  <https://orcid.org/0009-0007-0599-2941>

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