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Bedtime social media use, sleep, and affective wellbeing in young adults: an experience sampling study

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Background: Findings from primarily cross-sectional studies have linked more extensive social media use to poorer sleep and affective wellbeing among adolescents and young adults. This study examined bedtime social media use, sleep, and affective wellbeing, using an experience sampling methodology with the aim of establishing a day-to-day temporal link between the variables. The study hypothesized a positive association between increased bedtime social media use and lower affective wellbeing the following day, mediated by poorer sleep. **Methods:** Using a smartphone application, 101 undergraduate students (M_{age} = 19.70 years, SD = 1.09 years), completed daily questionnaires assessing the previous night's bedtime social media use and sleep duration and satisfaction (one measurement per day, questionnaire sent at 08:00), and momentary affective wellbeing (five measurements per day, at randomly varying times between 08:00 and 22:00 on weekdays and 10:00 and 22:00 on weekends), for 14 consecutive days. Objective assessments of total sleep time and sleep efficiency were obtained via wrist-worn actigraphs. By means of separate multilevel models, it was tested whether increased bedtime social media use predicted poorer sleep the same night, whether poorer sleep was predictive of positive and negative affect the following day, and whether sleep mediated the relationship between social media use and affective wellbeing. **Results:** Increased bedtime social media use was not associated with poorer sleep the same night. Apart from subjective sleep satisfaction, no other sleep variable (i.e., subjective sleep duration, objective total sleep time and objective sleep efficiency) predicted positive or negative affect the following day. **Conclusions:** This study found that bedtime social media use is not detrimental to the sleep and affective wellbeing of healthy young adults. However, it is possible that bedtime social media use may be harmful to the sleep of vulnerable individuals.
Keywords: Bedtime social media use; sleep duration; sleep satisfaction; actigraphy; positive affect; negative affect; depressive symptoms; experience sampling; ecological momentary assessment.

Introduction

Social media has become a central part of young adults' lives, with reports suggesting that approximately 90% of this population uses at least one social media website (Smith & Anderson, 2018). On the one hand, social media affords its users' important benefits, such as staying in touch with friends and family. On the other hand, it has been linked to a range of negative consequences, for example to poorer sleep (Levenson et al., 2016, 2017), lower affective wellbeing (Sagioglou & Greitemeyer, 2014; Weinstein, 2018), and poorer mental health (Keles et al., 2019).

Studies examining the link between social media use and sleep have reported that increased use of social media, specifically before sleep, is associated with poorer sleep patterns. In a recent study using data from the Millennium Cohort Study on individuals aged between 13–15 years in the UK, Scott et al. (2019) found that longer time spent on social media during the day was associated with later sleep times and later wake up times on school days, as well as difficulty falling back asleep after night-time awakening. Studies also report that increased social media use at night before sleep is associated with more sleep disturbances (Levenson et al., 2016, 2017). It is known that the blue light emitted from electronic devices such as smartphones can interfere with melatonin secretion, thereby interfering with the body's ability to fall asleep (Cajochen et al., 2011). Engaging in social media in bed before sleep might also replace and hence reduce sleep time, or increase emotional or cognitive arousal, making it difficult to mentally switch off (Levenson et al., 2016, 2017). However, it may also be that adolescents and young adults use social media in bed as a sleeping aid, as shown in a three-year longitudinal study by Tavernier and Willoughby (2014).

When examining the relationships between social media use and mental health and affective wellbeing among adolescents and young adults, research suggests that excessive social media use is associated with a higher risk of displaying depressive symptoms (Donnelly & Kuss, 2016; Keles et al., 2019; Lin et al., 2016; Woods & Scott, 2016), anxiety symptoms (Primack et al., 2017), and having lower self-esteem (Kalpidou et al., 2011; Valkenburg et al., 2006).

Conflict of interest statement: No conflicts declared.

Evidence on the impact of social media use on affective wellbeing (*i.e.*, the frequency and intensity of positive and negative emotions and mood, Luhmann et al., 2012) of adolescents has highlighted that longer periods of social media use are linked to lower levels of positive affect and higher levels of negative affect (Sagioglou & Greitemeyer, 2014; Weinstein, 2018), perhaps due to the negative social comparisons that users engage in while browsing (Brown & Tiggemann, 2016; Lup et al., 2015; Weinstein, 2018; Yoon et al., 2019). However, when assessing these associations in samples of young adults, studies have found mixed results, suggesting that the risk of developing poor mental and affective wellbeing as a result of social media use is at least lower in this population, than previously thought. For instance, while there is evidence for a link between increased social media use and decreased positive affect (Wang et al., 2015), some studies have found no relationship between social media use and other wellbeing indicators such as depressive symptoms (Berryman et al., 2018; Jelenchick et al., 2013).

Studies considering the relationship between social media use, mental or affective wellbeing and sleep purport that excessive social media use is linked to both poorer sleep indicators and poorer mental health (e.g., Scott et al., 2019) . Such evidence points to a possible domino-effect relationship between the three variables; specifically that the negative impact of social media use on adolescents' and young adults' sleep may further spill over to their affective wellbeing. It is well known that sleep plays an important role in maintaining healthy physical and mental functioning; for instance, sleep deprivation can be detrimental to an individual's affective wellbeing (Baum et al., 2014; Talbot et al., 2010). In a recent study involving adolescents, Shen et al. (2018) found that shorter sleep was associated with lower positive affect, while poorer subjective sleep quality was linked to higher levels of negative affect. Studies conducted on samples of young adults report similar findings, namely that subjective experience of poor sleep is linked to lower positive affect (Pilcher & Ott, 1998; Rossa et al., 2014).

The mediation of the relationship between social media use at night and poor mental wellbeing by poor sleep has been supported in studies with adolescents. Lemola et al. (2015) reported that increased social media use before sleep might be associated with shorter sleep duration and more sleep difficulties, which in turn might be associated with higher levels of depressive symptoms. Similarly, Kelly, Zilanawala, Booker, and Sacker (2018) reported that excessive social media use may be associated with poor sleep amongst other factors, and that poor sleep may be related to increased depressive symptoms. As a major limitation, these studies have used cross-sectional designs, which do not allow causal or temporal interpretation. Thus, conclusions from these studies need to be inferred cautiously and are weak evidence for advice about media use to young people.

To overcome this important limitation, our study employs an experience sampling methodology over 14 consecutive days to examine the temporal links between participants' bedtime social media use, sleep, and affective wellbeing. Our study aimed to answer the following questions. First, is increased social media use at night before sleep associated with poorer sleep afterwards? Second, based on Lemola et al.'s (2015) research, does poor sleep mediate the relationship between social media use the previous night and affective wellbeing the following day? In particular, the primary hypotheses were (a) increased social media use before sleep is negatively associated with both subjective and objective sleep quality indicators (*i.e.*, shorter subjective sleep duration, shorter actigraphy-measured total sleep time, poorer subjective sleep satisfaction, and lower actigraphy-measured sleep efficiency) the same night; (b) Poorer sleep quality indicators the previous night (i.e., shorter subjective sleep duration, shorter actigraphy-measured total sleep time, poorer subjective sleep satisfaction, and lower actigraphy-measured sleep efficiency) are associated with increased negative affect and decreased positive affect the following day; and, (c) Sleep quality indicators (i.e., subjective sleep duration, actigraphy-measured total sleep time, subjective sleep satisfaction and actigraphy-measured sleep efficiency) will mediate the positive relationship between increased social media use before sleep and higher levels of negative affect and lower levels of positive affect the following day. Based on the rationale that sleep the previous night might differentially impact affective wellbeing at different time points in the following day (Könen et al., 2016; Konjarski et al., 2018; Wrzus et al., 2014), we also explored whether associations of bedtime social media use and sleep with affective wellbeing the following day were stronger for positive and negative affect reported in the morning versus the afternoon.

Finally, following the notion that individuals differ in their vulnerability to effects of stressors on sleep (Drake et al., 2004), we explored whether associations between social media use at night, sleep, and affective wellbeing are more pronounced in the subgroup of participants with increased depressive symptom levels (that were measured once at the beginning of the study), as a potential indicator of increased vulnerability. In particular, this exploratory analysis was driven by the rationale that individuals with higher levels of depressive symptoms at baseline are more vulnerable to experiencing both disrupted sleep and higher levels of negative affect over the 14 days that the study took place (Vargas et al., 2015).

Method

Design and procedure

Undergraduate students across the University of Warwick, who owned either an Android or iOS smartphone, were invited to participate through the University research participant recruitment system as well as from a previous study where individuals had consented to be contacted for the experience sampling study. Data collection occurred in five batches, between October 2017 and February 2018 (batch 1: 31st Oct till 14th Nov, 2017; batch 2: 21st Nov till 5th Dec, 2017; batch 3: 9th Jan till 23rd Jan, 2018; batch 4: 30th Jan till 13th Feb, 2018; batch 5: 20th Feb till 6th March, 2018) because only 25 actigraphy devices were available for concurrent testing. Each batch took part in the study for 14 consecutive days, always beginning on a Tuesday. During the introductory session, after signing informed consent forms, participants completed a 30-min baseline questionnaire, where information regarding demographics, emotional investment in social media, sleep habits and behaviour, and depressive symptoms in the preceding two weeks were collected (see *Measures* section). The data were anonymized through unique identification codes, which were later used to link the questionnaire data with the actigraphy and experience sampling data. Participants were compensated £5 for completing the questionnaire.

Next, each participant received an actigraph, with the instruction to wear it on the non-dominant wrist for the entire study, and through each night (they were specifically instructed to put the actigraphs on before bedtime every night, in case they removed it during the day due to any reason, for example, for engaging in contact sports that might cause damage to the device or harm to other people).

Participants then downloaded the experience sampling application mEMA (Mobile Ecological Momentary Sampling; www.ilumivu.com) on their smartphones. Through mEMA, participants received daily questionnaires that assessed their use of bedtime social media, sleep, and positive and negative affect across the 14 days. Per day, participants received six prompts. The first was sent at 08:00 every morning, with a questionnaire that collected subjective information about the previous night's sleep and bedtime social media use. Participants were free to respond to this questionnaire at any time during the day but to mitigate any potential memory effects, they were advised to fill it in as soon as they woke up, or at least within the first half of each day. The freedom to respond to this prompt at any time ensured non-interference with wake times, especially on weekends. The remaining five prompts were sent between 08:00 and 22:00 on weekdays, and between 10:00 and 22:00 on weekends, and were programmed to vary randomly within these broader windows, with a minimum of at least one hour between two prompts. At each of these five prompts, participants had to respond to items assessing their momentary positive and negative affect, and could only do so within 20 min of receiving the prompt. In total, each participant received 84 prompts (i.e., 14 days × 6 prompts a day). While participants were encouraged to respond to as many prompts as they could, they were also instructed to ignore the prompts in situations that could cause danger or nuisance to themselves or others around them (e.g., while driving, or when they were attending lectures). Compensation for participation was determined based on the number of prompts responded to. For each day of participation, individuals could receive £2.50 (and thus a total of £35 over 14 days). To receive the full amount, participants had to respond to at least 56 out of the 84 prompts (67%) and were therefore allowed to miss an average of two prompts per day (33%).

At the end of the study, participants were invited to the lab for a debrief session, where they were thanked for their participation and their experiences of participation were noted in a brief standardized questionnaire. The actigraphy devices were collected and compensation was provided.

Figure 1 depicts the design of the study.

Participants

Figure 2 shows the recruitment of participants in a flow diagram. A total of 129 undergraduate students across academic departments from the University of Warwick were recruited for the study. Of these, 13 were unable to participate due to problems in downloading mEMA. Four participants dropped out after the study commenced (one found participation too "tedious" and "intrusive", and three were lost to follow-up). Data of four additional participants were excluded due to low compliance in the experience sampling survey (i.e., responding to less than 60% of the prompts). One participant's data could not be used due to technical errors in downloading actigraphy data. Further, data of five participants were excluded due to incomplete day-level data (detailed in the *Multilevel analysis* section below). Last, one participant was excluded from analysis due to their age being more than ten standard deviations above the average age (*i.e.*, 32 years old). This resulted in a final sample of 101 participants (Age: M = 19.70 years, SD = 1.09 years, range = 18–22 years; females = 65.3%). Of these, 44 were 1st-year students, 29 were 2nd-year students, 27 were 3rd-year students, and one was a 4th-year student.

Measures and instruments

Baseline questionnaire. The baseline questionnaire included questions regarding demographics, such as age, sex and year of study, and standardized questionnaires listed below. First, emotional investment in social media was assessed using an adapted version of the Social Integration and Emotional Connection subscale of the Social Media Use Integration Scale (Jenkins-Guarnieri et al., 2013). Participants responded to seven questions (e.g., *I feel disconnected from friends when I have not logged into social media*) on a 5-point scale (*1 = Strongly disagree* to *5 = Strongly agree*). Higher scores reflected higher levels of investment in social media, and the scale displayed an internal consistency of α = .84.

The Pittsburgh Sleep Quality Index (PSQI; Buysse et al., 1989) was used to obtain information on sleep indicators. Specifically, two subscales were utilized to measure subjective sleep duration (component 3) and subjective sleep quality (component 1).

Depressive symptoms were measured using the 10-item Center for the Epidemiologic Studies of Depression Short Form (CESD-10; Andressen et al., 1994). Participants responded on a 4-point scale (*0 = Rarely or none of the time to 3 = All of the time*), where higher scores reflected greater severity of symptoms, and a cut-off of 10, as defined by Andressen et al. (1994) was considered as increased level of depressive symptoms. The scale displayed an acceptable internal consistency (α = .79).

Experience sampling. The first prompt sent each day assessed the previous night's bedtime social media use and sleep. Social media use was measured by asking participants to indicate specifically with regard to the last hour before sleep, how many minutes they had spent engaging in (a) communicating with others by text, chat, or phone/video call (e.g., using WhatsApp) and, (b) using social media sites or applications (e.g., Facebook and Instagram). Total social media use the previous night before sleep (in minutes) was calculated by adding together participants' responses across these two items.

Sleep duration was assessed by asking participants to indicate on a time scroller (a) at what time they had switched off the lights to sleep the previous night, and (b) at what time

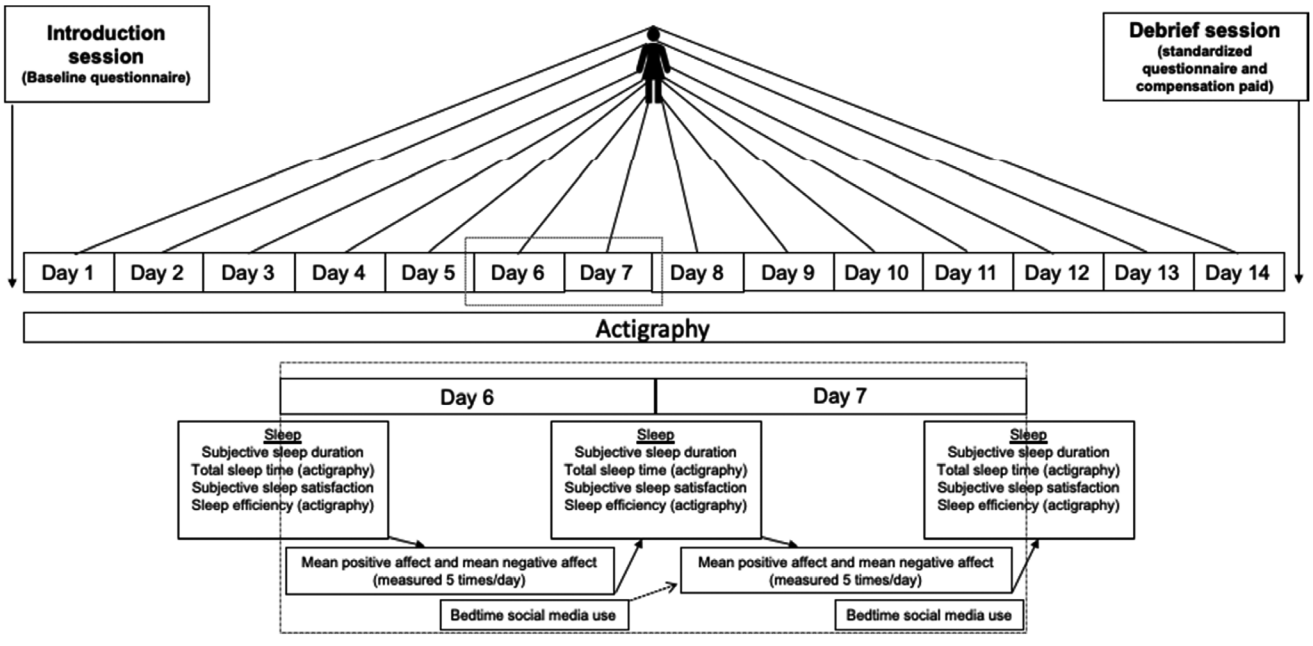

Figure 1 Design of study, as detailed under days 6 and 7 (can be generalised to all 14 days), and analysis plan as represented by the arrows between boxes

had they woken up in the morning. Subjective sleep duration for each night was calculated by taking the difference between lights off time the previous night and awakening time the following morning. Sleep satisfaction was assessed by asking participants to indicate on a 4-point scale (*1 = Very dissatisfied* to *4 = Very satisfied*), how satisfied they were with their sleep the previous night.

Positive affect (PA) and negative affect (NA) were measured using five positive items (happy, enthusiastic, content, relaxed, and attentive) and five negative items (upset, annoyed bored, sad, and worried) taken from the Positive and Negative Affect Scale (PANAS; Watson, Clark, & Tellegen, 1988) and Russel's Circumplex Model of Affect (Russell, 1980). With five prompts each day, participants were repeatedly asked to indicate on a 5-point scale (*1 = Not at all* to *5 = To a large extent*), the extent to which they felt each of the ten affective states in the moment they received the prompt. Each item was presented as a separate question. Principal Axis Factoring with varimax rotation revealed a two-factor structure, with one positive affect factor and one negative affect factor (See Appendix S1). Based on the results of the factor analysis, the item 'bored' was excluded from further analysis. Scores for positive affect and negative affect were computed by taking an average of the five positive items and four negative items, respectively. Higher scores indicated higher levels of positive and negative affect, respectively. The PA scale displayed a good reliability of $\alpha = .81$, and the NA scale displayed an acceptable reliability of $\alpha = .78$. The two scales were negatively correlated at $r = -.54$, $p < .001$.

Actigraph device. Objective indicators of sleep were measured via the wGT3X-BT device (ActiGraph), which recorded information regarding participants' movements and activity by using a 3-axis MEM accelerometer. Total sleep time and sleep efficiency were calculated via the ActiLife 6 software (provided by ActiGraph), using the Sadeh scoring algorithm with 60-second epoch length (Meltzer et al., 2012). The actigraph used in this study did not have a button by which participants could indicate the exact times that they went to sleep or when they woke up the next morning. Thus, anchors of each sleep episode was determined by participant's subjective sleep diaries; lights off time ('what time did you switch off the lights to sleep?') was used to anchor the beginning of a sleep period, and get out of bedtime ('what time did you get out of bed this morning?') was used to anchor the end of a sleep period. These retrospective assessments were taken each morning.

Data analyses

The data processing and analysis plan was preregistered on the Open Science Framework on 1st November 2018 (https://osf.io/d6hpf). One exploratory analysis, which was not detailed in the preregistration, was performed on two subgroups of participants with either higher or lower levels of depressive symptoms. Changes made to the analysis plan are described in Appendix S2.

Descriptive statistics. Descriptive statistics were calculated for the demographic information and standardized questionnaires recorded at baseline.

Multilevel analyses. Using the 'mixed' package in STATA 16, multilevel models were performed to test whether (a) bedtime social media use predicted sleep indicators the same night, (b) sleep indicators predicted positive and negative affect the following day, and (c) bedtime social media use predicted positive and negative affect the following day. Separate crossed effects models were performed to test each hypothesis, with each predictor allowed to have a random intercept for each person and each day. Positive affect and negative affect were entered as dependent variables for models testing (a) and (c). Specifically, positive affect and negative affect were treated as two separate outcome variables, i.e., were not entered in statistical models together. To test whether sleep indicators mediated the relationship between social media use and affective wellbeing, Akaike Information Criterion values for each statistical model would be calculated and compared with one another.

The total number of possible observations for the entire sample was 8,568 (i.e., 84 prompts × 101 participants) of which 7,390 valid observations were recorded. For the primary

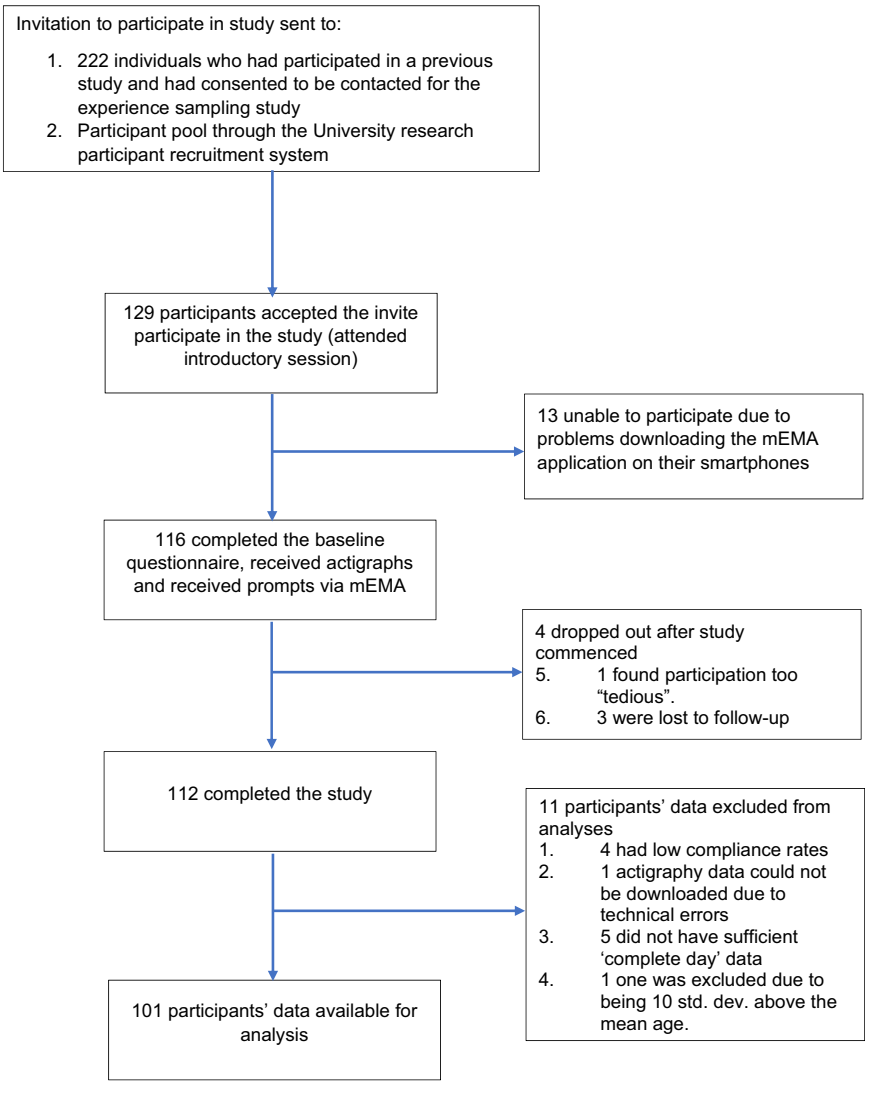

Figure 2 Participant recruitment flowchart

hypotheses, data of only those days were included in the analyses where complete information was available for (a) bedtime social media use the previous night, (b) all four sleep indicators for the previous night, and (c) at least one response regarding positive and negative affect the following day (out of the possible five per day). This further reduced the number of observations for analyses to 5,383 (73% of available data).

To explore whether bedtime social media use and sleep is more strongly associated to affective wellbeing the following morning than afternoon, the first two affect measurements of each day were classified as 'morning measurements' (i.e., sent to participants before 12 pm) and the third and fourth affect measurements were classified as 'afternoon measurements' (i.e., sent to participants after 12 pm), done separately for positive affect and negative affect. This hypothesis was tested using a crossed effects model, where the predictor was allowed to have a random intercept for each person and each day. The time of day (morning and afternoon) was treated as a fixed effect.

Finally, an exploratory analysis was performed with the same multilevel models that were used to test the primary hypotheses with two subgroups, one with participants who had been identified as having increased depressive symptom levels (i.e., scores of 10 or higher) and one with lower depressive symptom levels (i.e., scores of 9 or lower) based on the baseline CESD-10 scores (Andressen et al., 1994).

Data transformation. In order to facilitate interpretation in terms of effect sizes, we z-standardized the predictors (bedtime social media use), mediators (subjective sleep duration, actigraphy based total sleep time, subjective sleep satisfaction and actigraphy based sleep efficiency), and outcome variables (positive affect and negative affect) before analysis.

Results

Baseline questionnaires and experience sampling items

Descriptive statistics are displayed in Table 1.

Baseline questionnaire. The mean score for the Social Integration and Emotional Connection subscale was 22.72 (SD = 6.21; range = 7–34; higher scores indicate higher investment).

PSQI scores indicated that participants' subjective sleep duration per night was an average of 7 hr 22 min (SD = 1 hr 12min). On average, participants

Table 1 Descriptive statistics for sample characteristics, baseline questionnaires and experience sampling questions for the full sample and two subgroups of participants with high and low depressive symptoms based on baseline CESD-10 scores

	Full sample (N = 101)		High levels of depressive symptoms (n = 50)		Low levels of depressive symptoms (n = 51)		Females (n = 66)		Males (n = 35)	
	Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*
Age (years)	19.70	1.09	19.63	1.05	19.55	1.14	19.69	0.97	19.40	1.29
Baseline Questionnaires										
Social Integration and Emotional Connection subscale	22.72	6.21	23.5	5.86	21.73	6.66	23.00	5.98	21.86	6.91
Pittsburgh Sleep Quality Index										
Sleep duration subscale	7 hr									
22min	1 hr									
12min	7 hr 9min	1 hr								
16min	7 hr									
35min	1 hr 5min	7 hr								
18min	1 hr									
13min	7 hr									
29min	1 hr									
10min										
Sleep quality subscale	1.13	0.63	1.36	0.63	0.90	0.54	1.06	0.58	1.26	0.70
Center for the Epidemiologic Studies of Depression Short Form	10.20	5.48	14.59	4.15	5.89	2.18	10.57	5.34	9.50	5.72
Experience Sampling items*										
Social media use in the last hour before sleep (min)[b]	8.68	14.72	10.07	15.27	7.39	13.93	9.03	15.84	7.97	12.08
Subjective sleep duration (min)[a]	466.12	105.79	463.49	109.73	467.87	101.98	469.16	101.46	459.92	113.86
Subjective lights off time[a]	00:54	2 hr								
16min	01:14	2 hr								
28min	00:35	2 hr 1min	00:40	1 hr						
28 min	01:24	3 hr								
13 min										
Subjective wake time[a]	08:30	1 hr								
34min	08:36	2 hr 7min	08:23	1 hr						
25min	08:29	1 hr								
19min	08:32	2 hr								
22min										
Actigraphy measured total sleep time (min)[b]	496.95	111.95	496.52	118.75	496.41	105.28	500.11	105.56	490.53	123.73
Subjective sleep satisfaction[a]	2.83	0.73	2.77	0.74	2.89	0.72	2.80	0.71	2.92	0.77
Sleep efficiency[b]	80.97	9.32	82.40	8.54	79.64	9.66	82.15	9.05	78.57	9.40
Positive affect[c]	2.74	0.82	2.51	0.78	2.93	0.79	2.68	0.78	2.84	0.87
Negative affect[c]	1.63	0.67	1.80	0.70	1.47	0.59	1.74	0.78	1.63	0.77

*Information collected over 14 consecutive day.
[a]Based on a single questionnaire that collected information about the previous night, and that was sent to participants each morning.
[b]Based on daily actigraphy data.
[c]Based on information collected via five questionnaires sent through the day at varying time points.

in the study reported good sleep quality (M = 1.13, SD = 0.63; range = 0–3), with 78 participants (77%) reporting either very good (0) or fairly good (1) sleep quality over the previous month.

Results from the CESD-10 revealed that 50 participants (49% of the total sample) experienced increased levels of depressive symptoms, scoring equal to or above the cut-off of 10 (M = 10.20, SD = 5.48; range = 1–27).

Social media use, sleep, positive affect and negative affect measured by experience sampling. Data collected over the 14 days indicated that on average, participants were spending 9 min on social media in the last hour before sleep at night. However, approximately 44% of all responses indicated that participants had not engaged in any bedtime social media use (i.e., zero minutes). Across all observations (i.e., across measurements and participants), subjective sleep duration averaged at around 7 hr and 46 min (SD = 1 hr 46min), while actigraphy measured total sleep time was around 8 hr 17 min per night (SD = 1 hr 52min). Subjective sleep satisfaction scores averaged 2.83 (SD = 0.73, where 1 = *very*

dissatisfied and 4 = *very satisfied*), while sleep efficiency estimated by the actigraphy was 80.97% (*SD* = 9.32%). Finally, the mean scores of positive and negative affect across all participants and measurements were *M* = 2.74 (*SD* = 0.82), and 1.70 (*SD* = 0.76), respectively.

Relationship between social media use, sleep, positive affect and negative affect

Results from the analysis examining the relationships between social media use, sleep, and positive and negative affect, respectively, are displayed in Table 2. Based on inspection of Q-Q plots of residual variance, all statistical models met the assumption of normality of residuals.

Multilevel models assessing the primary hypotheses showed that using social media at night before sleep did not predict subjective sleep duration, subjective sleep satisfaction or Actigraphy based sleep efficiency. However, increased use of social media the night before was associated with subsequent increased total sleep time measured with actigraphy (β = .05, *SE* = 0.01, *p* < .001. When assessing the link between sleep indicators and daily positive affect and negative affect, respectively, results showed that subjective sleep duration, actigraphy measured total sleep time, and sleep efficiency were not significantly associated with either affective state the following day (*p*> .05). However, higher levels of subjective satisfaction with sleep in the previous night significantly predicted higher levels of positive affect (β = 0.10, *SE* = 0.02, *p* < .001) and lower levels of negative affect (β = −0.07, *SE* = 0.02, *p* < .001) the following day. Finally, no association between bedtime social media use the night before and either positive or negative affect the following day was found. For this reason, a mediation analysis testing the role of sleep quality indicators in the relationship between social media use and affective wellbeing was not carried out.

Table 2 Results of multilevel mixed models conducted to test all primary hypotheses for the full sample

	n[a]	Coeff (unstd)	95% CI	*p*	*SE*
Sleep from social media use[b]					
Subjective sleep duration	5,383	.02	−.01, .04	.192	.01
Actigraphy measured total sleep time	5,383	.05	.02, .07	.000	.01
Subjective sleep satisfaction	5,383	.01	−.02, .04	.525	.01
Sleep efficiency	5,383	−.02	−.04, .00	.108	.01
Positive affect from sleep[c]					
Subjective sleep duration	3,703	.02	−.02, .05	.315	.02
Actigraphy measured total sleep time	3,703	.01	−.03, .04	.632	.02
Subjective sleep satisfaction	3,703	.10	.07, .13	.000	.02
Sleep efficiency	3,703	−.02	−.06, .01	.187	.02
Negative affect from sleep[d]					
Subjective sleep duration	3,706	−.02	−.05, .01	.240	.02
Actigraphy measured total sleep time	3,706	−.00	−.03, .03	.978	.02
Subjective sleep satisfaction	3,706	−.07	−.11, −.04	.000	.02
Sleep efficiency	3,706	.02	−.02, .05	.358	.02
Positive affect from social media use[d]	3,703	.02	−.01. .05	.237	.02
Negative affect from social media use[d]	3,706	−.00	−.04, .03	.851	.02

[a]Number of observations in the model.
[b]Predicting sleep from social media use before sleep the same night
[c]Predicting affective wellbeing the following day from sleep the previous night.
[d]Predicting affective wellbeing the following day from social media use the previous night.

Multilevel models were also performed to explore whether bedtime social media use and sleep, respectively, showed an association specifically with affective wellbeing on the following morning or on the following afternoon. Results showed that subjective sleep satisfaction had a positive association with 'morning measurements' of positive affect (*i.e.*, before 12 pm) and a negative association with 'morning measurements' of negative affect while no such associations for 'afternoon measurements' were found (β = 0.07, *SE* = 0.01, *p* < .001 and β = −.04, *SE* = 0.01, *p* = .007, respectively). No further associations were found (see Table 3).

Subgroup analysis

Exploratory analysis was conducted with two subgroups of participants who either showed increased depressive symptom levels (i.e., who scored 10 or higher on the CESD-10 at baseline; *n* = 50; Females = 36, Males = 14) or lower depressive symptom levels (i.e., who scored 9 or lower on the CESD-10 at baseline; *n* = 51; Females = 30, Males = 21). Analysis followed those used to test the primary hypotheses, and results are displayed in Table 4.

For participants with higher levels of depressive symptoms, results showed that bedtime social media use was negatively associated with subjective sleep duration (β = −.06, *SE* = 0.02, *p* = .003). Sleep satisfaction was positively associated with positive affect (β = .09, *SE* = .02, *p* < .001) and negatively associated with negative affect (β = −.07, *SE* = 0.02, *p* = .003), while actigraphy measured total sleep time was positively associated with negative affect (β = .05, *SE* = 0.03, *p* = .035) the following day. No association of social media use with positive or negative affect the following day was found.

For participants with lower levels of depressive symptoms, results showed that bedtime social media

Table 3 Results of multilevel mixed models conducted to test whether bedtime social media use and sleep are associated more strongly with affective wellbeing the following morning versus afternoon

	n[a]	Coeff (unstd)	95% CI	p	SE
Positive affect in the morning versus afternoon from					
Subjective sleep duration	2,939	.00	−.02, .03	.844	.01
Actigraphy measured total sleep time	2,939	.01	−.02, .03	.689	.01
Subjective sleep satisfaction	2,939	.07	.04, .10	.000	.01
Sleep efficiency	2,939	−.03	−.06, −.00	.049	.02
Social media use[b]	2,939	.00	−.03, .02	.990	.01
Negative affect in the morning versus afternoon from					
Subjective sleep duration	2,941	.01	−.02, .04	.586	.01
Actigraphy measured total sleep time	2,941	.01	−.02, .04	.387	.01
Subjective sleep satisfaction	2,941	−.04	−.06, −.01	.007	.01
Sleep efficiency	2,941	.02	−.01, .04	.321	.02
Social media use[b]	2,941	.02	−.02, .04	.413	.01

[a]Number of observations in the model
[b]Predicting sleep from social media use before sleep the same night.

use was positively associated with subjective sleep duration (β = .09, SE = 0.02, p < .001), and actigraphy measured total sleep time (β = 0.12, SE = 0.02, p < .001). Subjective sleep duration, actigraphy measured total sleep time, and subjective sleep satisfaction, were positively associated with positive affect (β = .08, SE = .03, p = .002; β = .06, SE = .03, p = .016; β = .11, SE = .02, p < .001, respectively), but negatively associated with negative affect the following day (β = −.10, SE = 0.02, p < .001; β = −.06, SE = 0.02, p = .013, and β = −.07, SE = 0.02, p = .001, respectively). Similar to the group with higher levels of depressive symptoms, no relationship between bedtime social media use and positive and negative affect the following day was found.

Discussion

Contrary to our primary hypotheses, bedtime social media use did not predict subjective sleep duration, sleep satisfaction, or sleep efficiency, while predicting longer objective total sleep time. Higher subjective sleep satisfaction was positively associated with positive affect and negatively associated with negative affect the following day, particularly when affect was measured in the morning. The sizes of these effects, however, were small. No other sleep indicator was associated with either positive affect or negative

Table 4 Outcome from models testing primary hypotheses on a subgroups of participants identified with high (scoring 10 or higher) and low levels of depressive symptoms based CESD-10 baseline scores

	n[a]	Coeff (unstd)	95% CI	p	SE
Subgroup with high depressive symptoms (n = 50)					
Sleep from social media use[b]					
Subjective sleep duration	2,603	−.06	−.10, −.02	.003	.02
Actigraphy measured total sleep time	2,603	−.03	−.07, .01	.094	.02
Subjective sleep satisfaction	2,603	−.02	−.06, .02	.356	.02
Sleep efficiency	2,603	−.02	−.05.01	.251	.02
Positive affect from sleep[c]					
Subjective sleep duration	1,771	−.03	−.08, .01	.129	.02
Actigraphy measured total sleep time	1,771	−.03	−.08, .01	.131	.02
Subjective sleep satisfaction	1,771	.09	.05, .13	.000	.02
Sleep efficiency	1,771	−.00	−.06, .05	.890	.03
Negative affect from sleep[c]					
Subjective sleep duration	1,772	.04	−.01, .09	.084	.03
Actigraphy measured total sleep time	1,772	.05	.00, .11	.035	.03
Subjective sleep satisfaction	1,772	−.07	−.12, −.03	.003	.02
Sleep efficiency	1,772	.02	−.05, .08	.628	.03
Positive affect from social media use[d]	1,771	.03	−.01, .07	.166	.02
Negative affect from social media use[d]	1,772	.01	−.04, .05	.830	.02
Subgroup with low depressive symptoms (n = 51)					
Sleep from social media use[b]					
Subjective sleep duration	2,780	.09	.05, .12	.000	.02
Actigraphy measured total sleep time	2,780	.12	.08, .15	.000	.02
Subjective sleep satisfaction	2,780	.03	−.00, .07	.086	.02
Sleep efficiency	2,780	−.03	−.06, .01	.134	.02
Positive affect from sleep[c]					
Subjective sleep duration	1,932	.08	.03, .13	.002	.03
Actigraphy measured total sleep time	1,932	.06	.01, .11	.016	.03
Subjective sleep satisfaction	1,932	.11	.07, .16	.000	.02
Sleep efficiency	1,932	−.03	−.08, .01	.142	.02
Negative affect from sleep[c]					
Subjective sleep duration	1,934	−.10	−.13, −.04	.000	.02
Actigraphy measured total sleep time	1,934	−.06	−.10, −.01	.013	.02

(continued)

Table 4 (continued)

	n^a	Coeff (unstd)	95% CI	p	*SE*
Subjective sleep satisfaction	1,934	−.07	−.11, −.03	.001	.02
Sleep efficiency	1,934	.01	−.03, .05	.599	.02
Positive affect from social media use[d]	1,932	.01	−.04, .06	.716	.03
Negative affect from social media use[d]	1,934	−.01	−.06, .04	.702	.02

[a]Number of observations in the model.
[b]Predicting sleep from social media use before sleep the same night.
[c]Predicting affective wellbeing the following day from sleep the previous night.
[d]Predicting affective wellbeing the following day from social media use the previous night.

affect the following day. Finally, social media use before sleep did not predict positive or negative affect the following day.

Our findings are contrary to previous studies in the field that have reported associations between increased bedtime social media use and poorer affective and mental wellbeing (Burke et al., 2010; Lin et al., 2016; Primack et al., 2017; Sagioglou & Greitemeyer, 2014), and between social media use and poor sleep (Lemola et al., 2015; Levenson et al., 2017; Scott et al., 2019). Important distinctions between our study and previous research might account for these dissimilarities. First, findings reported in the literature are largely based on cross-sectional studies, and therefore the direction of the relationship between social media use and affect remains unclear. It is also possible that a potential third variable is confounding the relationship between social media use and poor affective and mental wellbeing. By employing an experience sampling methodology, we were able to disentangle the day-to-day temporal associations between bedtime social media use, subsequent sleep, and mood the following day by accounting for within-individual change in these variables.

Second, a majority of studies in the field have been conducted on children and adolescents, with a focus on general media use on sleep and mental health (Chahal et al., 2013; Li et al., 2007; Van den Bulck, 2004ulck, 2004). Findings from our study echo those who have examined these relationships specifically among older adolescents and young adults, suggesting no association between social or general media use and sleep or mental health (Berryman et al., 2018; Jelenchick et al., 2013). Tavernier and Willoughby (2014) found that in young adults, sleep problems preceded bedtime media use and not vice versa. Unlike adolescents' and children who have earlier rise times on weekdays dictated by early school start times, university students are afforded more flexible rise times due to class schedules that often have later start times. Since attendance to lectures is most often non-mandatory, this also provides university students with the option to skip classes if those begin early in the morning. Consequently, university students may not be restricted to specific bedtimes, or may simply compensate for later bedtimes by waking up later the next morning. In our study, participants indicated on average a bedtime of 01:00 am, and a wake-up time of 08:30 am and their average subjective sleep was within the recommended range of sleep duration for their age group (7–9 hours for 18–25 year olds; Hirshkowitz et al., 2015), suggesting that participants were able to obtain, on average, a sufficient number of hours of sleep every night.

Our study focussed on bedtime social media use and not general electronic media use, suggesting perhaps that social media use alone may not be as detrimental as previously considered (Chahal et al., 2013; Lemola et al., 2015). However, it is important to note that participants in our study were not excessive users of social media at bedtime. The average social media use in the last hour before sleep across the 14-day study period was approximately nine minutes, with zero minutes use being indicated in 44% of all observations.

To assess whether bedtime social media use would differentially impact participants based on degree of vulnerability, we conducted a subgroup analysis comparing individuals with lower and higher levels of depressive symptoms, reported at baseline. We found that in participants with higher levels of depressive symptoms, bedtime social media use was negatively associated with subjective sleep duration; the size of this effect, however, was small. Our results are consistent with the notion that bedtime social media use can have a stronger negative impact on sleep in individuals who are more vulnerable to stress and depressive symptoms. Shorter sleep has been found to be a risk factor in experiencing depressive symptoms for adolescents and young adults (Pasch, 2010; Steptoe et al., 2006; Zhai et al., 2015). Zhai et al. (2015) suggested that this might be due to an increase in feelings of daytime tiredness, which can, in turn, be predictive of experiencing negative emotions and further increase depressive feelings. However, our results did not show an association between bedtime social media use and positive and negative affect the following day in the subgroup analysis, suggesting that bedtime social media use does not negatively affect the affective wellbeing of vulnerable individuals.

Finally, for individuals with lower levels of depressive symptoms, we found that shorter objective sleep (as measured by actigraphs) was associated with higher levels of negative affect the following day. This

aligns with findings from previous studies, for example Wrzus et al. (2014) reported poorer affective wellbeing when subjective sleep was shorter the previous night in a sample of non-clinical adolescents and young adults. We identified an opposite pattern in individuals with increased levels of depressive symptoms, whereby longer objective sleep was associated with higher levels of negative affect the following day. While there is previous research that links longer sleep with depressed mood (e.g., Zhai et al., 2015), the underlying reasons for the reversed effect for participants with higher levels of depressive symptoms observed in our study remains unclear.

Limitations and future research

This study is not without limitations. First, the retrospective subjective assessment of bedtime social media use on the following day may have led to underestimations of actual social media use. While we tried to mitigate this limitation by requesting participants to respond to the questions as soon as they woke up the next morning, future studies could make use of unobtrusively obtained objective assessments (e.g., using smartphone technology that records social media use). However, obstacles to accessing objective recordings of social media use include strict privacy legislation discouraging companies from sharing such data with researchers, but also that individuals access social media via multiple electronic devices such as smartphones, tablets or computers, which would require synchronically monitoring of various social media platforms. Second, the actigraphy devices used in our study did not allow participants to indicate the beginning and end of each sleep spell via button press, which may have affected the efficiency of the device in measuring accurate sleep anchors. We addressed this concern by using information from participants' subjective sleep diaries filled in the next day to anchor the beginning and end of each sleep episode, which may be subject to memory distortions. Third, the participants of the study were self-selected, and it is not clear whether they were representative of university students. To address this limitation, our sample was recruited across several academic departments and across different cohorts. However, the number of participants reporting levels of high depressive symptoms was greater than would be expected (i.e., 49% in the current study versus around 21% in young adults aged between 16–24 years, Office of National Statistics, 2017), which could be an effect of self-selection into the study. Fourth, due to the observational study design it was not possible to infer causality. For instance, findings of the subgroup analysis that participants with increased depressive symptom levels show an association between pre-sleep social media use and subsequent sleep which could involve both effects of social media use on sleep as well as effects of difficulties falling asleep on the propensity to use social media. Finally, some studies have suggested that different types of social media may yield differential impacts on wellbeing. For instance, passive consumption of social media (e.g., browsing content) has a more negative impact on mental and affective wellbeing than actively using social media (e.g., sharing content; Thorisdottir et al., 2019; Verduyn et al., 2015). We did not record these differences, and future research might examine the role of different types of social media use.

Conclusion

Our study provides evidence that bedtime social media use may not be as detrimental to the sleep and affective wellbeing of young adults as previously thought. While vulnerable young adults with increased levels of depressive symptoms might be at higher risk of experiencing a negative impact of bedtime social media use on subsequent sleep, their affective wellbeing the following day remained unaffected.

Supporting information

Additional supporting information may be found online in the Supporting Information section at the end of the article:

Appendix S1. Exploratory factor analysis used to examine the underlying structure of the positive affect and negative affect items in the experience sampling study.
Appendix S2. Changes to preregistered analysis plan.

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Key points

- Evidence largely from cross-sectional studies regarding the negative impact of social media use on sleep and affective wellbeing of young adults is mixed.
- Using an experience sampling methodology, we assessed within-individual variance and the temporal day-to-day link between social media use, sleep, and positive and negative affect in young adults over 14 days.
- Bedtime social media use did not predict poorer sleep the same night, nor was it associated with affective wellbeing the following day.
- Bedtime social media use may not be as detrimental for the sleep and affective wellbeing of young adults as previously thought.
- Future studies using objective assessments should examine the role of different types of electronic media use at night on sleep and affective wellbeing.

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