Original Article

What do people do before going to bed? A study of bedtime procrastination using time use surveys

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This work was conducted at Department of Psychology, Sungshin Women’s University.

Abstract

Study Objectives: Bedtime procrastination (BP) is defined as going to bed later than intended despite absence of external reasons. This study investigated sleep and psychological factors associated with BP in young adults, and further compared how high and low BP groups spend their time over 24 h and also 3 h prior to bedtime using time use surveys.

Methods: Young adults (N = 106) from the community were classified as either high (n = 54) or low (n = 52) BP group based on the Bedtime Procrastination Scale. All participants were asked to complete questionnaires on insomnia, depression, anxiety, stress, and chronotype, in addition to keeping a 7-day sleep diary and completing time use surveys over 48 h.

Results: Participants were 61.3% female, mean age 22.7 (±2.89) years old. Individuals in the high BP group reported significantly more depression, anxiety, and insomnia, went to bed later, woke up later, and had more eveningness tendencies compared to the low BP group. Results from the time use surveys revealed that the high BP group spent significantly more time engaging in leisure and social activity with the majority of time spent using media over 24 h compared to the low BP group. Finally, the high BP group spent on average approximately 451% (or 61 min) more time per day on their smartphone 3 h prior to bedtime compared to the low BP group.

Conclusions: Our results suggest that BP is negatively associated with sleep and mood, and should be considered a serious health-interfering behavior.

Key words: insomnia; smartphone; time use surveys; sleep disturbance; bedtime procrastination.

Statement of Significance

Bedtime procrastination (BP) is defined as going to bed later than intended, without having external reasons for doing so. Although previous studies have reported the negative effects of BP, very few studies have researched behavior characteristics of people who engage in BP. This study indicated that individuals who engage in BP also have negative associations with sleep and mood. Additionally, these individuals also engaged in significantly more smartphone usage 3 h prior to bedtime compared to those with low levels of BP. This highlights the need to consider BP as a serious health-interfering behavior, and updating existing behavioral interventions to add BP as a treatment target.
Introduction

Considering that maintaining desirable sleep habits is one of the keys to a healthy life, recent studies have begun to investigate bedtime procrastination (BP). BP is defined as “going to bed later than intended, without having external reasons for doing so” and has been recently gaining interest due to the exponential increase of smart devices in modern society [1]. Previous studies have shown that BP is quite prevalent in modern society, with up to 53.1% of young adults reporting engaging in BP [2]. Individuals who frequently engage in BP are more likely to experience insufficient sleep and fatigue, and are less likely to be satisfied with their sleep compared to those who do not engage in BP [1, 2]. These results suggest that BP can directly affect sleep and further decrease the quality of one’s life. Furthermore, individuals who engage in high levels of BP are generally known to also engage in general procrastination of other activities, have low levels of self-regulation [1], and more likely to have evenness tendencies [3].

In general, procrastination is associated with a variety of time-related variables. People who procrastinate adopt a present time perspective [4], tending to err in estimating time required for tasks and have difficulty managing time [5–7]. Previous studies have only examined the relevance of procrastination, mainly with regard to time perspective or time management capabilities [8–10]. However, these studies alone do not reflect the overall function of the behavior in understanding procrastination, which can be complemented by time use surveys.

Individuals may engage in BP for different reasons, and lack of self-control and aversion to bedtime routine have been the most studied thus far [11, 12]. However, BP should be regarded as a health-interfering behavior considering its negative consequences. Thus, adopting a behavioral approach similar to traditional health-interfering behaviors such as smoking and alcohol abuse may be helpful in gaining insight into the reasons why individuals engage in these behaviors [13]. A behavioral approach begins with the premise that these problematic behaviors serve multiple functions [14]. For example, while someone may understand that smoking is hazardous to their health, they may have a hard time with cessation because it helps them cope with stress. Similarly, understanding the functional relationship between BP and the contextual cues in their environment may be helpful in guiding future interventions.

Time use research methodology is used to study how people allocate their time during an average day [15]. Time use surveys are used to identify what an individual is doing, and the duration and timing of those activities [16]. This can provide information about an individual’s lifestyle by quantifying the timing and duration of each activity by analyzing their daily life microscopically [17]. Additionally, time use surveys provide ecological validity as it measures activities in their actual environments. For the purpose of this study, we were especially interested in the type of activity individuals engaged in prior to bedtime as it may help gain insight into the function of BP.

Thus, the current study examined behavior characteristics and activities of individuals who reported engaging in high BP by analyzing their time use patterns compared to those who engaged in low BP over 48 h. This study aimed to improve understanding of the type of activities a bedtime procrastinator might spend their time engaging in prior to sleeping in their own living environment. While analysis of time use surveys were mostly exploratory, we hypothesized based on past studies about the prevalence of smartphone use prior to bedtime that the high BP group would engage in higher use of smartphones prior to bedtime [18]. Additionally, this study aimed to investigate how BP related to individual sleep patterns and psychological characteristics.

Methods

Participants and procedures

A total of 106 participants in early adulthood were recruited by advertisements in the community. All participants (age range from 18 to 31) completed baseline survey questionnaires, 7-day sleep diaries, and time use surveys for 2 days asking to record all activities they engaged in. Participants were compensated with $5 after completion of the baseline survey and additionally received $9 for completion of the sleep diaries and time use surveys. This study was approved by the Institutional Review Board from the institution where the data were collected and written informed consent was obtained from all subjects prior to participation.

Participants were classified as either high BP group (n = 54, Mean age = 22.74, SD = 2.88) or low BP group (n = 52, Mean age = 22.65, SD = 2.94) based on the median score of the Bedtime Procrastination Scale (cutoff score 33). Individuals who reported being shift workers or being treated for sleeping disorders were excluded from the study as these factors may have influenced insufficient sleep beyond one’s control [1].

Measures

Demographic information

All participants were asked to submit basic demographic information on age, sex, education, and employment status. Education was divided into middle school / high school / attending university / university graduate and above. Employment was divided into unemployed or retired / student / housewife or house husband / office job / specialists and associated personnel / service job / army.

Bedtime Procrastination Scale

Bedtime Procrastination Scale (BPS) is a 9-item self-report questionnaire which was used to assess BP [1]. The English version of the BPS was translated into Korean and back-translated into English by independent bilingual individuals. Items 2, 3, 7, and 9 are inversely scored and higher score reflects to a higher level of BP. Internal consistency of the BPS was found to be satisfactory (Cronbach’s α = .85). The BPS has been validated for use in Korea [19].

7-Day sleep diary

Sleep patterns were assessed using sleep diaries for 7 consecutive days, and included variables such as Bed time (BT), Lights off (LO), Sleep onset latency (SOL), Wake time after sleep onset (WASO), Wake time (WT), Time out of bed (TOB), Sleep quality (SQ), Time in bed (TIB), Total sleep time (TST) and Sleep efficiency (SE).

Insomnia severity index

Insomnia severity index (ISI) was used to evaluate insufficient sleep which required participants to answer seven items on a
5-point Likert scale [20]. These items assess subjective insomnia severity, satisfaction of current sleep, the level of being interfered with daytime functioning due to sleep problems and worry about sleep over past 2 weeks. Higher scores indicate greater levels of insomnia symptoms and previous studies suggested cutoff point of 10 corresponding to high-risk for insomnia [21]. Internal consistency of the ISI was found to be acceptable in this study (Cronbach’s $\alpha = .77$).

**Munich chronotype questionnaire**

Chronotype was measured by Munich chronotype questionnaire (MCTQ) which was developed by Roenneberg et al. [22]. MCTQ assesses chronotype by estimating the timing of sleep in each work days and free days. In MCTQ variables, corrected mid-sleep time (MSFsc) is the indicator of chronotype with higher values of MSFsc representing greater eveningness tendency.

**Center for Epidemiologic Studies Depression Scale**

Depression was measured by the Center for Epidemiologic Studies Depression Scale (CES-D) which consists of 20 items on a 0–3 scale measuring frequency of depression symptoms over a past week [23]. A higher score reflects a higher risk of depression levels and clinical cutoff score is 16. Internal consistency of the CES-D was found to be good in this study (Cronbach’s $\alpha = .92$).

**State—Trait Anxiety Inventory form Y**

Anxiety was measured by State—Trait Anxiety Inventory form Y (STAI-Y) [24]. STAI-Y is a 40-item self-report questionnaire including two subscales with 20 state-anxiety and 20 trait-anxiety items on a 4-point Likert scale. A higher score represents higher levels of anxiety. The measures were found to have high internal consistency (Cronbach's α = .94 for state anxiety, Cronbach’s $\alpha = .91$ for trait anxiety).

**Perceived Stress Scale**

Perceived Stress Scale (PSS) is a 10-item self-report measure designed to assess perceived levels of stress during past a month [25]. A total score is calculated with a 5-point Likert scale with higher scores reflecting greater levels of perceived stress. Internal consistency of the PSS in this study was found to be satisfactory (Cronbach’s $\alpha = .84$).

**Time use survey**

Time use surveys are the most widely used assessment tool to measure daily time use patterns of individuals. All participants were provided with instructions on completing a hard copy of the time use survey, and they were asked to record the activities they engaged in for 2 days in 10-min intervals based on guidelines from the National Statistical Office of Korea [26]. Participants were asked to complete the survey retrospectively after the days they engaged in BP. In the case that the participants never engaged in BP while participating in the study, the participants were asked to report activities for the last 2 days of the study participation period.

Additionally, participants were also asked to separately record the actual time in which they went to bed with the intent of falling asleep, activities they engaged in up until bed time and the time zone if they went to bed after midnight. This was to complement the limitation that it is difficult to identify details of activities before bedtime for people who go to bed after midnight, because the time zone of the time use survey is divided according to 24 h a day from midnight to midnight of the next day. Considering this point, we calculated the average amount of time participants spent on each activity in minutes depending on 24 h a day and 3 h before bedtime respectively, to analyze the type of activities and behavioral context associated with BP. All responses were classified based on behavior classification and the behavior classification was designed to be tailored to the purpose of this study based on the 2014 time use survey behavior classification of Statistics Korea.

Based on behavioral classification guidelines by Statistics Korea, living behavior was divided into nine main categories: personal maintenance (including physiological time such as sleep), studying, labor, taking care of family members, participation and volunteer activity, housework, leisure and social activity, travelling, and others. Each main category is divided into 42 subcategories, and these subcategories are further divided into 138 subcategories. Based on this classification, the behavioral classification system was modified for the purposes of this study. Considering the relationship between procrastination and leisure activities using media revealed in previous studies, the main category was reduced to six categories, and subcategory of leisure and social activity was further classified according to media use (see Table 1).

The response rate for the time use survey is as follows: the total number of participants who completed the time use survey was 92.45% (98 out of 106), and the number of participants who submitted only 1 day of the time use survey was 3 out of 98 (submitted both days: 95). Missing data was treated as missing values and excluded from the calculation of the average time spent engaging in activities. Data for participants who submitted the surveys only 1 day were entered to reflect only 1 day, and the remaining day was entered as missing values.

**Statistical analyses**

Participants were divided into high and low BP groups based on median score of BPS because there are no published valid cutoff points for the scale. Descriptive statistics, independent t-tests, and chi-squared tests was performed to analyze demographics and sleep variables including insomnia severity, frequency of clinical insomnia symptoms, and chronotype. Analysis of Covariance (ANCOVA) controlling for gender was conducted to compare differences of psychological characteristics and time use patterns between groups. Data were analyzed using SPSS software version 21.0 (SPSS Inc., Chicago, IL).

**Results**

**Demographic information**

Participants were 61.3% female, and mean age was 22.7 (±2.89) years. The majority of the sample were attending university (78.3%) for education status and 90.6% were students for employment status. The differences between high and low BP groups were not significant for age, education, and job, but the low BP group had a significantly higher percentage (71.2%) of female participants ($\chi^2 = 4.161, p < .05$).
<table>
<thead>
<tr>
<th>Main category</th>
<th>Subcategory</th>
<th>Subcategory</th>
</tr>
</thead>
</table>
| Activities of daily living | Sleep | • Sleep (night)  
| | | • Insomnia  
| | | • Napping, dozing off  
| Meal | • Breakfast, lunch, and dinner  
| | | • Snacks and drinks  
| Hygiene | • Washing face  
| | | • Brushing teeth  
| | | • Shower and shampooing  
| | | • Bathing  
| | | • Bowel movement  
| Personal Maintenance | • Putting on clothes  
| | | • Beauty care (e.g. getting a haircut)  
| | | • Other personal care  
| Health care | • Home remedies  
| | | • Getting rest due to sickness  
| | | • Receiving medical services  
| Studying | School activity | • Attending class  
| | | • Break time  
| | | • Attending a school event  
| | | • Other school activity  
| Other learning activity | • Private lessons  
| | | • Taking online courses  
| | | • Assignment  
| | | • Studying alone  
| | | • Other learning activities after school curriculum  
| Labor | Job | • Working hours  
| | | • Break time during work  
| | | • Training related to work  
| | | • Looking for a job  
| | | • Other activities associated with work  
| Housework | • Preparing meals  
| | | • Washing dishes  
| | | • Cleaning up and organizing  
| | | • Doing the laundry  
| | | • Residential management, home care  
| | | • Running an errand  
| | | • Planning for housework  
| | | • Managing finances  
| | | • Taking care of family members  
| | | • Buying products/services for the home  
| | | • Use of local offices and financial institutions (e.g. banks)  
| | | • Other activities associated with housework  
| Leisure and social activity | Leisure activity using media | • Watching TV (include video watching)  
| | | • Using PC (searching for info, reading e-books, watching TV/movies/internet video, shopping, playing games and listening to the music/radio, leisure/general learning, other leisure activities using PC)  
| | | • Using smartphone (searching for info, reading e-books, watching TV/movies/internet video, shopping, playing games and listening to the music/radio, leisure/general learning, other leisure activities using smartphone)  
| | | • Other leisure activities using media  
| | Leisure activity without using media | • Personal hobbies  
| | | • Resting (resting without doing anything)  
| | | • Cultural and tourism activities  
| | | • Sports  
| | | • Religious activities  
| | | • Volunteering  
| | | • Other activities associated without media  
| Social activity | • Face-to-face socializing  
| | | • Webcam/socializing by phone  
| | | • E-mail/texting  
| | | • Other social activities  

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Psychological characteristics and BP
To compare the differences in psychological characteristics between groups, we performed ANCOVA with gender as a covariate. Individuals with high BP had significantly higher scores of depression ($F(1,103) = 5.578$, $p < .05$), state anxiety ($F(1,103) = 7.059$, $p < .01$) and trait anxiety ($F(1,103) = 5.377$, $p < .05$) compared to the low BP group after controlling for gender. However, there were no significant differences for stress level.

Bedtime procrastination and sleep measures
Comparison of sleep patterns between high and low BP groups are shown in Table 2. There were significant differences in bedtime (BT; $t = -4.508$, $p < .001$), Lights off (LO; $t = -4.477$, $p < .001$), Wake time (WT; $t = -3.209$, $p < .01$) and Time out of bed (TOB; $t = -3.498$, $p < .01$), but no differences in sleep efficiency, sleep latency, and total sleep time. Specifically, the high BP group went to bed on average 50 min later and woke up on average 46 min later than those in the low BP group. Additionally, the difference of MSFsc for the groups was significant, suggesting high BP group had more eveningness tendencies compared to the low BP group ($t = -3.181$, $p < .01$). The high BP group showed higher levels of insomnia severity ($t = -4.243$, $p < .001$) and had significantly higher rates clinical insomnia symptoms, indicated by a cutoff score of 10 on the ISI ($\chi^2 = 13.010$, $p < .001$).

Additional analyses comparing sleep patterns after controlling for eveningness (MSFsc) and gender indicated individuals with high BP had significantly lower scores on sleep quality ($F(1,60) = 4.475$, $p < .05$) and higher levels of insomnia severity ($F(1,61) = 5.289$, $p < .05$) compared to the low BP group. However, there were no significant differences for other sleep variables.

Time use patterns for 24 h based on categories of activities
Table 3 showed the high BP group spent significantly less time travelling ($F(1,95) = 6.859$, $p < .05$) and more time engaging in leisure & social activities ($F(1,95) = 17.685$, $p < .001$) compared to the low BP group over 24 h. We performed additional analyses based on subcategories of the main categories of activities to investigate group differences of time use patterns. There were statistically significant differences between groups with respect to time use of leisure

Table 2. Comparison in sleep patterns between groups ($n = 106$)

<table>
<thead>
<tr>
<th></th>
<th>Low bedtime procrastination</th>
<th>High bedtime procrastination</th>
<th>t or $\chi^2$</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(n = 52)</td>
<td>(n = 54)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean (SD) or N (%)</td>
<td>Mean (SD) or N (%)</td>
<td>t or $\chi^2$</td>
<td>P-value</td>
<td></td>
</tr>
<tr>
<td>BTa (hour:minute)</td>
<td>0.53 (0.49)</td>
<td>1.43 (1.04)</td>
<td>-4.508</td>
<td>&lt;.001***</td>
</tr>
<tr>
<td>LOa (hour:minute)</td>
<td>1.05 (0.49)</td>
<td>1.55 (1.04)</td>
<td>-4.477</td>
<td>&lt;.001***</td>
</tr>
<tr>
<td>WTa (hour:minute)</td>
<td>8.31 (0.56)</td>
<td>9.17 (1.30)</td>
<td>-3.209</td>
<td>.02**</td>
</tr>
<tr>
<td>TOBa (hour:minute)</td>
<td>8.46 (1.01)</td>
<td>9.43 (1.41)</td>
<td>-3.498</td>
<td>.01**</td>
</tr>
<tr>
<td>SOL (min)</td>
<td>19.54 (25.85)</td>
<td>22.33 (25.36)</td>
<td>-5.59</td>
<td>.577</td>
</tr>
<tr>
<td>WASO (min)</td>
<td>5.82 (7.28)</td>
<td>9.21 (13.82)</td>
<td>-1.574</td>
<td>.119</td>
</tr>
<tr>
<td>TIB (min)</td>
<td>472.68 (70.60)</td>
<td>479.48 (86.27)</td>
<td>-4.42</td>
<td>.606</td>
</tr>
<tr>
<td>TST (min)</td>
<td>432.25 (61.54)</td>
<td>422.72 (64.76)</td>
<td>.733</td>
<td>.411</td>
</tr>
<tr>
<td>SE (%)</td>
<td>91.87 (6.60)</td>
<td>88.94 (9.37)</td>
<td>1.850</td>
<td>.067</td>
</tr>
<tr>
<td>SQ (min:0.01)</td>
<td>3.32 (0.42)</td>
<td>3.15 (0.54)</td>
<td>1.794</td>
<td>.076</td>
</tr>
<tr>
<td>MSFsc (min)</td>
<td>5.56 (0.97)</td>
<td>6.54 (1.45)</td>
<td>-3.181</td>
<td>.02**</td>
</tr>
<tr>
<td>ISI (min)</td>
<td>9.13 (4.40)</td>
<td>12.83 (4.57)</td>
<td>-4.243</td>
<td>&lt;.001***</td>
</tr>
<tr>
<td>Frequency of clinical insomnia symptoms</td>
<td>25 (48.1)</td>
<td>44 (81.5)</td>
<td>13.010</td>
<td>&lt;.001***</td>
</tr>
</tbody>
</table>

*Time (hour: minute).
BT = Bed Time; LO = Light Off; SOL = Sleep Onset Latency; WASO = Wake After Sleep Onset; WT = Wake Time; TIB = Time Out of Bed; TST = Total Sleep Time; SE = Sleep Efficiency; SQ = Sleep Quality; MSFsc = Corrected Mid-sleep time; ISI = Insomnia Severity Index; Frequency of Clinical insomnia symptoms: ISI scores above 10.
*p < .05, **p < .01, ***p < .001

Psychological characteristics and BP
To compare the differences in psychological characteristics between groups, we performed ANCOVA with gender as a covariate. Individuals with high BP had significantly higher scores of depression ($F(1,103) = 5.578$, $p < .05$), state anxiety ($F(1,103) = 7.059$, $p < .01$) and trait anxiety ($F(1,103) = 5.377$, $p < .05$) compared to the low BP group after controlling for gender. However, there were no significant differences for stress level.
activities using media ($F(1,95) = 21.874$, $p < .001$) among leisure and social activities. There were no significant differences for other subdivided categories of activities such as labor, studying, and activities of daily living.

**Time use patterns 3 h before bedtime of leisure and social activities**

Considering the significant difference between BP groups for leisure and social activities over 24 h, we conducted analyses on activities that individuals engaged in 3 h before bedtime. There was a significant difference of leisure and social activities between groups 3 h before bedtime ($F(1,95) = 46.106$, $p < .001$; **Table 4**), with the high BP group spending significantly more time using media ($F(1,95) = 82.135$, $p < .001$). The tempogram in **Figure 1** illustrates that individuals with high BP engaged significantly more in leisure activities using media than the low BP group, especially as bedtime approached. Moreover, the high BP group spent significantly less time engaging in leisure activities without using media compared to the low BP group ($F(1,95) = 15.170$, $p < .001$), which were different from the 24-h results.

**Time use patterns based on leisure activities using media (24 h and 3 h before bedtime)**

Leisure activities using media were subdivided into several subcategories of activities and analyses were conducted to examine differences in time use patterns based on high and low BP.

Over 24 h, the high BP group spent significantly more time on activities with their smartphones compared to the low BP group ($F(1,95) = 14.945$, $p < .001$). However, there were no differences.

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**Table 3. Comparison of time use for 24 h (main and subcategory of activities) (n = 106)**

<table>
<thead>
<tr>
<th>Main category</th>
<th>Subcategory</th>
<th>Low bedtime procrastination (n = 52)</th>
<th>Mean (SD)</th>
<th>High bedtime procrastination (n = 54)</th>
<th>Mean (SD)</th>
<th>F</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activities of daily living</td>
<td>Sleep</td>
<td>659.30 (123.98)</td>
<td>615.73 (94.31)</td>
<td>3.181</td>
<td>.078</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leisure and Social activity</td>
<td>Leisure activity using media</td>
<td>143.20 (99.13)</td>
<td>275.83 (175.28)</td>
<td>21.874</td>
<td><strong>.001</strong>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leisure activity without using media</td>
<td>95.40 (90.56)</td>
<td>87.08 (73.87)</td>
<td>.994</td>
<td>.321</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social activity</td>
<td>57.60 (52.76)</td>
<td>70.21 (57.34)</td>
<td>1.929</td>
<td>.168</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Units per minute; Adjusted for gender.

$p < .05$, **$p < .01$**, ***$p < .001$.

**Table 4. Comparison of time use for 3 h before bedtime (leisure and social activities including subcategory) (n = 106)**

<table>
<thead>
<tr>
<th>Low bedtime procrastination (n = 52)</th>
<th>Mean (SD)</th>
<th>High bedtime procrastination (n = 54)</th>
<th>Mean (SD)</th>
<th>F</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leisure activity using media</td>
<td>Total</td>
<td>77.90 (45.63)</td>
<td>137.29 (37.63)</td>
<td>46.106</td>
<td><strong>.001</strong>*</td>
</tr>
<tr>
<td>Watching TV</td>
<td>39.10 (39.68)</td>
<td>119.17 (46.36)</td>
<td>82.135</td>
<td><strong>.001</strong>*</td>
<td></td>
</tr>
<tr>
<td>Using PC</td>
<td>8.30 (22.60)</td>
<td>16.35 (28.28)</td>
<td>2.318</td>
<td>.131</td>
<td></td>
</tr>
<tr>
<td>Using smartphone</td>
<td>12.20 (33.52)</td>
<td>16.56 (32.67)</td>
<td>.267</td>
<td>.607</td>
<td></td>
</tr>
<tr>
<td>Other leisure activities using media</td>
<td>17.60 (24.93)</td>
<td>79.48 (50.18)</td>
<td>62.121</td>
<td><strong>.001</strong>*</td>
<td></td>
</tr>
<tr>
<td>Leisure activity without using media</td>
<td>1.00 (4.29)</td>
<td>6.77 (20.56)</td>
<td>.3246</td>
<td>.075</td>
<td></td>
</tr>
<tr>
<td>Social activity</td>
<td>23.60 (34.15)</td>
<td>4.69 (14.16)</td>
<td>15.170</td>
<td><strong>.001</strong>*</td>
<td></td>
</tr>
<tr>
<td>Housework</td>
<td>57.60 (52.76)</td>
<td>70.21 (57.34)</td>
<td>1.929</td>
<td>.168</td>
<td></td>
</tr>
</tbody>
</table>

Units per minute; Adjusted for gender; Desktop computer, Laptop computer and tablet PC were included in using PC.

$p < .05$, **$p < .01$**, ***$p < .001$.
in watching TV, using PC, and other leisure activities using media between groups. There were also significant differences between groups in leisure activities using smartphones 3 h before bedtime ($F(1,95) = 62.121, p < .001$; Table 4). As bedtime approached, the high BP group spent more time (approximately 451% or 61 min more) using their smartphones in comparison with the low BP group. This is illustrated in the tempogram in Figure 2.

**Discussion**

This study investigated sleep and psychological factors associated with BP in young adults, and further compared how high and low BP groups spent their time differently engaging in various activities over 24 h and also 3 h prior to bedtime using time use surveys. The main results of the study indicate over 24 h and 3 h prior to bedtime, the high BP group spent significantly more time on leisure and social activities (especially using media) compared to the low BP group. Most of this time was spent on their smartphones, with the high BP group spending on average approximately 451% (or 61 min more) more time per day on their smartphone 3 h prior to bedtime compared to the low BP group. Additionally, individuals in the high BP group reported more depression and anxiety, went to bed on average 50 min later than those in the low BP group, woke up on average 46 min later, and had more eveningness tendencies compared to the low BP group. Additionally, the high BP group reported more insomnia severity, with a higher proportion of individuals meeting criteria for clinical insomnia symptoms. This is the first study, to the best of our knowledge, that investigated specific activities associated with BP using time use surveys.

**Sleep and psychological characteristics of BP**

In our study, BP was significantly associated with depression and anxiety, with the high BP group reporting significantly higher levels of depression and anxiety than the low BP group. These results are generally consistent with previous studies, which report that people who engage overall in procrastination experience negative feelings, report problems with interpersonal relationships, have low life satisfaction, guilt and self-criticism, and in particular, depression and anxiety [27–32]. Unlike previous studies on procrastination, which mainly focused on general or academic procrastination, this study also highlights the importance of focusing on BP as it may be associated with negative consequences.
In our study, individuals in the high BP group had more evening tendencies compared to the low BP group. This is consistent with previous studies that have reported that individuals with eveningness tendencies engage in more procrastination compared to other chronotypes [33–35], and also supports previous studies that have reported that eveningness significantly predicts BP [36]. In general, individuals with eveningness tendencies are more likely to have irregular sleep patterns, later bed and wake times, lower sleep quality and experience insufficient sleep [37–39]. Our study also found that there were differences in sleep quality and insomnia, even after controlling for gender and circadian preference when comparing the high and low BP groups. This suggests that low sleep quality and higher insomnia symptoms reported by those who engage in BP is independent of circadian preferences in its negative impact on sleep. This is consistent with previous studies reporting that individuals engaging in high BP experience more daytime fatigue and more days of sleep deprivation [1, 2]. These studies in addition to our results showing the negative impact that BP has on mood and sleep together highlights the importance of considering BP as a serious health-interfering behavior.

Media use in high and low BP groups

Individuals in the high BP group engaged in more leisure and social activity both over 24 h and 3 h prior to bedtime, especially leisure activity using media compared to the low BP group. This indicates that leisure and social activity are both important functions to consider for BP. In general, previous studies have reported that media use increases closer to bedtime [11, 36]. In a study by Kubiszewski and colleagues [40] in 332 adolescents, 69% of their participants watched TV, used the computer or used their smartphone more than three times per week prior to bedtime. Additionally, another study with 1,508 adults found that 90% of their sample used electronic media 1 h before bedtime, with approximately 60% reporting watching TV [41]. A study by Broers [36] reported that 93.5% of participants used electronic media when engaging in BP, with individuals who engaged in more BP reporting significantly more use of electronic devices. In summary, previous studies indicate that frequent use of media for leisure activities also occur in the general population, and our study results implicate that the amount of time and frequency spent using media is significantly higher in individuals who engage in BP.

With regard to specific types of media, individuals in the high BP group spent significantly more time on their smartphone over 24 h and 3 h prior to bedtime, with smartphone usage increasing in the high BP group closer to bedtime. This adds to previous literature that past studies did not further investigate specific types of leisure activities or electronic devices in association to BP [2, 11, 36]. Considering that our study did not reveal group differences in time spent watching TV or using the computer, or other leisure activities using media, we can conclude that BP was exclusively and mainly associated with smartphone usage.

Smartphone usage can be problematic before bedtime, as previous studies have reported media usage being associated with having a negative effect on sleep and psychological well-being, such as depressive symptoms and suicidal tendency [42]. Bright light emitted from electronic devices can affect neurons in the thalamus that regulate sleep and wake, which subsequently reduces sleepiness and increases arousal [43]. Mobile phones in particular significantly predicted sleep problems and increased the risk of sleeping problems, such as increased insomnia and fatigue [40, 44], and negative effects on mood [45]. Especially in the case of depression, there are several studies reporting that smartphone addiction may aggravate depression or reinforce smartphone addiction due to depression [46–48]. Considering the literature, the differences of high and low BP groups in this study may be reflected in the mutual relationship of variables related to BP.

Clinical implications

There are clinical implications for existing sleep treatments in incorporating additional interventions to reduce BP, which until now have generally neglected to consider BP as treatment target. With increasing evidence that BP, especially due to smartphone usage, has negative effects on sleep and mood, this study provides a basis for future studies to explore further questions that may be incorporated into clinical settings. For example, adopting a behavioral perspective based on applied behavioral analysis that assumes all behaviors have functions [49], it is important to analyze the main function of BP, especially what purpose is served for an individual in using one’s smartphone prior to bedtime. Future studies should consider both leisure and social activities as important functions in the context of BP when designing behavioral interventions. For example, does the individual who engages in BP feel their need for social interaction or leisure is not fulfilled during the day? While this study cannot ascertain causality of the relationship between BP and its functions, if BP is in fact reinforced due to leisure and social functions, considering behavioral modification procedures (e.g. differential reinforcement of alternative behavior) that have helped reduce other traditional health-interfering behaviors may be helpful.

Future questions should also address the following questions. Considering the association between BP and negative mood, what is the causal relationship? Does depression cause individuals to engage in more BP to avoid rumination? Additionally, does reduction in smartphone usage and BP alleviate these symptoms? These questions need to be addressed in future studies to develop more effective interventions in the modern era. While there are many effective sleep interventions available, many of these interventions were developed during a time that smartphone usage was not widespread, which suggests that some of these interventions may need to be updated.

Limitations

This study has several limitations. First, this study investigated young adults as participants, and due to small sample size compared to that of ordinary time-use studies, there are limits to the representativeness of the sample and generalizing the results of this study. Therefore, in future studies, it is necessary to expand the age range of the sample population, recruit more participants and replicate the findings.

Second, because the BPS does not have a cutoff point, this study used the median value of the scale to distinguish groups. However, the median value may vary depending on the sample being recruited, and therefore the differences between groups...
may vary. In fact, when comparing the distribution of BPS score from this study and a previous study, the average BPS score of participants in this study was slightly higher compared to a previous study [11] (30.47 ± 7.02 vs. 24.90 ± 8.64). This may be due to a wider age range of the participants in the previous study, which varied from 18 to 90 years, whereas this study was likely to have resulted because the study subjects were recruited around those in 20s, who are generally more prone to bedtime procrastination and evenness. Thus, if the group is to be categorized using this scale in future study, it is necessary to establish an appropriate cutoff point to more clearly distinguish the tendency of BP.

Third, because of the nature of being a cross-sectional study, there are limitations in ascertaining causal relationships of measurement variables. Subsequent studies therefore need to verify the effects of BP on sleep and psychological characteristics through a longitudinal study, or the effect of BP on relationship between media use and other psychological variables.

Fourth, the pattern of time use may vary depending on each day of the week or weekday and weekend, but there is a restriction in this study that time use surveys is written over only 2 days during the study period. Therefore, it is necessary to consider the day of the week or separately analyze time use patterns for weekdays and weekends.

Finally, the study could have been strengthened by using an objective sleep measure, such as actigraphy, or using more intricate measures of activities, such as ecological momentary assessment to measure the relationship between BP and daily activities. These should be implemented in future studies to clarify the function of BP behavior.

**Conclusion**

In summary, the results of this study indicate that individuals who engage in high levels of BP report more depression and anxiety symptoms, have lower sleep quality and higher risk of insomnia compared to those who engage in low BP. In addition, these high BP individuals also spend more time on their cell phones during the day and also closer to bedtime compared to those in the low BP group. The findings suggest that BP may be an important treatment target in clinical settings, and further studies are necessary in identifying and reducing risks and developing effective intervention.

Additionally, the results of this study indicate that the proportion of activities using media is relatively large in the context of BP. Based on these results, when individuals who tend to have high BP receive sleep interventions, the activities and behavioral characteristics of BP need to be represented in treatment. It can be expected that establishing additional interventions to modify sleep-interfering behaviors could be used as basis for improving quality of sleep and life for people who have BP.

This study has the following implications: This study further provided specific information on sleep patterns and psychological characteristics of people who have BP in areas beyond the scope not presented by previous studies. This is meaningful in that it seeks to expand the field of research in BP by revealing that people who have BP may be more vulnerable to psychological and sleep problems. It is also meaningful that by applying the methodology by time use survey, which is rarely used in psychological research, this study has objectively identified the time use pattern of the participants and has broadened our understanding of the behavioral context in BP.

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