Effect of Restricting Bedtime Smartphone Use on Well-Being for Young Adults: An Experimental Design

Citation

Permanent link
https://nrs.harvard.edu/URN-3:HUL.INSTREPOS:37370063

Terms of Use
This article was downloaded from Harvard University’s DASH repository, and is made available under the terms and conditions applicable to Other Posted Material, as set forth at http://nrs.harvard.edu/urn-3:HUL.InstRepos:dash.current.terms-of-use#LAA

Share Your Story
The Harvard community has made this article openly available. Please share how this access benefits you. Submit a story.

Accessibility
Effect of Restricting Bedtime Smartphone Use on Well-Being for Young Adults: An Experimental Design

Victoria Lynn Shepherd

A Thesis in the Field of Psychology
for the Degree of Master of Liberal Arts in Extension Studies

Harvard University
March 2022
Abstract

Today's young adults grew up in a time of rapid technology growth impacting personal interactions, behavior, and well-being. Research shows both positive and negative impacts of smartphone use. However, as smartphone prevalence and usage time increased over the decades, a disturbing trend emerged among teens associating cell phone use with decreases in sleep duration and a decline in well-being outcomes. The teens from those studies are now young adults. Little evidence exists about the possible connection between smartphone use in the hours prior to planned sleep (bedtime). This study measured the impact of bedtime smartphone restriction on well-being among a sample population aged 18 to 30 ($N = 33$). Two levels of experimental groups were instructed to restrict smartphone use either 1 hour or 3 hours prior to bedtime for 1 week. A control group used smartphones as usual. The Subjective Happiness Scale (SHS), Quality of Life Scale (QOLS), and Smartphone Addiction Scale - Short Version (SAS-SV) and survey questions about smartphone and social media use were implemented at the beginning and end of the week. Retrospective sleep characteristics and behaviors were reported at the beginning of the week using the Ultra-Short Munich Chronotype Questionnaire. A daily diary was used to record sleep behaviors and smartphone use during the study week based on the Consensus Sleep Diary. A series of ANOVAs and $t$-tests compared pre- and post-experiment scores. Well-being scores were expected to improve. In two of the three measures (SHS and QOLS), the hypothesis held. Exploratory analyses of diary entries found improvements to sleep onset latency resulting in greater
sleep efficiency, suggesting that participants experienced improvements that could not be significantly detected through self-report well-being measures alone. Further research is encouraged. Implications and complications due to the COVID-19 pandemic are discussed.
In memory of my grandmother, Opal Prater. Her resilience during difficult times is an inspiration. This thesis is a testament to her unconditional love and encouragement.
Acknowledgments

I would like to thank everyone who helped make this thesis possible. First, and foremost, I thank my thesis director, Dr. Edward Pace-Schott, for his expert guidance and support. Without his dedicated involvement through every step of the process, this thesis would never have been accomplished. I hope this work honors his contribution to my academic progress. I am honored and forever grateful for his time.

My advising team was instrumental in keeping me moving forward. We all had to pivot during a time of great uncertainty. My research advisor, Dr. Adrienne Tierney, supported my work with grace, and I appreciate her patience and expertise. My academic advisor, Dr. Charles Houston, III, was instrumental in choosing the best path toward reaching my academic goals. I also thank my thesis coordinator, Gail Dourian, for helping me navigate through the setbacks. Additionally, I thank every faculty, staff, and board member for their commitment to health and well-being.

I must thank everyone who took the time to participate in this study. I am deeply grateful for each contribution toward this research. I also extend special thanks to the American Physical Society for their assistance in participant recruitment.

Finally, I am profoundly grateful for my family and loved ones for not letting me give up. Thank you for your support, patience, and understanding during this unforgettable academic adventure.
# Table of Contents

Dedication

Acknowledgments

Chapter I. Introduction

  Smartphone Use and Sleep

  Social Media and Well-Being

  Nighttime Exposure to Light

  Hypothesis

Chapter II. Methods

  Participants

  Measures and Materials

    Well-Being Measures

    Sleep Characteristics and Behaviors Measures

    Study Related Material

  Study Protocol and Procedures

  Statistical Analyses

    Data Screening

Chapter III. Results

  Primary Analysis

  Primary Analyses of Well-Being Outcomes
List of Tables

Table 1. Covariates Considered to Adjust Group Comparisons of Measures Outcomes .. 20
Table 2. Demographics Characteristics for Primary Analysis at Baseline .................. 23
Table 3. Means, Standard Deviations and ANOVA for Well-Being Measures of Continuous Variables at Baseline ................................................................. 24
Table 4. Means, Standard Deviations, and One-Way ANOVA for Well-Being Continuous Outcome Variables after Bedtime Smartphone Restriction .................................. 27
Table 5. Descriptive Characteristics for Screen Time and Sleep at Baseline ............... 37
Table 6. Means, Standard Deviations, and ANOVA of Smartphone and Sleep Continuous Variables at Baseline ................................................................. 38
Table 7. Means, Standard Deviations, and One-Way ANOVA for Smartphone Use Continuous Variable Outcomes ................................................................. 41
Table 8. Means, Standard Deviations, and T-test for Sleep Continuous Variable Outcomes Using Pooled Groups ................................................................. 43

Appendix K. Results of ANCOVA Controlling for Covariates on Well-Being Change Scores .................................................................................................................. 68
List of Figures

Figure 1. Comparison Between Groups for Subjective Happiness Scores ...................... 28
Figure 2. Comparison Between Groups for Quality of Life Scores .......................... 29
Figure 3. Comparison Between Groups for Smartphone Addiction Scores ............... 30
Figure 4. Within Groups Differences After Bedtime Smartphone Restriction .......... 32
Figure 5. Within Groups Differences After Bedtime Smartphone Restriction ........... 33
Figure 6. Within Groups Differences After Bedtime Smartphone Restriction .......... 34
Figure 7. Screenshot Example of Weekly Smartphone Use via Apple's Screen Time Feature ................................................................. 53
Chapter I.
Introduction

Today’s young adults grew up during an age of rapid technology growth. For some, smartphones quickly replaced the use of cellular phones as they moved through their adolescent and teen years (Twenge et al., 2017). Smartphones make it convenient to connect with others and carry out routine tasks previously done using multiple devices. Despite these benefits, young adults are more likely to report anxiety and depression than other generations (Odgers, 2018). The author connects the ubiquitous use of smartphone technology and social media as a likely explanation. Ninety-six percent of U.S. adults aged 18 to 29 own a smartphone (Anderson, 2019) and use them an average of 5 hours and 42 minutes per day (Zalani, 2021). Given the prevalence of this technology, mounting research shows stress associated with the social demands of digital connectivity (Turkle, 2012) and other factors may lead to sleep disruption (Elhai et al., 2019; White, 2011). Sleep quality is vital for healthy mental and physical well-being (Watson et al., 2015). Furthermore, good sleep quality is significantly associated with positive subjective well-being (Lemola et al., 2013). Similarly, sleep efficiency predicts life satisfaction better than sleep duration (Ness & Saksvik-Lehouillier, 2018). These findings suggest an association between the effects of smartphone use and sleep on well-being, defined by Diener (1984) as subjective happiness and life satisfaction.

Most work in this area has focused on the effects of nighttime smartphone use among adolescents. Few experimental studies focused on adult subjects. Even so, it is highly important to explore these effects as individuals enter adulthood. Arnett (2004),
describes young adulthood as a time of increasing independence when individuals tend to establish lifelong habits. These choices have long term consequences. Thus, the current study investigated whether smartphone restriction in the hours before planned sleep time would improve well-being.

Smartphone Use and Sleep

As device use increased over the last two decades, early studies voiced concern about the psychological and physical impact on individuals. A trend emerged in multiple studies associating screen time increase with shortened sleep duration, and excessive device use was a risk factor for adverse sleep outcomes (Hale et al., 2015). To investigate the possible factors responsible for these changes, Twenge et al. (2017) analyzed data from two national surveys of high school students conducted since 1991. Defining insufficient sleep as less than 7 hours most nights, the researcher reported insufficient sleep increased from 26% in 1991 to over 40% in 2015. Additionally, individuals using devices five or more hours per day were 50% more likely to experience insufficient sleep compared to peers using devices less than 1 hour per day. Results from a similar analysis of 2017 data by Baiden et al. (2019) found that students with excessive screen time behavior were 1.34 times more likely to have insufficient sleep compared to peers without excessive screen time behavior. These results were replicated in a recent national survey of Australian technology use by Oviedo-Trespalacios et al. (2019) showing a significant increase in smartphone use and sleep loss over a 13-year study period. A meta-analysis confirmed these findings that excessive technology use has a significant effect on sleep duration (Mei et al., 2018). Together, the evidence points to excessive smartphone use as a risk factor for insufficient sleep. This is significant because young
adults are at greater risk of excessive smartphone use (Gutierrez et al., 2016; Oviedo-Trespalacios et al., 2019) and, therefore, at greater risk of insufficient sleep.

The convenience of smartphone technology gives people access to the internet day and night. Because of its portability, smartphones increase the likelihood of nighttime and even bedroom use. Therefore, it is not surprising to find most U.S. adults use smartphones in bed. A National Sleep Foundation survey found that 90% of Americans use light emitting devices within one hour of bedtime and that greater nighttime use was associated with poor sleep outcomes in all age groups (Gradisar et al., 2013). In a large cross-sectional study of adults’ bedtime device use by Bhat et al. (2018), 70% reported using electronic devices in bed. Almost 15% spent an hour or more using their devices in bed. Furthermore, individuals under age 30 were more likely to bring smartphones to bed compared to other age groups, and high use at bedtime was associated with insomnia, anxiety, and short sleep duration. Similarly, a recent report revealed 79% of millennials (individuals born between 1980 and 1996) take their smartphones to bed (Qualtrics, 2020). Given that most young adults are using their smartphones in bed, it is important to examine how this behavior affects sleep and well-being.

These studies and other correlational evidence about the negative effects of nighttime smartphone use on sleep among young adults continue to grow, yet very few experimental studies can be found. In one study, Hughes and Burke (2018) found limiting bedroom device use for half of the adults in their experimental study was associated with small but significant improvements to well-being. The improvements were attributed to better sleep quality based on qualitative responses to the survey. However, it is unclear whether a smartphone was used prior to entering the bedroom. Moreover, the sample
included a broad range of ages to represent the general population in the United Kingdom. Given that their study voiced concern about small effect sizes, an intervention experiment using a sample of young adults could yield stronger effects since young adults are at greater risk for excessive phone use, poor sleep quality, and more likely to take their phones to bed compared to people in older age groups. Perrault et al. (2019) provided one of the only experimental studies that limited nighttime screen use. Even though this study focused on adolescents aged 12 to 19 after 9 p.m. during school nights, the results are informative. This within-subjects study used diaries to record device use and activities after 9 p.m. A wearable device recorded sleep to establish a baseline for the first 2 weeks. Then, participants agreed not to use devices after 9 p.m. on school nights for the following 2 weeks. The intervention was associated with earlier sleep onset, longer sleep duration, and improved daytime performance. These findings were confirmed by a recent pilot study among 38 Chinese university students by He et al. (2020). Participants were randomized into a control group using smartphones as usual and an experimental group instructed to abstain from device use 30 minutes before bedtime for four weeks. Results from sleep measures, diaries, and mood measures demonstrated that the intervention increased sleep quality and duration, and improved mood. Taken together, these findings support the notion that an intervention approach could result in similar outcomes in a young adult population.

Social Media and Well-Being

A considerable amount of research exists about the effects of Social Networking Sites (SNS) on well-being and have shown both positive and negative outcomes (Kross et al., 2021). Negative effects depend on the level of emotional investment in social media.
Hunt et al. (2018) found connections to anxiety and identified fear of missing out (FOMO) was associated with greater baseline SNS use by participants in an intervention study. This is significant because anxiety resulting from being separated from SNS during phone restriction could outweigh the possible benefits of an intervention.

Young adults are not only more likely to take their smartphones to bed, but, using diary surveys from first year university students, Orzech et al. (2016) revealed that SNS increases in the minutes leading up to bedtime. In a similar study, Levensen et al. (2016) found that using social media before bed was associated with sleep disturbance using a large-scale study of a nationally representative sample of U.S. young adults. Interestingly, the author explained the frequency (number of times the smartphone was opened) predicted sleep disturbance greater than total screen time. This finding adds to the concept that strong connections to smartphones may be a risk factor for poor sleep quality. Likewise, Yang et al. (2020) suggested that restricting smartphone use in the hours prior to bedtime mitigates the negative impact of SNS by reducing exposure to social media. Thus, reducing pre-sleep arousal from SNS, and smartphone use in general, influences sleep quality.

Taken together, these studies suggest that limiting SNS before bedtime may, in some cases, increase anxiety yet improve sleep quality in other cases. Regardless, the influence of smartphone use prior to sleep is an important factor for well-being. These influences can be better understood by collecting an objective measurement of SNS using features available in today’s smartphones. For example, Apple’s iPhone Screen Time feature provides information about frequently used applications and time spent on social media.
Nighttime Exposure to Light

Despite evidence of the negative effects of screen time, it is not entirely clear what might be causally responsible for sleep disturbances. A theoretical framework by Cain and Gradisar (2010) offers three mechanisms to explain how using a smartphone at night effects sleep. First, sleep time is displaced by engaging in screen time which delays bedtime, even though wake time remains constant due to school or work start time. This results in shortened total sleep duration. Second, cognitive arousal and mental activation leads to delayed sleep onset. It takes longer to get to sleep. Finally, exposing the retina to light suppresses the production of melatonin, delaying sleep onset and interrupting sleep quality. It is important to note that there is no agreement among researchers about which mechanism represents the greater effect on sleep and nighttime smartphone use.

That said, there is evidence that the light itself is causing a problem. The alerting effects of short-wavelength light, like those commonly found in modern electronic devices, have been found to help prevent undesirable sleepiness in shift workers, those suffering from jet lag or seasonal mood disorders (Cajochen, 2007). Therefore, exposing the retina to similar light (often referred to as blue light) before bedtime could interfere with planned sleep. A review by Ostrin (2019) showed that retina exposure to blue light inhibits the production of melatonin, a hormone that plays a critical role in sleep and the human circadian system that is the foundation of the sleep-wake cycle. This connection is a function of the physiological systems regulating sleep that respond to daily cues. Exposure to light, as illustrated by Saper (2013), is the most important cue influencing wakefulness through visual and neural pathways (see also Scheer & Shea, 2007). Researchers have found the photochemical melanopsin (activated by the short wave
component of light) effects not only the suprachiasmatic nucleus (SCN) to entrain the
circadian clock but also targets multiple brain system favoring wakefulness to sleep
(Foster, 2021; Lazzerini Ospri et al., 2017). This finding explains how individuals using
smartphones shortly before bedtime might shift (delay) sleep time and impair sleep
quality. Furthermore, O’Hagan et al. (2016) points out that even though smartphones are
smaller than other devices, light intensity reaching the retina is greater because the device
is typically held closer to the eyes, and younger individuals are more sensitive to the
effects of exposure compared to older adults.

It seems counterintuitive that a smaller device would have greater light intensity
compared to larger devices, but an experimental study by Heo et al. (2017) demonstrated
nighttime smartphone use increased next day sleepiness and task errors. Using a sample
of young adults, this controlled, randomized, double-blind study investigated the effects
of light-emitting diode light on humans at night using smartphones, rather than
simulating the device using a lightbox. Although not statistically significant, reduction in
melatonin and cortisol levels and increased body temperature suggested a relationship to
the negative impact on sleep. Chang et al. (2015) showed that night use of light emitting
devices (e.g., e-readers) impairs next-morning alertness. These results demonstrate
avoiding the alerting light spectrum in smartphones in the hours before bedtime may
improve sleep quality and next day alertness.

Hypothesis

With so few experimental studies examining the effects of bedtime smartphone
use on well-being, this study implemented a restriction on smartphone use in the hours
before planned sleep (bedtime) in a U.S. young adult population. Participants, aged 18 to
30, were randomized to a control group and two experimental groups. The control group was instructed to use their smartphones as usual. One experimental group was asked to restrict smartphone use 1 hour prior to bedtime while the other experimental group was asked to restrict smartphone use for 3 hours prior to bedtime. This examination expected that participants who restricted smartphone use at least 1 hour prior to bedtime would experience increased subjective well-being, compared to the control group, as measured by improvements on self-report instruments of subjective happiness, quality of life, and smartphone addiction. In addition, this study expected to find improvements to sleep duration and quality and a reduction in screen time and SNS time due to the restriction.

Given the prevalence of smartphone use among young adults, the current study attempted to add to the literature on smartphone use and well-being. It aimed to find a greater understanding of the effects of smartphone use in the hours before bedtime on well-being. The results of this study may have practical implications for individuals seeking to improve well-being.
Chapter II.

Methods

This study design was a multi-level, parallel group, randomized intervention experiment conducted to compare subjective well-being outcomes of two levels of bedtime smartphone restriction to a control group. Participants were assessed at two time periods: baseline assessment and upon completing the seven-day experiment. Study flow is presented in Appendix A.

Participants

Participants were recruited over a 3-month period from May 15, 2021 to August 19, 2021 using two approaches: a convenience sample and invitations placed on social media platforms. The original research strategy focused on college students using volunteers from student chapters of a non-profit science organization known to the researcher. However, due to various delays, the study was released at the end of the school year for most students. Responses to invitations placed on the organization's social media pages were fewer than expected. Given the low initial response rate, the study eliminated "college student" as an inclusion criterion. A modification was submitted to the IRB, and it was approved May 24, 2021. A revised invitation was later placed on a variety of social media and academic research platforms to recruit a non-clinical sample of young adults (see Appendix B).
To be included in the study, respondents were required to be smartphone users residing in the U.S., fluent in English and at least 18 years old but no older than age 30, at the time of the study. Participation was excluded for respondents with a diagnosis of any sleep disorder or cardinal symptoms of a sleep disorder. In addition, respondents indicating overnight work, irregular sleep schedules, caring for a child under 2 years old, or having a current bed partner that may interrupt sleep were excluded.

The rationale for including the 30-year-old age group was to provide balance within the sample for generational influences. The population of interest spans two generations of birth cohorts with similar and different behavior characteristics. The generations are explained by Dimock (2019) as millennials (individuals born between 1981 and 1996) and Generation Z (individuals born after 1997). Using these dates, participants in our sample between the age of 18 to 24 were considered Generation Z at the time of the study. Adding one more age level by year to the sample provided the chance for participants over 25 (millennials) to be evenly distributed across the groups during randomization.

Measures and Materials

Several validated, reliable self-report measures were adapted for online use to capture happiness, subjective well-being, risk of smartphone addiction, and sleep factors. In addition, study related questions recorded demographics and smartphone use behaviors. Missing response data for scored instruments were adjusted by using the mean for that item.
Well-Being Measures

Well-being is defined as subjective happiness and life satisfaction (Diener, 1984). Informed by a study by Hughes and Burke (2018), the following instruments were used to assess well-being. In this prior study, these measures showed significant positive outcomes after this intervention study on bedroom smartphone use. Therefore, these measures were selected to advance the current study.

The Subjective Happiness Scale (SHS) is a 4-item self-report measure with a 7-point Likert scale response format to measure an individual's perceived happiness (Lyubomirsky & Lepper, 1999; see Appendix C). The first two questions ask respondents to identify a point on the scale they consider describes them as a happy person (1 = *not a very happy person;* 7 = *a very happy person*). The second item asks respondents to compare their rate of happiness to their peers (1 = *less happy;* 7 = *more happy*). The third and fourth items ask respondents to compare themselves to people who are generally happy, or not very happy, to the extent that these characterizations describe themselves (1 = *not at all;* 7 = *a great deal*). A single composite score is computed by averaging the responses to the four items after reverse coding the fourth item. Scores range from 1.0 to 7.0, with higher scores reflecting greater happiness. This brief questionnaire showed good to excellent internal consistency (Cronbach's $\alpha = 0.86$) in past studies (Lyubomirsky & Lepper, 1999).

The Quality of Life Scale (QOLS) is a 16-item self-report measure with a 7-point Likert scale response format to capture an individual's perceived satisfaction to life situations (Burckhardt et al., 1989; see Appendix D). The instrument covers a range of domains including physical well-being, relationships, self-improvement, and
independence. Respondents are asked to indicate their satisfaction across 16 items (1 = terrible; 7 = delighted). Scores are summed for a total score and ranging from 16.0 to 112 with higher scores indicating greater quality of life. The average score among healthy adults is approximately 90. Past studies reviewed by Burckhardt and Anderson (2003) show very high reliability (Cronbach's $\alpha = 0.90$).

The Smartphone Addiction Scale-Short Version (SAS-SV) examines problematic smartphone use through a 10-item self-report measure with a 6-point Likert scale response format (Kwon et al., 2013; see Appendix E). Questions were adapted for the present study by this researcher into first-person statements to improve clarity. For example, "Using my smartphone longer than I had intended" was changed to "I use my smartphone longer than intended" (1 = strongly disagree; 6 = strongly agree). Scores are totaled and range between 10.0 and 60.0. A higher total indicates an increased risk of smartphone addiction (or problematic device use). The diagnostic threshold indicating smartphone addiction risk differs between genders (male = 31; female = 33). The SAS-SV demonstrated high internal consistency (Cronbach’s $\alpha = 0.91$) in its initial validation study (Kwon et al., 2013). Similarly, an analysis by Harris et al. (2020) validated its use for a U.S. population of emerging adults (age 18 to 24).

Sleep Characteristics and Behaviors Measures

A combination of sleep measures and diaries were used to determine chronotype and self-reported sleep patterns at baseline and a sleep diary to record sleep behaviors during the study week.
Aiming for brevity, Munich Chrono Type Questionnaire-Ultra Short Version (µMCTQ) contains six questions from the standard MCTQ to calculate sleep variables including sleep duration on workdays and free days to calculate chronotype for early types or late types (Ghotbi et al., 2020; see Appendix F). Respondents indicate their usual sleep behavior on workdays and the time they normally go to sleep and wake up on free days. Scores are calculated using a formula to determine the midpoint of sleep on free days (Ghotbi et al., 2020).

The Consensus Sleep Diary (CSD) was adapted for online use and tracks daily sleep behavior during a 7-day period (Carney et al., 2012; see Appendix G). Participants record information in the morning about sleep and activity for the prior evening including what time they tried to go to sleep (lights out) and how long it took to get to sleep. Participants are also asked to rate sleep quality on a 5-point scale (1 = very poor; 5 = very good). An open-ended question allowed explanatory information about responses (e.g., "I have a cold"). Three study-related questions were added to the CSD. First, an ordinal question to ask participants about previous day physical activity level (1 = inactive; 2 = active; 3 = very active). Second, a question to indicate the time smartphones use ended for the night. Finally, participants were asked if the day was a workday (including school) or a free day.

Study Related Material

An online screening survey was created to automatically screen respondents for inclusion in the study using inclusion and exclusion criteria (see Appendix H). Similarly, an online self-report questionnaire was created to collect information about participant demographics including age, level of education, and race/ethnicity. Finally, an online
self-report questionnaire was created to collect information about the previous 7 days of smartphone use, including time spent using social media. Participants reported the amount of total screen time, social media time, and favorite social media sites (see Appendix I).

Study Protocol and Procedures

Participants responded to an anonymized hyperlink embedded in an invitation posted on social media leading to a short online screening survey through the Qualtrics platform (Provo, Utah: Qualtrics). This hyperlink contained a query code to record which source was used to link to the survey (e.g., Facebook). IP addresses were not collected. Participants read an electronic version of informed consent to decide whether to proceed, or not, to the screening questions. Those consenting to participate responded by recording an electronic signature. A link to download a copy of the form was provided. To keep responses anonymous, a unique numerical identifier was automatically assigned to each participant to link distribution of the daily diary surveys and the post-experiment surveys. Consenting participants answered a screening survey containing questions concerning inclusion and exclusion criteria.

If any of the inclusion or exclusion criteria were not met, the survey automatically ended sending the participant to a message screen. Excluded participants were informed they did not meet the criteria for participation, and the data from their screening survey would be destroyed.

If, and only if, the participant met the requirements to participate in the study, they were automatically re-directed to a separate survey to enter their email address to
receive an anonymized study link to the study. E-mail addresses were stored separately from the study data to protect participant anonymity.

Consenting participants received an e-mail containing the anonymized link to enroll in the study. Upon entering the study, the survey software randomly assigned participants to one of three groups: a control (CTL) group and two experiment groups (1-HR) and (3-HR). Participants then branched by group to a screen describing their study condition.

CTLs were asked to keep a one-week online diary tracking their activities during the study week including smartphone usage, sleep, and physical activity. Each day’s diary took two to three minutes to complete. CTLs were instructed to use smartphones as usual. They were informed they would receive an e-mail link each day and were encouraged to fill them out within an hour of waking. They were reminded that they will be invited to return to complete a follow-up survey in one week. The final question asked if they wished to continue. Participants who opted-out were directed to an end of survey page thanking them for their participation.

Participants in the 1-HR group received the same diary instruction as the CTL group. They received additional instruction to restrict smartphone and electronic device use one hour prior to planned bedtime. Urgent calls or texts would be permitted. The restriction would last 1 week, and they would be invited to participate in a follow-up survey at the end of the week. The final question asked if they wished to continue. Participants who opted-out were directed to an end of survey page thanking them for their participation.
Participants in the 3-HR group received the same diary instruction as the CTL and 1-HR groups. They were directed to restrict smartphone and electronic device use three hours prior to planned bedtime for 1 week. They were invited to complete a follow-up survey at the end of the week. The final question asked if they wished to continue. Participants who chose to opt-out were directed to an end of survey page thanking them for their participation.

All groups were asked to report typical smartphone use for the previous week and given instructions on how to use the Screen Time feature for iPhone or the Digital Well-Being feature for Android phones to help with their responses. All groups answered the same baseline survey measures, presented in random block order after demographic questions and smartphone use information was entered. The survey instruments included: (a) Subjective Happiness Scale, (b) Quality of Life Scale, (c) Smartphone Addiction Scale, and (d) Ultra-Short Munich Chronotype Questionnaire.

A daily e-mail link to the diary survey was sent each night to the participants. The surveys were scheduled to be distributed at 5 a.m. according to the time zone in which each participant resided.

Upon completion of the study week, participants received an email with the link to the follow-up survey containing the same measures as the baseline survey, except that the demographic questions and the chronotype questionnaire were eliminated. This survey typically took less than ten minutes to complete. Intervention group participants were asked two questions to help the researcher understand the results. Participants in the experiment groups were asked to rate their level of difficulty adhering to the study restrictions on a 5-point scale (1 = very difficult; 5 = not difficult) and how likely they
were to continue the restrictions on their own (yes, no, maybe). At the end of the follow-up survey, participants viewed a debriefing message explaining the scope of the study and were thanked for their participation (see Appendix J). Once all data were collected, email lists were destroyed.

This study and all its materials were reviewed and approved by the Harvard University-Area Committee on Use of Human Subjects (IRB).
Statistical Analyses

Primary outcome measures included subjective well-being assessed using SHS, QOLS, and SAS-SV well-being measures. Secondary analyses of outcome measures of sleep duration and efficiency were collected using the modified Consensus Sleep Diary. Smartphone and social media use were self-reported with the suggested aid of Apple's Screen Time or Android's Well-Being application.

Analyses of variance (ANOVA) and t-tests were used to evaluate results using IBM SPSS Statistics (Version 27.0. Armonk, NY: IBM Corp.). Prior to hypothesis testing, assumptions for the main outcome variables were evaluated for normality, linearity, multicollinearity, and homoscedasticity according to methods described in Field (2013). Outliers were identified through visual inspection of box plots and analyzed for accuracy. If an outlying response was found to be accurate but within ± 3 SD from the mean, it remained in the model. Assumptions were determined to be satisfied if the variable distribution among the three groups associated with skew and kurtosis were less than |0.8| and |3|, respectively. The Shapiro-Wilk test was pre-selected to interpret normality between groups because the sample size was less than 50. The Shapiro-Wilk tests showed that no distribution of scores significantly differed from normality across participants. Furthermore, the assumption of homogeneity of variance was tested based on Levene's F test (p > .05). Where the assumption of homogeneity of variance was violated, the ANOVA reports the alternative Welch's F value. To test the hypothesis for the primary analyses, a one-way ANOVA measured the mean difference of the change in score from pre- to post-experiment between the control and experimental (restriction) groups of the self-report measures (SHS, QOLS, and SAS-SV).
Because self-report outcome scores might have been influenced by the baseline scores, groups were also compared after adjusting for each baseline score using separate analyses of covariance (ANCOVA). Similarly, because the self-report outcome scores might have been influenced by factors other than the direct effects of the intervention, groups were compared after adjusting each outcome variable for specific covariates (Table 1) in separate ANCOVAs. Covariates were post-hoc estimates of factors potentially affecting post-experiment scores and included demographic (e.g., age), trait (e.g., chronotype), estimated subjective sleep characteristics at baseline, and screen time and social media behavior at baseline. No further analysis was conducted if any Group x Covariate interaction was significant. ANCOVAs in which the Group x Covariate interaction was not significant were repeated excluding the interaction term. One-way ANOVA with planned comparisons (or post-hoc tests using Fisher's Protected LSD) were used to specify main and interaction effects between groups due to the experiment. Then, paired sample t-tests compared pre- and post-experiment test scores within each group. The level of significance was set to a p-value of < .05. Results are presented in the next chapter.
Table 1

**Covariates Considered to Adjust Group Comparisons of Measures Outcomes**

<table>
<thead>
<tr>
<th>Estimated factor</th>
<th>Covariate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>Exact age within the 18 to 30 year range</td>
</tr>
<tr>
<td>Average sleep duration</td>
<td>Baseline weekly average computed from sleep questionnaire</td>
</tr>
<tr>
<td>Chronotype</td>
<td>Score computed from sleep questionnaire</td>
</tr>
<tr>
<td>Baseline social media</td>
<td>Self-reported total time (in minutes) of social media use</td>
</tr>
<tr>
<td>Baseline SHS</td>
<td>Score computed from the Subjective Happiness Scale</td>
</tr>
<tr>
<td>Baseline QOLS</td>
<td>Score computed from the Quality of Life Scale</td>
</tr>
<tr>
<td>Baseline SAS-SV</td>
<td>Score computed from the Smartphone Addiction Scale</td>
</tr>
</tbody>
</table>

Data Screening

A total of 233 participants responded to the screening survey. One hundred sixty-eight participants either opted-out or were screened out resulting in 65 participants enrolling in the study. Fifty-four participants completed the baseline measures and 42 completed the study and follow-up survey. One response was removed for answering the measures with the same repeated answer. Three responses were flagged as duplicates and removed. Three were removed for incomplete surveys, specifically the post experiment survey was not complete after the study week, and too much data was missing to be informative. Finally, one record was removed after indicating working a nightshift job in the daily diary comments. One result was missing data for two items in the QOLS and was treated by entering the mean for the item. A total of 33 participants were included in the final analysis.
Chapter III.

Results

The purpose of this study was to examine the effects of bedtime smartphone restriction on subjective well-being. The primary hypothesis of this study expected that participants in the restriction groups would differ from participants in the control group who were not instructed to restrict bedtime smartphone use. Further, it was expected that participants in the restriction groups would achieve greater improvements to change scores compared with the control group for SHS, QOLS, and SAS-SV. In two out the three measures, the hypotheses held. Secondary analyses included examining the differences in smartphone use and sleep outcomes. As expected, participants in the restriction groups reduced average daily screen time. Contrary to the study hypothesis, no differences between groups were found in average time using SNS, or sleep duration and efficiency. Finally, an exploratory analysis examined associations between the primary and secondary analysis results. After pooling the restriction groups and including only those participants reaching a daily minimum average of 1 hour bedtime smartphone restriction, mean group differences compared with the control group were found for SHS, QOLS, sleep onset latency, total screen time, sleep efficiency and sleep quality. No group differences were found for SAS-SV, SNS, or sleep duration.
Primary Analysis

A total of 33 participants were included in the final sample. Descriptive statistics associated with the primary analysis of well-being measures for the groups at baseline are shown in Table 2. The groups showed proportional distribution between groups, and no significant differences were detected. Most participants were female (78.8%) and White (57.6%). The overall mean age was 25.5 years old ($SD = 3.47$) with birth cohorts almost evenly represented between groups. Eighteen participants (54.5%) were between age 25 to 30 and considered millennials, and fifteen (45.5%) represented Generation Z between age 18 to 24. No significant differences were found between groups for baseline continuous outcome variables (see Table 3). No group differences were found when ANCOVA was used to control for potential confounding factors (see Appendix K).
### Table 2

**Demographics Characteristics for Primary Analysis at Baseline**

<table>
<thead>
<tr>
<th>Baseline characteristic</th>
<th>1-HR</th>
<th>3-HR</th>
<th>CTL</th>
<th>Full sample</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
<td>n</td>
<td>%</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>8</td>
<td>73</td>
<td>9</td>
<td>82</td>
</tr>
<tr>
<td>Male</td>
<td>3</td>
<td>27</td>
<td>2</td>
<td>18</td>
</tr>
<tr>
<td><strong>Age group</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age 18 to 24</td>
<td>5</td>
<td>45</td>
<td>6</td>
<td>55</td>
</tr>
<tr>
<td>Age 25 to 30</td>
<td>6</td>
<td>55</td>
<td>5</td>
<td>45</td>
</tr>
<tr>
<td><strong>Education</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High school/some college/</td>
<td>5</td>
<td>45</td>
<td>6</td>
<td>55</td>
</tr>
<tr>
<td>associate or trade school</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>University or graduate degree</td>
<td>6</td>
<td>55</td>
<td>5</td>
<td>45</td>
</tr>
<tr>
<td><strong>Race/Ethnicity</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>10</td>
<td>91</td>
<td>3</td>
<td>27</td>
</tr>
<tr>
<td>Black, mixed race, or other</td>
<td>1</td>
<td>9</td>
<td>8</td>
<td>27</td>
</tr>
</tbody>
</table>

*Note.* $N = 33$ ($n = 11$ for each condition). Participants were on average 25.5 years old ($SD = 3.5$), and participant age did not vary by condition. 1-HR = 1 hour restriction; 3-HR = 3 hour restriction; CTL = control.
Table 3

Means, Standard Deviations and ANOVA for Well-Being Measures of Continuous Variables at Baseline

<table>
<thead>
<tr>
<th>Measures</th>
<th>1-HR</th>
<th>3-HR</th>
<th>CTL</th>
<th>ANOVA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$M$</td>
<td>$SD$</td>
<td>$M$</td>
<td>$SD$</td>
</tr>
<tr>
<td>SHS</td>
<td>4.5</td>
<td>0.6</td>
<td>5.1</td>
<td>0.8</td>
</tr>
<tr>
<td>QOLS</td>
<td>82.0</td>
<td>9.3</td>
<td>82.6</td>
<td>12.3</td>
</tr>
<tr>
<td>SAS-SV</td>
<td>29.4</td>
<td>8.0</td>
<td>29.7</td>
<td>11.3</td>
</tr>
</tbody>
</table>

Note. $N = 33$ ($n = 11$ per condition). 1-HR = 1 hour restriction; 3-HR = 3-hour restriction; CTL = control; SHS = Subjective Happiness Scale; QOLS = Quality of Life Scale; SAS-SV = Smartphone Addiction Scale-Short Version.
Primary Analyses of Well-Being Outcomes

A one-way ANOVA was conducted to investigate the effect of bedtime smartphone restriction on participant subjective happiness, perceived quality of life, and smartphone addiction risk (see Table 4). Post-experiment outcome variables are reported as change scores calculated as the mean difference between post- minus pre-experiment scores. Mean change scores for SHS, QOLS, and SAS-SV were examined for differences by group (CTL, 1-HR, 3-HR). Positive scores indicate improvement in subjective happiness and perceived quality of life for SHS and QOLS. Negative scores indicate a decrease in the risk of smartphone addiction for SAS-SV. For ANOVAs, effect sizes are reported for the experimental effect and linear trend as Omega (ω). Planned contrasts effect sizes are reported as (r). Field (2013) advises reporting effect sizes in this way gives the most unbiased results with large or small effects similar to Cohen's d: 0.2 = small, 0.5 = medium, and 0.8 = large effects.

Subjective Happiness Change Score Outcome

Subjective happiness differed between the groups as there was a statistically significant effect of bedtime smartphone restriction on SHS change scores, $F(2,30) = 3.75, p = .035, \omega = 0.37$ (see Figure 1). The linear trend was not significant, $F(1,30) = 2.83, p = .103, \omega = 0.43$ indicating that as restriction time increased, SHS change scores did not increase proportionately. Planned contrasts revealed that both restriction times significantly increased SHS compared to no restriction time, $t(30) = 2.57, p = .017, r = .42$, but a 3-HR restriction did not significantly increase SHS compared to a 1-HR restriction, $t(30) = -1.03, p = .312, r = .17$. 
Quality of Life Change Score Outcome

Quality of life differed between the groups as there was a statistically significant effect of bedtime smartphone restriction on QOLS change scores, $F(2,30) = 4.61, p = .010, \omega = 0.47$ (see Figure 2). The linear trend was significant, $F(1,30) = 7.62, p = .010, \omega = 0.41$ indicating that as the restriction time increased, QOLS change scores increased proportionately. Planned contrasts revealed that both restriction times significantly increased QOLS compared to no restriction time, $t(30) = 3.03, p = .005, r = .48$, but a 3-HR restriction did not significantly increase QOLS compared to a 1-HR restriction, $t(30) = 0.28, p = .780, r = .001$.

Smartphone Addiction Change Score Outcome

Prior to hypothesis testing, one outlying factor above the $± 3\,SD$ from the mean was removed from the SAS-SV data set. Smartphone addiction risk did not differ significantly between the groups as there was no statistically significant effect of bedtime smartphone restriction on SAS-SV change scores, $F(2,29) = .089, p = .915, \omega = .24$. (see Figure 3). While all groups improved SAS-SV by decreasing scores, there were no statistically significant linear trends. No other statistically significant group comparison differences were found.
Table 4

Means, Standard Deviations, and One-Way ANOVA for Well-Being Continuous Outcome Variables after Bedtime Smartphone Restriction

<table>
<thead>
<tr>
<th>Measures</th>
<th>1-HR</th>
<th>3-HR</th>
<th>CTL</th>
<th>ANOVA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>SHS(^a)</td>
<td>0.7</td>
<td>0.7</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>QOLS(^a)</td>
<td>3.2</td>
<td>6.6</td>
<td>4.0</td>
<td>6.7</td>
</tr>
<tr>
<td>SAS-SV(^b)</td>
<td>-1.1</td>
<td>2.2</td>
<td>-0.6</td>
<td>4.8</td>
</tr>
</tbody>
</table>

Note. Totals represent the mean difference in score pre- and post-experiment. 1-HR = 1 hour restriction; 3-HR = 3 hour restriction; CTL = control; SHS = Subjective Happiness Scale; QOLS = Quality of Life Scale; SAS-SV = Smartphone Addiction Scale-Short Version

\(^a\)\(N = 33\) (\(n = 11\) per condition). \(^b\)\(N = 32\) (\(n = 10\) for 3-Hr).
Figure 1

Comparison Between Groups for Subjective Happiness Scores

Note. N = 33 (n = 11 per condition). Subjective happiness scores are shown as the difference post- minus pre-experiment by group. 1-HR = 1 hour restriction; 3-HR = 3 hour restriction; CTL = control. Error bars are standard errors.
**Figure 2**

*Comparison Between Groups for Quality of Life Scores*

![Bar chart showing comparison between groups for quality of life scores.](image)

*Note:* $N = 33$ ($n = 11$ per condition). Quality of life scores are shown as the change difference post- minus pre-experiment by group. 1-HR = 1 hour restriction; 3-HR = 3 hour restriction; CTL = control. Error bars are standard errors.
Figure 3

Comparison Between Groups for Smartphone Addiction Scores

Note: \( N = 32 \) (\( n = 11 \) per CTL and 1-HR condition; 10 per 3-HR condition). Smartphone addiction scores are shown as the change difference post- minus pre-experiment by group. 1-HR = 1 hour restriction; 3-HR = 3 hour restriction; CTL = control. Error bars are standard errors.

Within Group Differences Pre- to Post-Experiment

A paired sample \( t \)-test was conducted to compare the significance of the scores pre- and post-experiment on well-being within groups (see Figures 4–6). On average, participants in the 1-HR group (\( M = 0.7 \pm 0.7 \)) experienced a statistically significant increase in SHS scores pre- to post-experiment, \( t(10) = 3.62, p = .005, d = 1.09 \). Participants in the 3-HR group (\( M = 0.5 \pm 0.5 \)) experienced similar results with a
statistically significant increase in SHS scores pre- to post-experiment, \(t(10) = 2.92, p = .015, d = 0.88\). These results suggest that restricting bedtime smartphone use had a large effect on subjective happiness.

No significant change in the QOLS scores was found for the 3-HR group (\(M = 4.0 \pm 6.7\)). These results suggest bedtime smartphone use had a trending effect on quality of life, \(t(10) = 1.97, p = .077, d = 0.59\) even though QOLS score changes were not significant for participants in the 1-HR group, \(t(10) = 1.61, p = .139, d = 0.48\). No significant within group mean differences were found for SAS-SV. However, improvements across time were found in the predicted direction.
Figure 4

*Within Groups Differences After Bedtime Smartphone Restriction*

*Note.* $N = 33$ ($n = 11$ per condition). Subjective Happiness Scale scores at pre- and post-restriction for all groups. 1-HR = 1 hour restriction; 3-HR = 3 hour restriction; CTL = control. Error bars show standard errors.
Figure 5

*Within Groups Differences After Bedtime Smartphone Restriction*

Note. *N* = 33 (n = 11 per condition). Quality of Life Scale scores at pre- and post-restriction for all groups. 1-HR = 1 hour restriction; 3-HR = 3 hour restriction; CTL = control. Error bars show standard errors.
Figure 6

Within Groups Differences After Bedtime Smartphone Restriction

Note. N = 32 (n = 11 per CTL and 1-HR condition; 10 per 3-HR condition). Smartphone Addiction Scale-Short Version scores at pre- and post-restriction for all groups. 1-HR = 1 hour restriction; 3-HR = 3 hour restriction; CTL = control. Error bars show standard errors.
Participant Reactions to the Restriction Conditions

Participants in the restriction groups were asked two questions on the post-experiment survey to assess the difficulty of the experimental condition. First, they were asked to rate how difficult they found adhering to the study’s smartphone restriction by rating 1 for very difficult to 5 for not difficult. Of the 22 participants, two found the restrictions very difficult and six found it not difficult at all or somewhat difficult. Next, participants were asked if they would consider continuing the study restrictions in the future. Of the 21 participants who responded, 13 indicated they would continue with the smartphone restriction and 6 indicated "maybe." The two "no" responses came from participants in the 3-HR group.

Secondary Analyses

Secondary analyses of screen time, SNS and sleep behaviors were conducted using ANOVA and t-tests. Baseline descriptive characteristics and continuous variables did not significantly differ between groups (see Tables 5–6).

Participant Smartphone Behaviors and Sleep Characteristics at Baseline

At the beginning of the study week, more than half of the participants reported using social media 2 or more hours per day (51.5%) and averaged about 4 1/2 hours of screen time per day. A slight majority were considered at risk for smartphone addiction according to SAS-SV baseline scores (54.5%). TikTok was reported as the most preferred social media site (n =13), followed by Instagram (n = 12). Four participants preferred Twitter, while three participants listed Facebook as their favorite SNS. One participant listed WeChat as their favorite.
Regarding sleep behaviors, the mean average of all participants reported 7 hours and 39 minutes of sleep per night, prior to the study week. Approximately one-third (34%) averaged 8 or more hours per night prior to the study week. Most participants reported being employed and/or attending school at least five days per week (66.7%), and over one-quarter (27.2%) worked and/or attended school one to four days per week. Two participants reported not working or going to school.
Table 5
Descriptive Characteristics for Screen Time and Sleep at Baseline

<table>
<thead>
<tr>
<th>Baseline characteristic</th>
<th>1-HR</th>
<th>3-HR</th>
<th>CTL</th>
<th>Full sample</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
<td>n</td>
<td>%</td>
</tr>
<tr>
<td>ST &gt; 5 hrs per day</td>
<td>3</td>
<td>27</td>
<td>1</td>
<td>9</td>
</tr>
<tr>
<td>SNS &gt; 2 hrs per day</td>
<td>8</td>
<td>73</td>
<td>5</td>
<td>45</td>
</tr>
<tr>
<td>SAS-SV risk a</td>
<td>5</td>
<td>45</td>
<td>6</td>
<td>55</td>
</tr>
<tr>
<td>Sleep Duration &lt; 8 b</td>
<td>8</td>
<td>73</td>
<td>5</td>
<td>45</td>
</tr>
<tr>
<td>Work/school</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5+ days per wk</td>
<td>7</td>
<td>64</td>
<td>8</td>
<td>73</td>
</tr>
<tr>
<td>4 or less days per wk</td>
<td>4</td>
<td>36</td>
<td>3</td>
<td>27</td>
</tr>
</tbody>
</table>

Note. N = 33 (n = 11 for each condition). Participants were on average 25.5 years old (SD = 3.47), and participant age did not vary by condition. 1-HR = 1 hour restriction; 3-HR = 3 hour restriction; CTL = control; TST = total screen time; SNS = social networking sites; SAS-SV = smartphone addiction scale-short version.

a Participants were categorized as at-risk for smartphone addiction based on cut-off scores by gender (Female ≥ 31; Male ≥ 33; Kwon et al., 2013). b Sleep duration was calculated from the Ultra-Short Munich Chronotype Questionnaire and reflects typical sleep and wake times prior to the study week.
## Table 6

*Means, Standard Deviations, and ANOVA of Smartphone and Sleep Continuous Variables at Baseline*

<table>
<thead>
<tr>
<th>Measures</th>
<th>1-HR</th>
<th></th>
<th>3-HR</th>
<th></th>
<th>CTL</th>
<th></th>
<th>ANOVA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><em>M</em></td>
<td><em>SD</em></td>
<td><em>M</em></td>
<td><em>SD</em></td>
<td><em>M</em></td>
<td><em>SD</em></td>
<td><em>F</em>(2,30)</td>
</tr>
<tr>
<td>ST <em>a</em></td>
<td>3.80</td>
<td>1.48</td>
<td>2.99</td>
<td>1.57</td>
<td>4.06</td>
<td>1.41</td>
<td>1.56</td>
</tr>
<tr>
<td>SNS <em>a</em></td>
<td>2.23</td>
<td>0.98</td>
<td>2.12</td>
<td>1.67</td>
<td>2.08</td>
<td>0.92</td>
<td>.044</td>
</tr>
<tr>
<td>SD <em>b</em></td>
<td>7.71</td>
<td>0.54</td>
<td>8.03</td>
<td>0.93</td>
<td>7.26</td>
<td>0.73</td>
<td>2.88</td>
</tr>
</tbody>
</table>

*Note. N = 33 (n = 11 per condition). 1-HR = 1 hour restriction group; 3-HR = 3 hour restriction group; CTL = control; SNS = social network sites, TST = total screen time; SNS = social network sites; SD = sleep duration.*

*a* Reported as the average daily mean for the 7 days prior to the study week. *b* Derived from the Ultra-Short Munich Chronotype Questionnaire.
Smartphone Use Behavior Outcomes

Upon completion of the study week, post-experiment survey responses were analyzed for differences between groups for smartphone use behaviors and are reported in Table 7. A one-way ANOVA was conducted to compare the effect of smartphone restriction on mean daily screen time, SNS time, and the time between ending device use and lights out (time participants began trying to go to sleep) between groups for the previous 7 days of the study week.

Screen time differed significantly between the three groups, $F(2,30) = 5.79$, $p = .007, \omega = .47$. Participants in the CTL group had the highest average daily screen time ($M = 4.69 \pm 1.08$) followed by the 1-HR group ($M = 3.93 \pm 1.52$) and the 3-HR group ($M = 2.76 \pm 1.36$). Post hoc comparisons indicated that screen time in the CTL group differed significantly from screen time in the 3-HR group ($p = .004$) but not compared to the 1-HR group. No significant differences were found between the 1-HR and 3-HR groups. Average SNS time did not differ significantly between groups. Absolute SNS time was highest for the CTL group ($M = 2.35 \pm 0.92$) followed by the 3-HR group ($M = 1.93 \pm 1.29$) and the 1-HR group ($M = 1.90 \pm 1.02$), in that order.

The average elapsed time (in minutes) between participants ending device use and lights out differed significantly between groups, $F(2,30) = 5.79$, $p = .007, \omega = 0.59$. Because homogeneity of variances was violated (Levene's $p = .016$), the Welch test was conducted. The results from the Welch's test also indicated a significant difference among the groups, Welch's $F(2, 15.39) = 16.64$, $p < .001$. The 3-HR group averaged almost 82 minutes between the end of device use and lights out ($M = 81.64 \pm 46.27$). The 1-HR
group averaged almost 77 minutes ($M = 76.91 \pm 44.29$), and the CTL group averaged more than 17 minutes ($M = 17.55 \pm 13.46$). The Games-Howell post hoc test indicated that the average time in the 1-HR group differed significantly from the average time in the CTL group, $p = .003$ as well as the difference between 3-HR and CTL groups, $p = .002$. The mean difference between the 1-HR and 3-HR group was not statistically significant, $p = .968$.

Considering this finding and that participants in the 3-HR restriction achieved less than 50% of the bedtime smartphone restriction time requirement of 3 hours, the 3-HR and 1-HR groups were pooled for the remainder of the secondary analysis to create a restriction group (RST).
Table 7

Means, Standard Deviations, and One-Way ANOVA for Smartphone Use Continuous Variable Outcomes

<table>
<thead>
<tr>
<th>Variables</th>
<th>1-HR</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>ANOVA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>ST</td>
<td>3.93</td>
<td>1.53</td>
<td>2.76</td>
<td>1.36</td>
<td>4.69</td>
<td>1.08</td>
</tr>
<tr>
<td>SNS</td>
<td>1.90</td>
<td>1.02</td>
<td>1.93</td>
<td>1.29</td>
<td>2.35</td>
<td>0.92</td>
</tr>
<tr>
<td>DELO a</td>
<td>76.91</td>
<td>44.29</td>
<td>81.64</td>
<td>46.27</td>
<td>17.55</td>
<td>13.46</td>
</tr>
</tbody>
</table>

Note. N = 33 (n = 11 per condition). Reported as mean daily hours unless noted. 1-HR = 1 hour restriction; 3-HR = 3 hour restriction; CTL = control; ST = screen time; SNS = social network sites; DELO = device end use before lights out.

*a Average daily minutes. Welch statistic reported with 95% CI [2, 15.39].

* p = .007

** p < .001
Secondary Analyses After Pooling Restriction Groups

The remaining secondary analyses will focus on sleep outcomes after pooling the restriction groups (RST compared to CTL). Sleep duration average was reported at the beginning of the study week retrospectively and could not be compared to sleep duration as reported in the diary studies. The baseline sleep duration did not consider sleep onset latency time and wakening after sleep onset as did the sleep diaries. Therefore, rendering any pre- to post-experiment analysis would be inaccurate.

An independent t-test was conducted to compare significant differences between the groups post-experiment for sleep outcomes. Results presented in Table 8 show no statistically significant differences between groups for sleep outcomes. Even after pooling the groups, sleep duration times (as reported in the sleep diaries during the study week) were approximately the same between RST and CTL. It is important to note that, while not significant, mean differences in sleep variables showed a positive trend between groups.
Table 8

*Means, Standard Deviations, and T-test for Sleep Continuous Variable Outcomes Using Pooled Groups*

<table>
<thead>
<tr>
<th>Variables</th>
<th>RST (n = 22)</th>
<th>CTL (n = 11)</th>
<th>t(31)</th>
<th>p</th>
<th>d</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
<td></td>
</tr>
<tr>
<td>Sleep duration (^a)</td>
<td>7.23</td>
<td>1.04</td>
<td>7.23</td>
<td>1.07</td>
<td>-0.026</td>
</tr>
<tr>
<td>Device use in bed (^a)</td>
<td>9.50</td>
<td>20.55</td>
<td>11.82</td>
<td>11.22</td>
<td>0.419</td>
</tr>
<tr>
<td>Sleep onset latency (^a)</td>
<td>18.05</td>
<td>12.00</td>
<td>19.45</td>
<td>12.46</td>
<td>0.272</td>
</tr>
<tr>
<td>Sleep efficiency (^b)</td>
<td>94.52</td>
<td>4.75</td>
<td>93.83</td>
<td>3.82</td>
<td>-0.420</td>
</tr>
<tr>
<td>Sleep quality (^c)</td>
<td>3.57</td>
<td>0.63</td>
<td>3.30</td>
<td>0.51</td>
<td>-1.176</td>
</tr>
</tbody>
</table>

*Note.* RST = restriction group; CTL = control group. \(^a\) Measured in minutes. \(^b\) Measured in percentage. \(^c\) Sleep quality is mean score from self-report 5-point scale (1 = poor, 5 = excellent).
Comparisons of Pooled Restriction Group Participants Reporting 1 Hour Minimum Compliance to CTL Group

An exploratory examination of the sleep diaries was conducted to determine how many participants complied with the smartphone restrictions during the study week. This level of analysis was not done in the primary analysis because diaries were not included in the Hughes and Burke (2018) study, upon which, this study attempted to replicate and advance. Therefore, participants from the RST group who did not meet or exceed 1 hour of bedtime smartphone restriction were excluded from this analysis. Nine participants were removed from the restriction group leaving 12 compliant participants (RSTc) and 11 participants (CTL) for a total of 23 participants for analysis.

An independent-samples t-test was conducted to determine differences in smartphone use and sleep behaviors between the RSTc and CTL groups. Equal variances were not assumed when violations to homogeneity were indicated by Levene's test and are reported accordingly. On average, participants spent more hours per day using their smartphones in the CTL group ($M = 4.69 \pm 1.08$) than participants in the RSTc group ($M = 3.35 \pm 1.62$), a statistically significant mean difference of 1.34 hours, $t(21) = 2.31$, $p = .031$, $d = 0.96$. Although not significant, participants in the CTL group averaged 2 hours and 21 minutes using SNS per day which was 24 minutes longer per day than the RSTc group. The average time between the end of device use and lights out differed significantly by group, $t(14.29) = -6.92$, $p < .001$, $d = 2.79$. Participants in the RSTc group ($M = 94.25 \pm 35.74$) ended device use before lights out earlier than the CTL group ($M = 17.55 \pm 13.46$). In other words, the RSTc group averaged 5 times longer not using devices before attempting sleep than did the CTL group. Similarly, average time of
smartphone use in bed was significantly higher for the CTL group \((M = 11.82 \pm 11.22)\) than the RSTc group \((M = 1.83 \pm 3.38)\), \(M = 9.99, t(11.66) = 2.84, p = .015, d = 1.22\). The CTL group spent nearly 10 minutes longer using their phones in bed before putting them away for the night compared to the RSTc group.

There were, in addition, differences between groups regarding sleep characteristics. Sleep onset latency was shorter in average minutes for the RSTc group \((M = 11.00, \pm 4.07)\) than the CTL group \((M = 19.45 \pm 12.46)\), a statistically significant difference, \(M = 8.46, t(11.95) = 2.15, p = .037, d = 0.93\). No significant differences were found in sleep duration between the groups. With that said, there were significant differences between groups regarding sleep efficiency and self-rated sleep satisfaction. Higher sleep efficiency was found in the RSTc group \((M = 96.68 \pm 1.76)\) than the CTL group \((M = 93.83 \pm 3.82)\), a statistically significant difference, \(M = -2.85, t(21) = -2.33, p = .040, d = 0.97\). A similar difference was found for self-rated sleep quality. Higher self-ratings of sleep quality were reported by the RSTc group \((M = 3.78 \pm 0.29)\) than CTL \((M = 3.30 \pm 0.51)\), a statistically significant difference, \(M = -0.47, t(21) = -2.76, p = .016, d = 1.15\).
Table 9

Means, Standard Deviations, and Independent T-test for Smartphone Use and Sleep

Outcomes Comparing CTL with Pooled RSTc with 1 or more Restriction Hours

<table>
<thead>
<tr>
<th>Variables</th>
<th>RSTc (n = 12)</th>
<th>CTL (n = 11)</th>
<th>t(21)</th>
<th>p</th>
<th>d</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
<td></td>
</tr>
<tr>
<td>ST a</td>
<td>3.35</td>
<td>1.62</td>
<td>4.69</td>
<td>1.08</td>
<td>2.31</td>
</tr>
<tr>
<td>SNS a</td>
<td>1.96</td>
<td>1.19</td>
<td>2.35</td>
<td>0.92</td>
<td>0.89</td>
</tr>
<tr>
<td>DUIB</td>
<td>1.83</td>
<td>3.38</td>
<td>11.82</td>
<td>11.22</td>
<td>2.84</td>
</tr>
<tr>
<td>DE-LO</td>
<td>94.25</td>
<td>35.74</td>
<td>17.55</td>
<td>13.46</td>
<td>-6.92</td>
</tr>
<tr>
<td>SOL</td>
<td>11.00</td>
<td>4.07</td>
<td>19.45</td>
<td>12.46</td>
<td>2.15</td>
</tr>
<tr>
<td>SD a</td>
<td>7.46</td>
<td>0.70</td>
<td>7.23</td>
<td>1.07</td>
<td>-0.64</td>
</tr>
<tr>
<td>SE b</td>
<td>96.68</td>
<td>1.76</td>
<td>93.83</td>
<td>3.82</td>
<td>-2.26</td>
</tr>
<tr>
<td>SQ c</td>
<td>3.78</td>
<td>0.29</td>
<td>3.30</td>
<td>0.51</td>
<td>-2.76</td>
</tr>
</tbody>
</table>

Note. Mean time is reported in daily minutes unless otherwise noted. RST = restriction group with mean daily minutes of DELO ≥ 60; ST = screen time; CTL = CTL group; SNS = social network sites; DUIB = device use in bed; DELO = device use end before lights out, SOL = sleep onset latency; SD = sleep duration; SE = sleep efficiency; SQ = sleep quality.

a Reported in average daily hours. b Total mean score calculated from daily diary entries in percentage. c Total mean score calculated from the daily diary entries. Participants self-rated sleep quality on a 5-point scale (1 = poor, 5 = excellent).
Chapter IV.

Discussion

This study contributes to the well-being and smartphone behavior literature by examining the effects of smartphone restriction before bedtime on well-being for young U.S. adults. The primary analyses of this examination showed that restricting bedtime smartphone use improved subjective happiness and perceived quality of life but did not reduce smartphone addiction risk. Additionally, while screen time decreased, SNS time remained steady, even among those in the restriction groups not using smartphones at night. Exploratory analyses comparing the CTL group with pooled participants with at least 1 hour of smartphone restriction showed significant improvements to sleep quality but not sleep duration. This result suggests the total time spent using SNS is not as influential as good sleep quality on individual well-being.

Activities associated with smartphone use like engaging in social media, messaging, playing games, consuming news, and e-mailing are easier to access due to the portability of smartphones with continuous internet access (Derks & Bakker, 2014). Thus, screen time has increased over the years for most young adults as well as the prevalence of bedtime use. Studies linking excessive smartphone use (Cabré-Riera, 2019; Demir & Sumer, 2019) or time spent using social media (Berryman et al., 2018; Kross et al., 2013) to negative well-being outcomes demonstrate the need to understand how to reduce the risk to well-being from smartphone use behavior. Few studies focus on the effects of time of day spent using smartphones for adults. The findings from this study
add to the Hughes and Burke (2018) study about restricting bedroom use of smartphones. In their study, qualitative results suggested the improvement in well-being outcome measures were associated with improved sleep. The present study provides evidence for the benefits to sleep of reducing smartphone use before bedtime.

Overall, the primary study results showed participants in both the restriction and control groups improved in subjective happiness across the 1-week experimental period with the 1-HR groups showing significant improvement. Additionally, absolute values of smartphone addiction risk declined for all participants, although no statistical significance was found between or within groups. Improvements seen in the control group could be a function of participation bias since the daily diary focused on smartphone use by asking participants to record when they ended device use at night. This may have led to greater awareness of time spent on smartphones during the study. With that said, primary results from the QOLS showed a significant improvement in scores for both restriction groups and a decrease in average score for the control group signifying improved well-being resulted from restricting smartphone use before bedtime. A few reasons could explain the lack of finding a significant difference in SAS-SV between the groups. It is possible smartphone addiction is a characteristic of the participants in this sample, in general, rather than a measure that could capture change over a one-week intervention. Additionally, this study did not specifically address smartphone addiction. As such, those already higher in SAS-SV may have been influenced by the intervention to change smartphone behavior before bedtime, but not enough to change overall smartphone behavior.
The finding that the 1-HR group did not differ from the 3-HR group suggests that restriction "dose", or length of restriction time, did not make a difference in happiness or quality of life. This might be the case for a few reasons. First, abstaining from smartphone use for 3 hours prior to bedtime may not be realistic. In fact, since no participant in the 3-HR group achieved that level of restriction confirms that the study condition, even if found to be beneficial, may not be practical. Given how much young adults rely on their smartphones, this finding is not surprising. Second, both groups averaged similar restriction times. It is conceivable that the homogeneity achieved by both groups concealed detectable differences because both groups received similar instructions that influenced behaviors. Another possibility is that light exposure and pre-sleep alerting behaviors in the 1 hour period preceding sleep had greater impact on sleep outcomes than light exposure earlier in the evening. Finally, the intervention may not have been needed for some participants. It is possible some individuals already abstained from device use at night.

Average total screen time decreased in the restriction groups, but there was little change in SNS time. This result may be explained by the age of the participants in this sample and their strong connection to social media. This suggests social media is an influential factor determining smartphone use behaviors. For some, abstaining from social media may not be beneficial. An intervention study by Vally and D'Souza (2019) determined that abstaining from social media may not result in positive outcomes depending on how users interact with the platforms. Active social media engagement is a significant factor, according to Verduyn, et al. (2017). Their study discovered that active engagement with social media has greater influence on well-being than the amount of
time an individual uses SNS. They found active users (those creating or participating with content) are less likely to measure low in well-being scales compared to inactive users who passively consume content.

This type of engagement may be especially relevant during the ongoing COVID-19 pandemic. Many U.S. states and cities implemented mandates for mask wearing indoors and in some public spaces. While this study was conducted well over a year since the March 2020 lockdown, it was still common for individuals to work from home and limit outings. Many activities that previously required in-person attendance were replaced with virtual participation - school, work, banking, meetings, etc. A survey study of 1,408 participants revealed that social media served an important role during the pandemic to help individuals stay connected to increase resiliency (Marzouki et al., 2021). This finding may explain how SNS remained relatively steady during the restriction week even among those using their smartphones less during the study. The increase in the popularity of TikTok during the pandemic may also be a factor to explain steady SNS engagement. TikTok was the most popular SNS among this study's sample population. The short video platform provides active and entertaining content facilitating virtual connection during a time of limited in-person social interaction (Feldkamp, 2021). Downloads of the TikTok application increased 180 percent at the start of the pandemic, and that growth continued over the year (Iqbal, 2021). Globally, active users grew from 700 million in 2020 to 1 billion in 2021 (Statista, 2021).

The effects of the COVID-19 pandemic may also account for the reason sleep duration was not significantly different between groups. Individuals may simply have been sleeping longer during that time. Research by Kantermann (2020) explained that the
time not used for socializing and commuting left more time for sleep for some individuals and led to improved sleep behavior. Wright et al. (2020) found that 92% of the university students in their study slept a minimum of 7 hours per night during lockdown conditions. Overall, the participants in the present study achieved similar sleep duration.

Much of the variance in the primary analysis can be explained by the study design itself. While the primary analysis focused on the well-being outcome variables used in the Hughes and Burke (2018) study, the use of a daily diary, as was done in Perrault et al. (2019), led to important insights into the connection between bedtime smartphone use and sleep. Additionally, using the diaries to check for compliance with the study restriction helped reduce misinterpretation of the true effects of the restriction.

Sleep is an integral part of good physical and mental well-being. Overall, the proportion of young adults not achieving adequate sleep raises concern about well-being given the number of cross-sectional studies associating bedtime smartphone use with poor sleep quality (Alshobaili & AYousefi, 2019; Exelmans & Van den Bulck, 2016), depression, anxiety, and negative well-being (Bhat et al., 2018; Demirci, 2015; Elhai et al., 2019; Woods & Scott, 2016). Such findings demonstrate the adverse effects of inadequate sleep on young adult well-being. In the present study, the number of young adults averaging more than 3 hours of screen time may be underestimated given the possible inaccuracies of self-report data. Every effort was made to encourage using objective measures available on all smartphones, but some inconsistencies emerged (see Limitations). Even so, the findings of the present study provide evidence for an association between bedtime smartphone use, poor sleep quality and well-being.
Limitations and Future Directions

The results from this study should be considered along with several limitations and weaknesses. Inaccurate data from self-report smartphone use is possible. Even though participants were encouraged to use the built-in features from their smartphone to report weekly minutes used, it is likely some individuals may have reported incomplete weekly information. For example, Apple's Screen Time feature requires several steps to get to the correct screen that shows data from a complete week (see Figure 7). Even though participants were given links to information about how to use these features, it is possible some participants recorded the data from the first screen that appears under the weekly use tab. That screen displays the running total of the current week's screen time. Future studies using this strategy to collect objective data about smartphone use should consider better instructions or short training videos on how to use this feature. It is also possible that some participants relied on memory instead of the feature to record screen time. Andrews et al. (2015) showed that self-report screen time estimates can vary widely compared to actual use.
Figure 7

Screenshot Example of Weekly Smartphone Use via Apple's Screen Time Feature

Note. This figure demonstrates the image users see while seeking data for weekly smartphone minutes. The image on the left shows selecting the weekly report screen with the current week in progress. Users must swipe the screen up to see a toggle button to review complete data from the previous week as shown in the image on the right.

While the online survey format may have been limited, technology offers possible solutions to improve future accuracy. First, obtaining access to screenshots of the weekly report or similar method to utilize an application to capture data use may help. However, it may be challenging to find an objective solution due to privacy issues. Second, presenting a study overview and/or instructions in a more engaging manner may help overcome possible error due to misunderstanding the instructions. Short videos and
infographics may be more effective. Third, it may be more convenient for participants to opt-in to receive push reminders through a messaging application or platform they are already using instead of receiving e-mail reminders that might get lost in a SPAM folder. Finally, offering an electronic version of the sleep diary could produce more accurate data than the way it was utilized here.

Another limitation that may have influenced results are the well-being measures used to assess subjective happiness and quality of life. Responses to these surveys depend on the current state or mood of the participant, which is not likely to change over a 1-week period. Meyer et al. (2013) described this potential bias as the present-state effect when individuals believe treatment effects are better or worse than they really are because of their current mood. As such, this effect may explain the wide variance in some results by improvements in mood due to adequate sleep or vice versa. Tempesta et al. (2020) demonstrated how mood, effected by 5 nights of sleep restriction, influenced the negative perception of positive visual images. The researchers found participants who experienced inadequate sleep were more likely to react negatively to positive images than participants with adequate sleep.

This study's dataset was limited to young adults. Therefore, these findings are not generalizable to a broader population. As the reliance on smartphones continues to grow in the future, these findings may provide insight into best practices for smartphone use before bedtime, especially for emerging and young adults establishing long term habits.

More than two-thirds of the sample was comprised of female participants. Even though the groups did not differ significantly in gender distribution, it should be noted that selection bias could have influenced the results by gender. Bönte et al. (2018)
describes that selection bias could influence a sample population since female
respondents are more likely to self-select in a study compared to volunteering for a
competition. Hence, the original study design, using a convenience sample of university
physics students, attempted to moderate the possibility of a gender skewed sample. Male
students accounted for 80% of student chapter membership at the time this study was
launched (American Physical Society, n.d.). Therefore, the rationale to sample from a
male dominated population could have helped reduce the potential gender gap between
participants given that female respondents were more likely to volunteer for the study.

There were several challenges to participant recruitment and retention resulting in
a small sample size, thus limiting power and interpretation of the results. Offering
compensation or a prize drawing as an incentive to complete all phases of the study could
have increased participation but was not considered as part of the original study design
using a volunteer population. Another solution is to use compensated panels offered by
survey platforms like Amazon's MTurk or Prolific. However, time and budget limitations
prevented pursuing this solution.

Regardless of these limitations, this study can be adapted to examine the effects of
bedtime smartphone restriction in different ways. Future studies could utilize measures to
quantify well-being that are more reliable among young adults. Technology to objectively
collect sleep behaviors could improve accuracy. For example, wearable technology like a
smartwatch, fitness tracker or actigraphy can objectively measure sleep parameters. It is
important to note there is some debate among researchers about the accuracy of
commercially available wearable technology, especially fitness trackers, compared to
medical-grade Actigraphy (see Asgari Mehrabadi et al., 2020 and Liang & Chapa-Martell, 2019 for more detail).

The results from this study suggest a need for a moderation analysis using a larger sample population to determine the strength and relationship between bedtime smartphone restriction and sleep for improved subjective well-being.

Future studies could test different iterations of this study design. Given that most participants in the restriction group indicated a willingness to continue the restriction condition, extending the study duration to 2 or more weeks could assess changes to well-being better than 1 week. Longitudinal studies are needed to test the hypothesis and possible long-term benefits. Another way to test the hypothesis could be to adjust the restriction time before bedtime. For example, is restricting device use 30 minutes before bedtime as effective as 60 minutes, or does 90 minutes provide the optimal benefit?

Focusing on a population of emerging adults (age 18 to 25) is another promising direction. The next generations of teenagers will become adults with their own experience using exclusively smartphone technology. A better understanding of these effects on their well-being is necessary.

This research attempted to identify the effects of bedtime smartphone use on the subjective well-being for young adults. Based on the findings of this experimental study, it can be concluded that young adults who engage in smartphone use before bedtime are more likely to experience poorer sleep quality and subjective well-being compared to young adults who did not use smartphones before sleep. This study demonstrated that restricting smartphone use 1 hour before planned sleep led to shortened sleep onset latency, improved sleep efficiency, and better sleep quality. While sleep duration did not
change significantly for the study participants, these results support the association of bedtime smartphone use and sleep as important factors impacting well-being. Smartphone users should consider ways to reduce bedtime device use in the hours before planned sleep. Therefore, changes in bedtime routine by reducing or eliminating screen time before sleep could improve sleep quality and subjective well-being.
Appendix A.

Study Flow

Participants recruited through social media ad link

Participants read online information explaining details of the study process and time commitment

Participants sign consent and answer screening questions

Inclusion Criteria:
- Age 18 to 30
- Smartphone user
- Currently residing in the U.S.
- Fluent in English

Exclusion Criteria:
- Indicates cardinal symptoms of a sleep disorder.
- Current employment involving shift work or inability to keep a regular sleep schedule.
- Current bed partner that may interrupt sleep.
- Caring for a child under 2 years old.

End of Survey

Participants e-mailed a link to Initial Survey thru embedded Participant ID

Initial Survey: Demographic Data; SHS; QOLS; MCQT; SAS-SV; SNS Use

Randomization

Control: Normal Use

1HR: Abstain 1hr prior to planned sleep

3HR: Abstain 3hr prior to planned sleep

Maintain Daily Survey (each morning) for 7 Days
Consensus Sleep Diary; Physical Activity

Follow-Up Survey: SHS; QOLS; SAS-SV; SNS use;
Study Related questions for Intervention Groups;
Debrief

58
Appendix B.

Recruitment Invitation

RESEARCH PARTICIPANTS NEEDED

*Adults between the ages of 18 and 30 are invited to participate in a research study examining the effects of smartphone use on well-being.*

Participation in this study requires answering two (approx. 7-10 mins) online surveys as well as filling out a short daily online diary and following study restrictions for one week.

Participants should own a smartphone and reside in the U.S. Your identity is anonymous to the researcher.

Research conducted by Victoria Shepherd - Graduate Student Master of Liberal Arts (ALM) in Extension Studies at Harvard University Questions? Email: vis767@g.harvard.edu
Appendix C.

Subjective Happiness Scale

For each of the following statements and/or questions, please circle the point on the scale that you feel is most appropriate in describing you.

1. In general, I consider myself:

   1  2  3  4  5  6  7

   not a very happy person

   a very happy person

2. Compared with most of my peers, I consider myself:

   1  2  3  4  5  6  7

   less happy

   more happy

3. Some people are generally very happy. They enjoy life regardless of what is going on, getting the most out of everything. To what extent does this characterization describe you?

   1  2  3  4  5  6  7

   not at all

   a great deal

4. Some people are generally not very happy. Although they are not depressed, they never seem as happy as they might be. To what extent does this characterization describe you?

   1  2  3  4  5  6  7

   not at all

   a great deal

(Lyubomirsky & Lepper, 1999)
Appendix D.

Quality of Life Scale

QUALITY OF LIFE SCALE (QOL)

Please read each item and circle the number that best describes how satisfied you are at this time. Please answer each item even if you do not currently participate in an activity or have a relationship. You can be satisfied or dissatisfied with not doing the activity or having the relationship.

<table>
<thead>
<tr>
<th>Item</th>
<th>Delighted</th>
<th>Pleased</th>
<th>Mostly Satisfied</th>
<th>Mixed</th>
<th>Mostly Dissatisfied</th>
<th>Unhappy</th>
<th>Terrible</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Material comforts home, food, conveniences, financial security</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>2. Health - being physically fit and vigorous</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>3. Relationships with parents, siblings &amp; other relatives-</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>communicating, visiting, helping</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Having and rearing children</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>5. Close relationships with spouse or significant other</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>6. Close friends</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>7. Helping and encouraging others, volunteering, giving advice</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>8. Participating in organizations and public affairs</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>9. Learning- attending school, improving understanding, getting</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>additional knowledge</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Understanding yourself - knowing your assets and limitations</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>- knowing what life is about</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Work - job or in home</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>12. Expressing yourself creatively</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>13. Socializing - meeting other people, doing things, parties, etc</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>14. Reading, listening to music, or observing entertainment</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>15. Participating in active recreation</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>16. Independence, doing for yourself</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

(Burckhardt et al., 1989).
### Appendix E.

**Smartphone Addiction Scale - Short Version**

<table>
<thead>
<tr>
<th>Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Missing planned work due to smartphone use</td>
</tr>
<tr>
<td>2. Having a hard time concentrating in class, while doing assignments, or while working due to smartphone use</td>
</tr>
<tr>
<td>3. Feeling pain in the wrists or at the back of the neck while using a smartphone</td>
</tr>
<tr>
<td>4. Won’t be able to stand not having a smartphone</td>
</tr>
<tr>
<td>5. Feeling impatient and fretful when I am not holding my smartphone</td>
</tr>
<tr>
<td>6. Having my smartphone in my mind even when I am not using it</td>
</tr>
<tr>
<td>7. I will never give up using my smartphone even when my daily life is already greatly affected by it.</td>
</tr>
<tr>
<td>8. Constantly checking my smartphone so as not to miss conversations between other people on Twitter or Facebook</td>
</tr>
<tr>
<td>9. Using my smartphone longer than I had intended</td>
</tr>
<tr>
<td>10. The people around me tell me that I use my smartphone too much.</td>
</tr>
</tbody>
</table>

Overall alpha = .911; Scale Mean = 25.26; SD = 10.78.  
doi:10.1371/journal.pone.0083558.t003

(Kwon et al., 2013)
Appendix F.

Ultra-Short Munich Chronotype Questionnaire

μMCTQ

The following section will ask you questions in regards to your sleep and wake behavior on work- and work-free days. Please estimate an average of your 'normal' sleep behavior over the past 6 weeks.

I have been a shift- or night-worker in the past three months yes __ no __

Normally, I work _____ days/week.

Please answer all the following questions even if you do not work or work 7 days/week. Please don't forget to circle AM or PM.

On WORKDAYS ...
... I normally fall asleep at ___:___ AM/PM (this is NOT when you get into bed, but rather when you fall asleep)
... I normally wake up at ___:___ AM/PM (this is NOT when you get out of bed, but rather when you wake up)

On WORK-FREE DAYS when I DON'T use an alarm clock …
... I normally fall asleep at ___:___ AM/PM (this is NOT when you get into bed, but rather when you fall asleep)
... I normally wake up at ___:___ AM/PM (this is NOT when you get out of bed, but rather when you wake up)

(Ghotbi et al., 2020)
<table>
<thead>
<tr>
<th>Today's date</th>
<th>04/01/17</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. What time did you get into bed?</td>
<td>22:15 p.m.</td>
</tr>
<tr>
<td>2. What time did you try to go to sleep?</td>
<td>11:30 p.m.</td>
</tr>
<tr>
<td>3. How long did it take you to fall asleep?</td>
<td>55min.</td>
</tr>
<tr>
<td>4. How many times did you wake up, not counting your final awakening?</td>
<td>3 times</td>
</tr>
<tr>
<td>5. In total, how long did these awakenings last?</td>
<td>1 hour 10 min.</td>
</tr>
<tr>
<td>6. What time was your final awakening?</td>
<td>6:35 a.m.</td>
</tr>
<tr>
<td>7. What time did you get out of bed for the day?</td>
<td>7:20 a.m.</td>
</tr>
<tr>
<td>8. How would you rate the quality of your sleep?</td>
<td>Poor</td>
</tr>
<tr>
<td>9. Comments (if applicable)</td>
<td>I have a cold</td>
</tr>
</tbody>
</table>
Appendix H.

Screening Survey

[Informed Consent inserted here]

1. What is your age?
   Under 18*, 18-24, 25-30, Over 30*
2. Do you currently use a smartphone?
   Yes, No*
3. Are you currently enrolled at a college or university?
   Yes, No*
4. Do you currently live in the United States and plan to reside in the U.S. during the duration of this one-week study?
   Yes, No*
5. Do you work overnight hours?
   Yes*, No
6. Are you currently caring for an infant under 2?
   Yes*, No
7. If you are in a relationship, is your sleep disturbed by a sleep-wake pattern that differs from your bed partner?
   Yes*, No
8. Have you ever been diagnosed with a sleep disorder such as narcolepsy, sleep apnea, periodic limb movement, sleepwalking, restless leg syndrome, nightmares, night terrors, insomnia, or excessive daytime sleepiness?
   Yes*, No

The following are just a few questions to check for sleep abnormalities:

9. Do you often have an uncontrollable urge to fall asleep during the day?
   Yes*, No
10. Do people consider you a loud snorer?
    Yes*, No
11. Has anyone ever reported that your legs kick or twitch during sleep?
    Yes*, No
12. Have you ever had weakness in your legs or felt your muscles go limp when excited, frightened, or surprised?
    Yes*, No
13. Has anyone ever reported that you act out in your dreams?
    Yes*, No

*Indicates failure to meet study inclusion criteria.
Appendix I.

Study Related Questions

Baseline Survey

The following questions will ask for information about how you typically use your smartphone during the week. To be as accurate as possible, we suggest using the time tracking feature available on most smartphones, if it is enabled. For example, iPhone Screen Time and Android Digital Wellbeing feature. If you are not already familiar with this feature, here is a link to learn more.


Android Device Users: https://wellbeing.google/

1. How much total time did you spend on your smartphone over the previous 7 days?
2. How much total time did you spend on social media sites over the previous 7 days?
3. How much total time did you use the following social media sites over the past 7 days? TikTok, Facebook, Twitter, Instagram, Snapchat, Tumblr
4. Which social media site is your favorite? Facebook (1); Twitter (2); TikTok (3); Instagram (4); Snapchat (5); WhatsApp (6); WeChat (7); QQ (8); Tumblr (9); Reddit (10); LinkedIn (11); Pinterest (12); Other (13).
5. Did you use a smartphone feature to determine usage time? Yes (1); No (2)

Follow-up Survey

1. How much total time did you spend on your smartphone over the previous 7 days?
2. How much total time did you spend on social media sites over the previous 7 days?
3. How much total time did you use the following social media sites over the past 7 days? TikTok, FaceTime, Twitter, Instagram, Snapchat, Tumblr
4. Did you use a smartphone feature to determine usage time? Yes (1); No (2).

Additional Questions on Follow-up Survey for Experimental Groups

1. How difficult was it to maintain the study restrictions? Very Difficult (1); Difficult (2); Somewhat Difficult (3); Slightly Difficult (4); Not Difficult (5).
2. Would you consider continuing to restrict bedtime use of your smartphone on your own after study restrictions are lifted? Yes (1); No (2); Maybe (3).
Appendix J.

Debrief Message

Thank you for your participation in our study! Your participation is greatly appreciated.

Please read the material on this form carefully to learn important information about your experience in this study.

Purpose of the Study: We informed you that the purpose of the study was to examine the effects of smartphone use on the well-being of young adults. The full scope of the research was withheld in order to avoid influencing your activities and responses to the surveys. This study aims to understand if abstaining from smartphone use in the hours before planned bedtime would lead to an increase in next day well-being. We define well-being as perceived life satisfaction. Our hypothesis is that an individual can improve well-being if the use of electronic devices in the hours before bedtime is avoided.

During this one-week study, we randomly assigned participants into three groups. One group used smartphones as normal. Another group was asked to abstain from using their smartphone and portable electronic devices one hour prior to planned bedtime for one week. Another group was asked to abstain from using their devices for three hours prior to planned bedtime for one week. All groups responded to daily and weekly online surveys.

Confidentiality:

Please do not disclose research procedures and/or hypotheses to anyone who might participate in this study in the future as this could affect the results of the study.

***Please keep a copy of this form for your future reference. Once again, thank you for your participation in this study!***

Further Reading(s):

If you would like to learn more about bedtime smartphone use and well-being please see the following references:


## Appendix K.

### ANCOVA for Possible Study Interaction Variables

**Results of ANCOVA Controlling for Covariates on Well-Being Change Scores**

<table>
<thead>
<tr>
<th>Covariate</th>
<th>SS</th>
<th>(F(2,27))</th>
<th>(p)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Subjective Happiness</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SHS Pre-</td>
<td>0.58</td>
<td>0.96</td>
<td>.394</td>
</tr>
<tr>
<td>Age</td>
<td>0.04</td>
<td>0.06</td>
<td>.947</td>
</tr>
<tr>
<td>Sleep duration</td>
<td>1.44</td>
<td>2.35</td>
<td>.114</td>
</tr>
<tr>
<td>Chronotype</td>
<td>0.06</td>
<td>0.10</td>
<td>.906</td>
</tr>
<tr>
<td>SNS</td>
<td>0.61</td>
<td>1.03</td>
<td>.370</td>
</tr>
<tr>
<td><strong>Quality of Life</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>QOLS-Pre</td>
<td>189.68</td>
<td>2.32</td>
<td>.118</td>
</tr>
<tr>
<td>Age</td>
<td>9.09</td>
<td>0.10</td>
<td>.908</td>
</tr>
<tr>
<td>Sleep duration</td>
<td>8.53</td>
<td>0.08</td>
<td>.920</td>
</tr>
<tr>
<td>Chronotype</td>
<td>14.23</td>
<td>0.14</td>
<td>.868</td>
</tr>
<tr>
<td>SNS</td>
<td>21.14</td>
<td>0.21</td>
<td>.813</td>
</tr>
<tr>
<td><strong>Smartphone Addiction</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SAS-SV Pre-</td>
<td>37.11</td>
<td>0.14</td>
<td>.868</td>
</tr>
<tr>
<td>Age</td>
<td>0.58</td>
<td>0.02</td>
<td>.978</td>
</tr>
<tr>
<td>Sleep duration</td>
<td>8.50</td>
<td>0.37</td>
<td>.696</td>
</tr>
<tr>
<td>Chronotype</td>
<td>1.86</td>
<td>0.07</td>
<td>.930</td>
</tr>
<tr>
<td>SNS</td>
<td>43.39</td>
<td>1.92</td>
<td>.166</td>
</tr>
</tbody>
</table>

*Note. N = 33. Results show Group \(x\) Covariate interactions. SHS = Subjective Happiness Scale; QOLS = Quality of Life Scale; SAS-SV = Smartphone Addiction Scale - Short Version; SNS = Social Network Sites.*
References


Arnett, J. (2004). *Emerging adulthood: The winding road from the late teens through the twenties*. Oxford University Press


He, J. -w., Tu, Z. -h., Xiao, L., Su, T., & Tang, Y. -x. (2020). Effect of restricting bedtime mobile phone use on sleep, arousal, mood, and working memory: A randomized
pilot trial. *PLOS ONE, 15*(2), Article e0228756. https://doi.org/10.1371/journal.pone.0228756


evening is associated with improved sleep and daytime vigilance in adolescents. *Sleep*, 42(9), Article zs125. https://doi-org.ezprod1.hul.harvard.edu/10.1093/sleep/zs125


