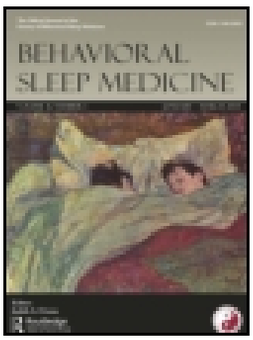

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Developing a Psychological Intervention for Decreasing Bedtime Procrastination: The BED-PRO Study

Sooyeon Suh*, Nayoung Cho*, Sonhye Jeoung, and Hyeyoung An

Department of Psychology, Sungshin University, Seoul, Republic of Korea

ABSTRACT

Introduction: Bedtime Procrastination (BP) is defined as the behavior of going to bed later than intended, without having external reasons for doing so. Previous studies have shown that BP has a negative effect on sleep and health, emphasizing the need to develop interventions to decrease BP. This intervention development study is a proof-of-concept study for a psychological intervention designed for decreasing bedtime procrastination, namely BED-PRO.

Material and Method: The intervention was developed based on behavioral modification principles and motivational interviewing techniques. The final intervention was a weekly three-session intervention, with one additional booster call. Twenty individuals with high BP participated in the study, and data was collected for pre- and post-intervention, and one-month follow-up. Individuals completed the Bedtime Procrastination Scale, Epworth Sleepiness Scale, Fatigue Severity Scale, Morningness-Eveningness Questionnaire, Insomnia Severity Index, and a sleep diary.

Result: Significant changes were found for BPS scores, bedtime procrastination duration (Δ51 mins, 63.8% reduction compared to baseline), wake after sleep onset, sleep efficiency and feeling refreshed upon awakening measured by sleep diaries following the intervention. In addition, changes in BPS, ISI, and ESS scores, wake after sleep onset, sleep efficiency and feeling refreshed upon awakening were maintained or continued to improve at 1-month follow-up.

Conclusion: This study verified the feasibility and acceptability of the BED-PRO intervention and the potential for being the first intervention to target bedtime procrastination. Considering the research about negative implications of BP, we expect that this intervention could be a step forward in considering BP as a serious health behavior.

Introduction

In modern society, individuals have instantaneous access to a wealth of information, specifically access to smartphones that can be used even in bed. Reflecting this trend, researchers introduced the concept of bedtime procrastination (Kroese et al., 2014). Bedtime procrastination refers to the behavior in which an individual goes to bed later than a voluntary planned time, despite anticipated negative outcomes (Kroese et al., 2014, 2016).

Bedtime procrastination is problematic because it negatively affects sleep and health. Individuals with high bedtime procrastination report significant fatigue and insufficient sleep compared to those who do not engage in bedtime procrastination (Kroese et al., 2014). In addition, high levels of bedtime procrastination were significantly associated with severe insomnia, lower sleep efficiency and sleep

CONTACT Sooyeon Suh alysuh@sungshin.ac.kr Department of Psychology, Sungshin Women's University, #911 Sungshin Building 2 Bomunro 34-da Gil, Seongbuk-gu, Seoul 02844, Republic of Korea

*These authors contributed equally to this study.

quality, and stronger eveningness tendencies (Chung et al., 2020). In addition, bedtime procrastination is closely related to the use of various media devices in bed before bedtime, with up to 72% of university students reporting using smartphones in bed prior to sleep (Dean, 2010). A study by our research team used time use surveys and found that individuals who scored high on BP used their smartphones 451% more compared to individuals with low BP 3 hours before bedtime (79.48 vs. 17.60 minutes, respectively; Chung et al., 2020). Prolonged use of media devices prior to bedtime may dysregulate circadian rhythm and disrupt sleep onset and deep sleep (Cajochen et al., 2011; Lockley et al., 2003; Wood et al., 2013). To date, however, there have been no intervention studies aimed at reducing or improving bedtime procrastination despite reports of the deleterious effects on sleep and health.

This study intended to develop an intervention to reduce bedtime procrastination by establishing a theoretical background based on motivational interviewing (MI) and the transtheoretical model (TTM). TTM is a model that divides an individual's readiness for change into five steps and recommends tailoring interventions to the corresponding stage (Prochaska et al., 1992; Prochaska & Velicer, 1997). MI and TTM promote collaborative interaction processes that explore individual feelings and thoughts about change, and promote motivation (Miller & Rollnick, 2012). MI is based on TTM, and is widely used in intervention studies to improve various health behaviors, such as smoking cessation, weight management, and exercise (Armstrong et al., 2011; Heckman et al., 2010; Jones et al., 2004; Lindson-Hawley et al., 2017; Martins & McNeil, 2009; Rollnick et al., 2008; West et al., 2007). Two key studies examined the appropriateness of the application of the transtheoretical model to academic procrastination and assisted in the design of our intervention model (Grunschel & Schopenhauer, 2015; O'Brien, 2002). The goal of this intervention was to reduce bedtime procrastination, which is a health behavior within the spectrum of procrastination, and to increase motivation to choose a health action called sleep. The intervention was designed to devise a way to intervene while considering the degree of readiness for individual change. Prochaska et al. (1993) propose five stages of change based on the individual's readiness for change (e.g., precontemplation, contemplation, preparation, action and maintenance). The study considered that participants in the study voluntarily participated in the intervention program for behavior change and therefore were at least at the preparation stage for the change. Thus, the intervention focuses on the progress from the preparation stage to the action stage by utilizing MI techniques that capitalize on enhancing motivation for individuals in this stage.

Behavioral modification principles were added to the intervention protocol for bedtime procrastination based on a previous study on procrastination, such as exploring the function of procrastination (Rozental & Carlbring, 2014). Through functional assessment, it is possible to identify the main function of bedtime procrastination, especially what emotional or behavioral purpose is served for an individual in engaging in bedtime procrastination. Behavioral techniques such as differential reinforcement of alternative behavior (DRA) has been shown to be helpful for a wide array of undesirable behaviors (Petscher et al., 2009). Utilizing such behavioral techniques can help reduce bedtime procrastination by finding alternative behaviors that may fulfill the same or similar function to reduce the original problem behavior. Imagery training was also used within sessions to make it easier for participants to form new sleeping habits in daily life. Several recent studies have shown that adding imagery training to existing psychotherapy is beneficial in enhancing therapeutic effects, especially when helping master new behaviors (Ahn & Kwon, 2018; H. Lee et al., 2018; McEvoy et al., 2015; McEvoy & Saulsman, 2014).

This study intended to develop an intervention to reduce bedtime procrastination (BED-PRO) and examine the feasibility and acceptability of the intervention utilizing a single-group pre-post, follow-up experimental design. We hypothesized that this pilot intervention would reduce bedtime procrastination in individuals and improve overall sleep indices. We also explore whether the intervention maintained its effects one month later.

Method

Study design

Since BED-PRO was the first intervention protocol for bedtime procrastination, the study was designed to follow the Stage Model of behavioral therapy for intervention development (Onken et al., 2014; Rounsaville et al., 2001). The current study was a Stage I study of the stage model, which is designed to develop the intervention, and verify the feasibility and acceptability of the developed intervention utilizing a single-group pre-post design. This study was approved by Sungshin Women's University Institutional Review Board (SSWUIRB 2018–020). All participants submitted written informed consent to participate in the study.

Participants

Selection criteria

Young adults (n = 20) in their 20s were selected to participate in the study based on previous studies that indicated general procrastination was the most common in early adulthood (McCown & Roberts, 1994). Individuals who scored 33 or higher on the Bedtime Procrastination Scale (BPS) were included in the study. Exclusion criteria were: Individuals (a) with a history of suicide attempts; (b) with a diagnosis of bipolar disorder, schizophrenia, or insomnia; (c) currently taking sleep medication; or (d) currently shift workers. Individuals with insomnia (ISI≥15) were excluded in this pilot study because individuals with insomnia may have different reasons for procrastinating their bedtime (e.g., aversion to going to bed due to inability to sleep) compared to individuals who merely engage in bedtime procrastination.

Recruitment

Participants were recruited through online and offline advertisements. Advertisements linked potential participants to a screening questionnaire. The process of selecting participants was done in three steps. First, participants were selected through the Bedtime Procrastination Scale (BPS). Participants were then checked to see if they met inclusion criteria through screening phone calls, which finalized the participant selection process (Figure 1).

Measurements

Bedtime procrastination

For this study, bedtime procrastination was measured by the BPS and sleep diaries.

Bedtime procrastination scale (BPS). The Bedtime Procrastination Scale was developed by Kroese et al. (2014). In this study, the inclusion criterion was a score of 33 or greater (33 was the median score used as a criterion to distinguish bedtime procrastination group in the previous study; Chung et al., 2020). The scale consists of 9 items rated on a 5-point Likert scale from 1 (almost never) to 5 (almost always). Total scores range from 9 to 45 and items of 2, 3, 7 and 9 are inversely scored. Cronbach's alpha for the BPS was .92 in Kroese et al. (2014) and .51 in this study.

Sleep diary. Participants were asked to keep a daily sleep diary for 4 weeks to closely examine their sleep during the intervention. In addition, a month after the booster call, participants were asked to perform a follow-up sleep diary for 7-day. Sleep diary indices included bedtime procrastination duration (in minutes), sleep onset latency (SOL), wake after sleep onset (WASO), total sleep time (TST), time in bed (TIB), bed time (BT), wake time (WT), sleep efficiency (SE), and feeling refreshed upon awakening (scale 1–5). Bedtime procrastination duration was calculated from the sleep diary by subtracting the initial time planned to go to sleep from the lights off (LO) time.

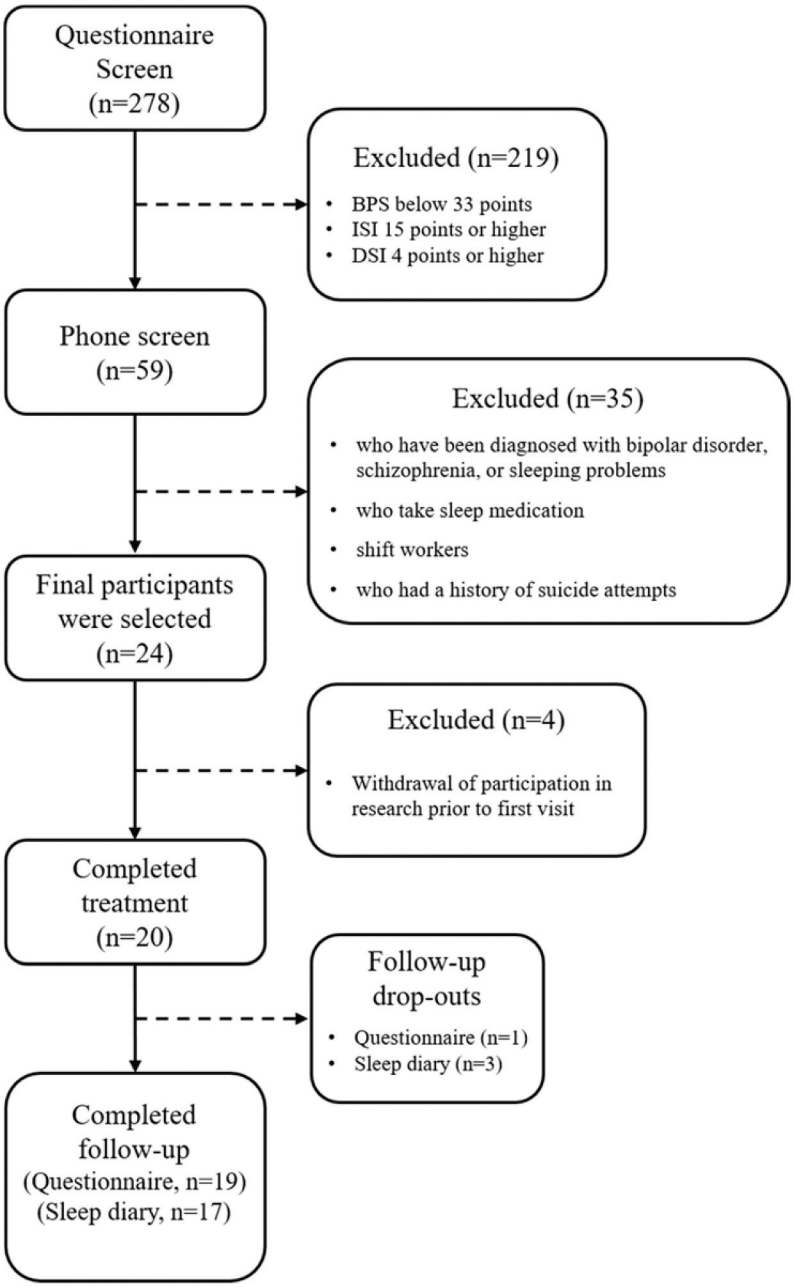

Figure 1. Flowchart of study.

Sleep indices

Insomnia severity index (ISI). The ISI, developed by Bastien et al. (2001), was used to evaluate the last 2 weeks of sleep disturbance based on diagnostic criteria for insomnia in the DSM-5. The Korean version of the ISI was used and validated by Cho et al. (2014). The ISI consists of seven items that were rated on a 5-point Likert scale from 0 to 4. Total scores range from 0 to 28, with high scores indicating

greater insomnia severity. Participants who scored above 15 in the screening questionnaire were classified as having clinical insomnia and were excluded in this study. Cronbach's alpha for the ISI was .74 in Bastien et al. (2001) and .47 in this study.

Epworth sleepiness scale (ESS). The ESS developed by Johns (1991). We used the Korean version of ESS that was validated by Cho et al. (2011). The ESS consists of eight items that were rated on a 4-point Likert scale from 0 to 3. Total scores range from 0 to 24, with high scores indicating greater daytime sleepiness. Cronbach's alpha for the ESS was .90 in Cho et al. (2011) and .69 in this study.

Fatigue severity scale (FSS). Fatigue was measured by the FSS which was developed by Krupp et al. (1989). We used the Korean version of FSS and validated by J. H. Lee et al. (2013). The FSS consists of nine items that were answered on a scale from 1 (strongly disagree) to 7 (strongly agree). The total FSS score is calculated as an average of the individual item responses. A high score indicates greater fatigue severity. Cronbach's alpha for the FSS was .93 in J. H. Lee et al. (2013) and .83 in this study.

Morningness-eveningness questionnaire (MEQ). The MEQ was developed by Horne and Östberg (1976). We used the Korean version of MEQ validated by Kim (2012). The MEQ consists of 19 items, which can be used to confirm which type of person they perceive themselves to be (morning type, evening type, or intermediate type). Total scores range from 16 to 86, with scores above 59 classifying individuals as morning type, scores ranging from 42 to 58 as intermediate type and scores below 41 as evening type. Cronbach's alpha for the MEQ was .77 in Kim (2012) and .65 in this study.

Procedures

Intervention overview

For baseline measurements, participants completed self-report questionnaires. Next, the intervention was introduced to the participant. Weekly intervention sessions were held for 50 minutes, for a total of three face-to-face sessions and one booster call session a week later after the final session conducted by telephone. After three intervention sessions, participants were asked to perform a post-intervention questionnaire. One week after the end of the intervention, the booster call session was held to confirm if there were any difficulties for the participant. Finally, a month after the booster call, participants were asked to perform a follow-up questionnaire. Participating therapists was one Ph.D. level clinical psychologist with Diplomate of Behavioral Sleep Medicine certification and a master's level graduate student receiving clinical supervision trained in behavioral sleep medicine.

Intervention components

A structured intervention manual was developed for the therapist, and the therapists were trained through role-play and demonstration to minimize therapist effects. The intervention manual included detailed instructions and the time required for each component of the intervention (Table 1).

For the first session, **"Reinforcing Motivation"** was the main theme. The first session was conducted using the following procedure: (a) psychoeducation regarding the intervention; (b) setting treatment goals; (c) exploring thoughts and feelings associated with bedtime procrastination by introducing the cognitive-behavioral approach to bedtime procrastination; (d) weighing pros and cons of BP; (e) functional analysis of BP; (f) enhancing motivation through exploring personal values of the participant and discussing value-congruent or incongruent nature of current bedtime schedule; (g) behavioral contracting of a bedtime schedule for the following week. The cognitive-behavioral approach to bedtime procrastination involved identifying the participant's thoughts and feelings that interfered with sleep, and increase the likelihood of engaging in BP, especially in the context of the functional analysis. For example, a participant's feelings of isolation and loneliness, in addition to thoughts such as, "I don't have many friends" could precipitate behaviors in participants that caused them to call friends or use social network services prior to bedtime.

Table 1. Session-by-session protocol of BED-PRO.

Session	Theme	Goals and Activities	Homework
1	Reinforcing motivation	• Goal Setting • Psychoeducation and introduction to the intervention • Introducing cognitive-behavioral model of bedtime procrastination • Weighing pros and cons of bedtime procrastination • Functional assessment of bedtime procrastination • Enhancing motivation through exploring values • Behavioral contracting	• Sleep Diary • Implementing the behavior contract
2	Attempting to change	• Reviewing homework • Re-addressing pros and cons of bedtime procrastination • Modifying behavior contract • Modifying pre-sleep activity plan and reset sleep and wake-up time • Imagery training	• Sleep Diary • Implementing the behavior contract
3	Maintaining change	• Reviewing homework • Discussing positive changes • Confirming goal achievement • Exploring changes in sleep • Relapse prevention • Feedback	• Sleep Diary • Implementing the behavior contract
Booster Call	Maintaining change in the long-term	• Reviewing maintenance behavior • Exploring coping strategies toward recurrence • Supporting self-efficacy	• Sleep Diary

Treatment techniques based on behavioral modification principles such as DRA were used to help find alternative behaviors that served the same function for bedtime procrastination. For example, if feeling lonely was a main trigger into engaging in BP, individuals would spend more time on these days on their smartphones communicating with other individuals or spending time on social network services. In this example, DRA would be used to find alternative ways to feel more connected to people that was during the day, and not close to bedtime, to decrease likelihood of engaging in BP.

The theme of the second session was **"Attempting to Change"**. During the session, specific difficulties experienced by the participant in implementing the behavioral contract during the first week were reviewed and validated. At the same time, the therapist strengthened and supported the participant's efforts. Subsequently, the participant was asked to reconsider the pros and cons of bedtime procrastination to explore changes in thoughts and attitudes. The participant then modified the behavioral contract to focus on specific barriers that interfered with change from the first week. Finally, the participant engaged in imagery training (as described in the behavior contract). Imagery training involves using vivid imagery of the participant engaging in a series of behaviors prior to bedtime activities that were written by the participant in the behavior contract.

The third session's theme was **"Maintaining Change"**. The therapist examined any difficulties the participant had in practicing the assignments during the second week. During this session, the therapist reinforced the efforts the participant had made to change. The therapist and participant reviewed and discussed the extent to which the participant has achieved their goals. The therapist and participant explored ways to maintain sleep habits and utilized relapse prevention techniques. The participant was asked to think of a high-risk situation in which bedtime procrastination became more frequent and perform imagery training to cope with the situation effectively rather than avoiding sleep with bedtime procrastination. Finally, feedback of the intervention is provided by the participant.

The theme of the booster call session is "**Maintaining change in the Long-term"**. During the booster call, the participant was asked to maintain changes and decrease BP without meeting the therapist. The therapist asked participants about their feelings about their changed behavior attempts (without a therapist) and examined any personal challenges or difficulties. Finally, the therapist supported the participant based on their strengths and resources shown during in-person sessions to enhance the participant's self-efficacy.

Data analysis

To test intervention effects, Wilcoxon Rank Test was used to compare pre- and post-intervention means on variables, and again to compare post-intervention and follow-up means to investigate treatment maintenance. Wilcoxon Rank test, a nonparametric test, was used because the sample size was small and did not meet the assumption of normality. A simple Bonferroni correction ($p < .025$) was applied to prevent Type 1 errors due to multiple comparisons (C. Bonferroni, 1936; C. E. Bonferroni, 1935). Specifically, Bonferroni Correction Method was used by comparing p-value and alpha with the value divided by the number of tests conducted (alpha/2).

Results

All 20 participants completed the BED-PRO intervention without any drop-out cases. However, there was missing data for one participant who did not provide 1-month follow-up data. In addition, three out of 20 participants did not provide follow-up data for sleep diaries.

Demographic information

Demographic Information can be found in Table 2. The intervention was conducted using participants recruited through advertisements and community flyers. 20 participants were selected (mean age = 20.9, standard deviation [SD] = 2.05), including 16 females (80.0%) and 4 males (20.0%). Regarding education level, 85.0% were currently enrolled as a student at a university, 5.0% had a bachelor's degree, and 10.0% had a master's degree. All participants were single. Regarding employment status, 90.0% were unemployed and 10.0% were employed. On average, the participants in the study responded to have strong eveningness tendencies, indexed by MEQ scores (Table 3).

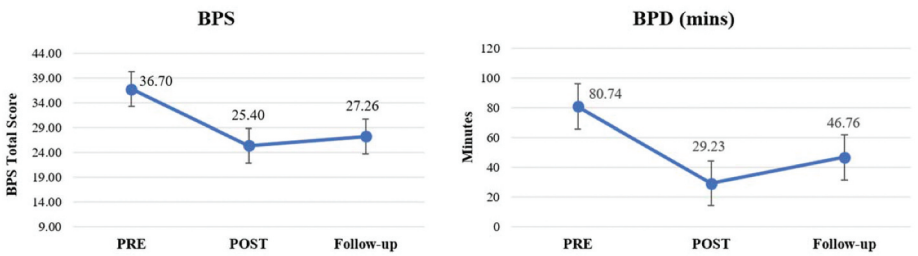

Figure 2. Pre-treatment, post-treatment, and 1-month follow-up of BPS and BPD. BPS, bedtime procrastination scale; BPD, bedtime procrastination duration, calculated from the sleep diary by subtracting initial time planned to go to sleep from the lights off.

Table 2. Demographics information (N = 20).

	N or M	% (SD)
Gender		
Female	16	80.0
Male	4	20.0
Age	20. 9	2.05
Education		
University student	17	85.0
Bachelor' degree	1	5.0
Master's degree or more	2	10.0
Marital status		
Single	20	100.0
Employment status		
Employed	2	10.0
Unemployed	18	90.0

Treatment outcome variables

Bedtime procrastination

Means and standard deviations can be found in Table 3. We evaluated the function of BP using functional analysis, and found the most common functions of BP were due to "emotion regulation" and "reward to self after a long day". Bedtime procrastination (BPS scores) decreased significantly from pre- to post-intervention (z= −3.924, p< .0005). In addition, reduction of bedtime procrastination (BPS scores) was maintained from post-intervention to follow-up (z= −1.224, p= .221) (Figure 2).

Additionally, following the intervention, bedtime procrastination duration (mins) significantly decreased from 80.74(± 45.60) to 29.23(± 26.94) minutes (z= −3.771, p< .0005), but increased at follow-up (46.76 min; z= −2.628, p= .009) (Figure 2).

Sleep

Sleep effiency increased following the intervention (z= −3.211, p= .01) from 82% to 87%, and was maintained at 1 month follow-up. Feeling refreshed upon awakening also increased significantly following the intervention (z= −3.211, p= .001), and was maintained at follow-up. In addition, WASO decreased significantly from pre- to post-intervention (z= −2.352, p= .019), and was maintained from post-intervention to follow-up.

Average Lights Off (LO) was 2:31 a.m. at pre-intervention, and was reported to be earlier at 2:14 a.m. at post-intervention (z= −2.203, p= .028), this value was not significant after Bonferroni correction. There were no significant differences between TST, TIB, SOL, BT, WT between pre- and post-intervention.

Insomnia severity decreased significantly from pre- to post-intervention (z= −2.914, p= .004), and also continued to significantly decrease at follow-up (z= −2.593, p= .010). Daytime sleepiness decreased significantly from pre- to post-intervention (z= −3.343, p= .001). and was maintained from post-intervention to follow-up.

Satisfaction evaluation & qualitative feedback

Satisfaction evaluation of the intervention was conducted immediately after the end of each session. The satisfaction evaluation consisted of a Likert scale from 1 to 4 with a score range of 8 to 32. The average satisfaction score for the entire intervention was 27.92 ± 3.55. While formal assessment of helpful components among the individuals who participated in the study were not collected, individuals subjectively reported that dealing with ambivalent feelings about change (weighing pros and

Table 3. Pre-treatment, post-treatment, and 1-month follow-up of questionnaire and sleep diary.

		Pre-intervention (N = 20) M(SD)	Post-intervention (N = 20) M(SD)	*z*	*p*	Post-intervention (N = 20) M(SD)	1-mo Follow-up (N = 19) M(SD)	*z*	*p*
Questionnaire	BPS	36.70 (3.20)	25.40 (5.96)	−3.924	.000***	25.40 (5.96)	27.26 (5.19)	−1.224	.221
	ISI	10.80 (2.95)	8.40 (3.19)	−2.914	.004**	8.40 (3.19)	6.37 (2.65)	−2.593	.010*
	ESS	10.15 (3.34)	6.85 (3.53)	−3.343	.001**	6.85 (3.53)	7.37 (3.59)	−.603	.546
	FSS	4.59 (0.86)	4.08 (0.92)	−1.756	.079	4.08 (0.92)	4.24 (0.79)	−.474	.636
	MEQ	35.90 (6.80)							
		Pre-intervention (N = 20)	Post-intervention (N = 20)	*z*	*p*	Post-intervention (N = 20)	1-mo Follow-up (N = 17)	*z*	*p*
		M(SD)	M(SD)			M(SD)	M(SD)		
Sleep diary	BPD (min)	80.74 (45.60)	29.23 (26.94)	−3.771	.000***	29.23 (26.94)	46.76 (37.22)	−2.628	.009*
	TST (min)	410.41 (74.05)	410.92 (46.44)	−1.419	.156	410.92 (46.44)	397.92 (47.45)	−1.551	.121
	TIB (min)	499.57 (82.97)	466.36 (46.06)	−1.717	.086	466.36 (46.06)	464.77 (76.62)	−.497	.619
	WASO (min)	8.32 (14.34)	3.61 (4.90)	−2.352	.019*	3.61 (4.90)	4.87 (7.95)	−.491	.623
	SOL (min)	10.90 (12.10)	15.36 (19.24)	−.598	.550	15.36 (19.24)	9.51 (12.27)	−1.655	.098
	SE (%)	82.30 (7.42)	87.89 (5.97)	−2.576	.010*	87.89 (5.97)	87.26 (7.75)	−.639	.523
	Sleep Quality	3.26 (0.64)	3.56 (0.60)	−1.894	.058	3.56 (0.60)	3.40 (0.66)	−1.166	.244
	Freshness	2.93 (0.63)	3.44 (0.66)	−3.211	.001**	3.44 (0.66)	3.32 (0.66)	−1.024	.306
	BT	25:38:39 (1:19:46)	25:48:21 (57:38)	−.056	.955	25:48:20 (57:38)	25:49:54 (1:17:02)	−.260	.795
	LO	26:31:25 (1:29:38)	26:14:30 (1:01:13)	−2.203	.028	26:14:30 (1:01:13)	26:20:54 (1:16:07)	−.734	.463
	WT	9:41:03 (1:11:11)	9:24:24 (59:53)	−.896	.370	9:24:24 (59:53)	9:13:13 (56:52)	−.260	.795

* $p < .025$, ** $p < .005$, *** $p < .0005$

Z-value is produced by Wilcoxon Rank test; *p*-value is produced by Wilcoxon Rank test with Bonferroni Correction.

BPS, bedtime procrastination scale; ISI, insomnia severity index; ESS, Epworth sleepiness scale; FSS, fatigue severity scale; BPD, bedtime procrastination duration; TST, total sleep time; TIB, time in bed; WASO, wake after sleep onset; SOL, sleep onset latency; SE, sleep efficiency; SQ, sleep quality; Freshness, feeling refreshed upon awakening BT, bed time; LO, lights off; WT, wake time.

MEQ: Total scores range from 16 to 86, with scores above 59 classifying individuals as morning types, scores ranging from 42 to 58 as intermediate types and scores below 41 as evening types.

cons) was the most helpful component of the intervention. In addition, participants also reported that the main barriers to making improvements in the intervention were due to changed schedules and stress during exam week for university students, and the variety of media devices within easy reach such as smartphones and tablet PCS. Participants in the participation also noted that the imagery training part of the intervention as least helpful.

Discussion

This study was a proof-of-concept study in developing and testing the feasibility and acceptability of a psychological intervention for reducing bedtime procrastination in young adults who were free of insomnia or other serious psychopathology. The intervention significantly reduced bedtime procrastination, and these changes were maintained at 1-month follow-up. The intervention also improved other sleep parameters, such as sleep efficiency, insomnia symptoms, and daytime sleepiness. Participantsin the study appeared to be highly motivated and satisfied with the outcome of the intervention, reflected by no drop-outs during the active treatment phase and high satisfaction scores. This was the first study, to the best of our knowledge, to test a psychological intervention specifically targeting bedtime procrastination.

Main intervention effects

The BED-PRO intervention for reducing bedtime procrastination developed in this study was found to be effective in reducing bedtime procrastination. As a result of the analysis, it was confirmed that bedtime procrastination was significantly reduced post-intervention via both the questionnaire (BPS scores) and sleep diary (minutes). There were statistically significant improvements from pre- to post-intervention for BPS scores, and improvements were sustained at follow-up.

Prior to the intervention, participants spent an average of 80.74 minutes engaging in bedtime procrastination, which was reduced by 51 minutes to 29.23 minutes per day following the intervention (63.8% reduction). However, reduction in time spent engaging in bedtime procrastination was not sustained at one-month follow-up. Although there was an average 33 minutes reduction from 80 minutes (pre-intervention) to 1-month follow-up (46 minutes), the changes were not statistically different. These results may reflect the nature of short-term interventions, which facilitate adapting new behaviors in a short period of time. While the participants may have habituated to new behaviors, previous studies have shown that there are limitations when participants try to maintain these behaviors long term. For example, previous studies have shown that the presence or absence of aftercare intervention for eating disorders has an effect on improving intervention outcomes and maintaining intervention effects even after intervention is terminated (Bauer et al., 2012). Despite these results, there were significant reductions on scores based on the Bedtime Procrastination Scale, which reflects the participant's perceived change in the degree or severity of bedtime procrastination. Scores based on BPS significantly decreased after the intervention compared to the baseline, and was maintained at 1-month follow-up.

One encouraging finding was there were no dropouts among study participants during the intervention. The reason for this may be that the intervention focused on enhancing internal motivation of the participants in the early stages based on motivational interviewing. Internal motivation of research participants is known in many studies as a factor predicting the adherence or dropout in intervention studies (Alfonsson et al., 2016; Perry, 2014; Ryan & Deci, 2000). In addition, bedtime procrastination is an important health behavior similar to exercise or smoking cessation that many individuals desire to change, but have difficulty making changes on their own. This may have increased their motivation to complete the intervention. Another reason for low drop-out may have been that the intervention was designed to be a short-term intervention with three weekly sessions and one booster session. The short-term nature of the intervention may have been easier for participants to adhere to treatment. Finally, the intervention was not

designed to delve into deeper emotional issues or psychiatric illnesses, and participants with serious illnesses were excluded from the study. Motivational interviewing with individuals who have serious physical or psychiatric illnesses may be vulnerable for higher dropout rate compared to the current intervention study. For example, a review paper on healthcare motivational interviewing for cancer survivors reported dropout rates between 19% and 35% (Spencer & Wheeler, 2016).

Intervention effects on sleep indices

A secondary aim of the study was to investigate the effects of reducing bedtime procrastination on other sleep indices, derived from sleep diaries and other self-report questionnaires. Following the intervention, participants showed significant improvements in daytime sleepiness and feeling refreshed upon awakening, and this was maintained until follow-up. In particular, for daytime sleepiness, the average was 10.15 points, which was within the mild range, but decreased to a normal level by 6 points after the intervention (Johns, 1991; Lim et al., 2009).

Some sleep indices did not improve following the intervention. In particular, total sleep time did not increase despite a decrease in bedtime procrastination. It appears that while BED-PRO is effective in targeting bedtime procrastination, this does not seem to extend to increasing total sleep time. It may be the case that individuals who engage in bedtime procrastination do not necessarily sleep less than those who don't, as shown in a study conducted by our research team (Chung et al., 2020). However, the results are inconclusive as other studies have shown that total sleep time was significantly shorter in those who showed more bedtime procrastination, which may reflect differences in samples (Kroese et al., 2014, 2016). One speculation is that individuals who participated in the intervention may be have turned their lights off earlier with the intention of going to sleep earlier. Despite improvements in bedtime procrastination, individuals participating in the study did not go to bed earlier or wake up earlier. While Lights Off (LO) did show an earlier average time following the intervention compared to baseline, the changes were not significant after Bonferroni adjustment. Further studies with larger sample sizes will be needed to clarify possible mechanisms of sleep improvement in this population.

The intervention was effective in improving sleep efficiency, and these effects were maintained at one-month follow-up. In addition, insomnia severity significantly decreased as indexed by ISI scores, and effects continued to improve at follow-up. While the intervention provided basic sleep hygiene training to improve sleep and encouraged improving sleep variability, the study did not include insomnia-specific treatment components. We speculate that one possibility of why sleep efficiency improved compared to other sleep indices were because we directly addressed the function of bedtime procrastination (e.g., emotional dysregulation, rewarding yourself for having a hard day) in the intervention. Often times, discussion of the function of BP mirrored more traditional psychotherapy, and working with the participant to find alternative methods to attain fulfillment of the function may have been more conducive to sleep because they directly addressed the issues of why they were having disrupted sleep in the first place. For example, identification of the antecedents of bedtime procrastination were often negative cognitions when doing a functional analysis, and methods such as expressive writing or cognitive reappraisal would come up as alternative behaviors to engage in instead of bedtime procrastination. While we did not directly measure smartphone use in bed in our intervention, one previous study from our research team documented longer use of smartphones in bed in individuals who engaged in high bedtime procrastination compared to those with low bedtime procrastination (Chung et al., 2020). It is possible that the intervention may have yielded effects by decreasing smartphone use in bed, which may have resulted in better sleep efficiency and lower insomnia severity scores. Bright light exposure prior to bedtime is known to diminish sleep quality and impact sleep (Cajochen et al., 2011; Lockley et al., 2003; Wood et al., 2013), and future studies will be needed to investigate whether a decrease in bedtime procrastination improves sleep and sleep quality due to decrease in media use in bed.

The intervention showed positive changes in daytime sleepiness, despite there being no changes in TST. We speculated that changes in sleep variability, that is, having more regular sleep schedules as a result of the intervention may have contributed to improvements in daytime sleepiness, as previous studies have suggested that higher variability of sleep was associated with greater increase in daytime sleepiness (El Hangouche et al., 2018; Manber et al., 1996). Future studies using larger samples should investigate whether reduced variability contributed to better daytime sleepiness.

The intervention yielded no improvement in fatigue. In a previous study, it was known that there was a positive correlation between bedtime procrastination and fatigue (Kroese et al., 2014, 2016), but this study confirmed that fatigue did not improve despite a reduction in bedtime procrastination. This suggests that bedtime procrastination may be more closely related to daytime sleepiness than fatigue, and the reason can be inferred from the nature of fatigue and sleepiness. Fatigue is a condition that requires rest, not sleep, while sleepiness is conceptualized as requiring sleep (Neu et al., 2010). Reductions in bedtime procrastination did not indicate guaranteed individual rest time, which may have been the reason for the null results.

Directions for future intervention refinement

Based on qualitative and quantitative results of the current study, the following issues should be considered in refining the intervention for future use. First, it may be helpful to modify the imagery training part of the intervention so it can be optional for the participant, and allocate more time exploring thoughts and behaviors associated with BP and ambivalent feelings within the intervention. Second, while the intervention used MI skills to enhance participant motivation, it was a manual-based intervention that has room for tailoring to the participant. Assessing specific stages of change prior to the treatment may help the clinician approach the treatment more flexibly. Third, introducing traditional cognitive-behavioral therapy techniques such as cognitive restructuring for negative cognitions that increase the likelihood of bedtime procrastination should be explored in future studies. Finally, number of sessions should be re-addressed in future sessions considering the difficulty in maintaining reduction in bedtime procrastination (in minutes) at one-month follow-up.

Limitations

This study has some limitations. First, this study has limitations in generalizing the effectiveness of the intervention because the intervention was conducted as a single group pre-post study design at an exploratory level. Without a control group, the results from this study should be interpreted with caution and effects such as spontaneous recovery or regression to the mean may have contributed to the observed results. In future studies, it is necessary to verify the effectiveness through randomized clinical trials in which control groups are set up and compared with intervention groups.

Second, participants who participated in the study with high bedtime procrastination reported strong eveningness chronotype. While the intervention was devised under the assumption that bedtime procrastination was mainly behavioral, there is a possibility that participants' delayed bedtimes relative to their desired bedtime can be attributed to biological factors. High circadian alerting signals in the evening would make it difficult for these individuals to disengage from activities and wind down for sleep. While it was beyond the scope of our study, future studies should focus on the relative contribution and directionality of bedtime procrastination and eveningness chronotype.

Third, ADHD was not screened in this study. ADHD is difficult to control impulse and has the characteristics of excessive nocturnal motor activity (American Psychiatric Association, 2013; Corkum et al., 2001), so it can be difficult to disengage from evening tasks and go to bed. So, this appearance is the same as that of the bedtime procrastination group, so it is possible that it was mixed with the bedtime procrastination.

Fourth, although the intervention was designed based on TTM, this study did not assess the specific stage of change of each individual participant. Future studies measuring stages of change in each individual will enable tailoring the interventions to each individual more possible.

In addition, mechanisms of why the intervention was effective was unclear. Future studies on larger and more diverse samples and clinical populations are necessary to establish stronger conclusions for the efficacy of this intervention.

Conclusions

Despite the above limitations, this study has the following significance. In the socio-cultural context of modern society, where bedtime procrastination is prevalent due to wide use of smartphones, this was a first attempt to develop an intervention to reduce bedtime procrastination, a relatively new health-interfering behavior that has emerged in modern society. This was the first intervention attempting to reduce bedtime procrastination. While conducted as a preliminary study as a single-group design, bedtime procrastination significantly decreased as a result of the study. In addition, improvements in sleep indicators such as wake after sleep onset, sleep efficiency, daytime sleepiness, insomnia severity, and feeling refreshed upon awakening were identified. The results are promising in that this may facilitate future studies regarding bedtime procrastination as a serious health behavior. Future studies utilizing more rigorous methodology will be needed to verify the effectiveness of the BED PRO intervention.

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ORCID

Sooyeon Suh http://orcid.org/0000-0003-0644-8634
Nayoung Cho http://orcid.org/0000-0002-3929-6852
Sonhye Jeoung http://orcid.org/0000-0003-3433-962X
Hyeyoung An http://orcid.org/0000-0003-2450-3924

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