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Research paper

The day-to-day bidirectional longitudinal association between objective and self-reported sleep and affect: An ambulatory assessment study

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ABSTRACT

Background: Ambulatory assessments offer opportunities to evaluate daily dynamics of sleep and momentary affect using mobile technologies. This study examines day-to-day bidirectional associations between sleep and affect using mobile monitoring, and evaluates whether these associations differ between people without and with current or remitted depression/anxiety.

Methods: Two-week ecological momentary assessment (EMA) and actigraphy data of 359 participants with current (n = 93), remitted (n = 176) or no (n = 90) CIDI depression/anxiety diagnoses were obtained from the Netherlands Study of Depression and Anxiety. Objective sleep duration (SD) and efficiency were obtained from actigraphy data. Self-reported SD, sleep quality (SQ), positive affect (PA) and negative affect (NA) were assessed by electronic diaries through EMA.

Results: A bidirectional longitudinal association was found between self-reported SQ and affect, while no association was found for self-reported SD and objective SD and efficiency. Better SQ predicted affect the same day (higher PA: b = 0.035, p < 0.001; lower NA: b = -0.022, p < 0.001), while lower NA on the preceding day predicted better SQ (b = -0.102, p = 0.001). The presence of current depression/anxiety disorders moderated the association between better SQ and subsequent lower NA; it was stronger for patients compared to controls (p = 0.003).

Limitations: Observational study design can only point to areas of interest for interventions.

Conclusions: This 2-week ambulatory monitoring study shows that, especially among depression/anxiety patients, better self-reported SQ predicts higher PA and lower NA the same day, while lower NA predicts better self-reported SQ. The value of mobile technologies to monitor and potentially intervene in patients to improve their affect should be explored.

1. Introduction

Depressive and anxiety disorders are highly prevalent psychiatric disorders (Zorn et al., 2017), associated with high disability (Vos et al., 2016), with at least a third of patients experiencing poor treatment outcomes (Gaynes et al., 2009). Disturbances in mood and sleep are core symptoms of affective disorders and are therefore intricately linked to each other (Kahn et al., 2013) .

Persons with affective disorders typically report low levels of positive affect (i.e., anhedonia) and high levels of negative affect (i.e., sad mood, guilt) on questionnaire and interview measures (American Psychiatric Association, 2013; Peeters et al., 2006). Sleep disturbances in affective disorders can entail difficulty initiating or maintaining sleep, or early morning awakening (insomnia), but also sleeping too much (hypersomnia), or both (Staner et al., 2006). As affect and sleep can fluctuate on a daily basis (Fung et al., 2014; Peeters et al., 2006), ambulatory assessments using mobile technologies (i.e., actigraphy devices and smartphones) may offer new opportunities to study the longitudinal

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day-to-day bidirectional associations between sleep and momentary affective states (i.e., positive and negative affect). With repeated measures throughout the day or even continuous data collection, high resolution data can be obtained that allows us to study associations within much smaller time-scales (within day or across days). Determining the extent to which sleep and affect interact on a daily level will provide additional insight and can inform on the usefulness of daily monitoring using mobile technologies and on target areas for (and timing of) user-feedback & micro-interventions.

Ecological Momentary Assessment (EMA) can provide detailed and frequent information on self-reported sleep quality and quantity, and on variations in mood and affect (Ebner-Priemer and Trull, 2009) assessed via a smartphone. This allows the examination of day-to-day bidirectional associations between self-reported sleep quality and affect. Better sleep quality has been found to predict improved affect in healthy controls as well as persons with depressive (Bouwmans et al., 2017; Bower et al., 2010; Triantafillou et al., 2019) and anxiety disorders (Triantafillou et al., 2019). Better affect has been found to be predictive of better self-reported sleep quality in both healthy controls as well as persons with depressive and anxiety disorders (Triantafillou et al., 2019).

Besides EMA, another ambulatory assessment, actigraphy, provides objective and daily measurements of a person's sleep quality and quantity in their living environments (Martin and Hakim, 2011). To date, less studies have examined the relationship between objectively assessed sleep and affect. Two studies found no bidirectional association between actigraphy-assessed sleep quality and mood in elderly (Parsey and Schmitter-Edgecombe, 2019) and between sleep duration and mood in a sample of persons with lifetime diagnosis of unipolar and bipolar depression and healthy controls (Merikangas et al., 2019). As in our previous study using the current sample we found that self-reported sleep and actigraphy-based sleep are often poorly correlated (Difrancesco et al., 2019), passive monitoring of sleep with wrist-worn actigraphy may provide new opportunities for sleep monitoring in patients with depression and anxiety.

The aim of this study was to investigate the (1) day-to-day bidirectional longitudinal association between sleep measures and positive and negative momentary affect from ambulatory assessments using mobile technologies, and (2) whether these associations differ in persons with and without current or remitted depression and/or anxiety disorders.

2. Method

2.1. Sample

Participants from the Netherlands Study of Depression and Anxiety (NESDA) were selected to participate in the Ecological Momentary Assessment (EMA) & Actigraphy sub-study (NESDA-EMAA). Details about NESDA have been provided extensively before (Penninx et al., 2008). NESDA was designed to investigate the course of depressive and anxiety disorders over a period of several years and the factors that influence the development and prognosis of such disorders. NESDA participants were initially included at the baseline assessment in 2004-2007 (n = 2981), and seen for the fifth time at the nine-year follow-up assessment wave (2014-2017, n = 1776) for a follow-up interview. At that time, also 367 siblings of NESDA participants were added, bringing the 9-year follow-up sample to 2143 subjects. At this wave, 384 participants enrolled for the EMAA sub-study. The NESDA study, including NESDA -EMAA, was approved by the VUmc ethical committee (reference number 2003/183) and all respondents gave informed consent for both the regular interview and the EMAA sub-study. See for a flowchart and details of the NESDA-EMAA in our previous work (Difrancesco et al., 2019; Schoevers et al., 2020).

Participants of the NESDA-EMAA study were asked to fill out the EMA assessments, an electronic diary on their smartphone, and to wear a wrist-worn actigraphy device (GENEActiv, Activinsights Ltd, Kimbolton, UK) for 14 days. In case participants did not possess a smartphone, or their phone was not suitable for participation (e.g. no internet bundle), a smartphone was provided for the duration of the study (n = 107, 27.9%). Participants of the EMA assessment completed a set of items 5 times a day (i.e. every 3 hours; fixed design). Of all sent EMA assessment invites to 384 participants, only 8.72% were missing. EMA data of 19 participants were excluded due to various reasons such as low response rate (response rate below 50%; in line with Servaas et al. (2017)) or technical failure, resulting in 365 participants with available data. Participants wore the wrist-worn GENEActiv actigraphy device on their non-dominant wrist, day and night. Of the 384 participants included in the NESDA-EMAA study, 14 had no available actigraphy data for several reasons, such as technical failure, resulting in 370 (96.4%) participants with available data. According to previously published criteria (da Silva et al., 2014), participant's actigraphy data were included in analyses if at least one week day and one weekend day of usable data was available, with at least 16 hours recorded per day and per night. The final sample was composed of 359 (93.5%) participants with on average 13.68 ± SE 1.26 valid days, of whom 90% of participants had complete 24-h actigraphy data for 14 days.

2.2. Assessment of depressive and/or anxiety disorders

As in the previous waves, at the 9-year follow-up, DSM-IV based diagnoses of depressive disorders (dysthymia and major depressive disorder) and anxiety (social anxiety disorder, panic disorder with and without agoraphobia, agoraphobia and generalized anxiety disorder) were established with the Composite International Diagnostic Interview (CIDI, version 2.1) (Wittchen, 1994). The interviews were conducted by specially trained clinical research staff. Participants were divided into three groups: 1) a group with no lifetime depressive and/or anxiety disorders, 2) a group with remitted depressive and/or anxiety disorders (having a lifetime, but not current (6-month) diagnosis), and 3) a group with current depressive or anxiety disorder in the past 6 months.

2.3. Ambulatory assessment variables

2.3.1. Positive and negative momentary affect states

EMA questionnaires were assessed five times a day and had up to 31 items per time point. They contained both momentary affect state items and other items on activities, context and lifestyle. To assess momentary affect states, items covering high and low arousal, positive and negative momentary affect states were used from the Uncovering the Positive Potential of Emotional Reactivity study (Bennik, 2015). Included items were: I feel satisfied, relaxed, upset, cheerful, irritated, listless, down, energetic, enthusiastic, nervous, bored, calm, and anxious. All items were rated on a 7-point Likert scale ranging from '1 = not at all' to '7 = very much'. As used previously (Schoevers et al., 2020), a positive affect (PA) subscale was calculated by taking the average of PA items (at this moment I feel satisfied, relaxed, cheerful, energetic, enthusiastic, and calm). Similarly, a negative affect (NA) subscale was calculated by averaging all NA items (at this moment I feel upset, irritated, listless/apathic, down, nervous, bored, anxious) (Schoevers et al., 2020).

2.3.2. Sleep variables

2.3.2.1. Actigraphy-assessed sleep. In this study, the accelerometer was set to sample at 30 Hz and raw actigraphy data was analyzed using an open source R package, GGIR (van Hees, 2017). As described before (Difrancesco et al., 2019), we used objective indicators of sleep: sleep efficiency per night [in %] and total sleep duration per night [in hh:mm]. The daily estimates were used in the current study. In short, objective sleep estimates were obtained using the GGIR package (van Hees, 2017) that uses an algorithm described extensively before (van Hees et al., 2018). This algorithm can distinguish whether inactivity

periods are sleep periods without the use of sleep diaries; the algorithm has been validated on a sample of the UK Biobank.

2.3.2.2. EMA-based sleep. Besides objectively assessed sleep duration, we also considered sleep variables collected in the EMA assessments, to get a full picture on how objective and self-reported measures relate. Self-reported sleep was assessed in each EMA questionnaire but for the purpose of this study were based on the first assessment of the day only. Included items were sleep duration ("How long did you sleep?" [in hh:mm]) and sleep quality. Sleep quality ("Did you sleep well?") was rated on a 7-point Likert scale ranging from '1 = not good' to '7 = very good'.

2.4. Covariates: age, sex and work/school days

Covariates were age, sex and work/school days at the time of the NESDA EMAA substudy. These covariates were selected as they have an established theoretical association with psychopathology and with sleep, circadian rhythm and physical activity levels, and have been regularly used in similar studies (Droomers et al., 2001; Stamatakis et al., 2007). Work/school days were identified with information from daily EMA assessment as participants were asked to document their location; if they reported their location to be at school/work at least once during a day it was counted as a work/school day.

2.5. Statistical analyses

For descriptive purpose, correlations between sleep variables were tested with Pearson's correlation.

Generalized estimating equation models (GEE) were used to test the bidirectional longitudinal association between momentary affect states assessed every three hours and EMA-based/actigraphy assessed sleep adjusting for age, sex and work days (a summary of the performed analyses is given in Fig. 1). Therefore, separate analyses were performed by first using momentary affect states (i.e., PA or NA) as outcome (Model 1) and then by using sleep variables (i.e., EMA-based sleep quality or EMA-based sleep duration or actigraphy-assessed sleep duration or actigraphy-assessed sleep efficiency) as outcome (Model 2). Although both short and long sleep duration (defined as ≤6 h and ≥10 h, respectively, (Levine et al., 2003)) are often reported in persons with depression/anxiety (Nutt et al., 2008; Zhai et al., 2015), a potential relationship between short and long sleep versus normal sleep (7 ≤ hours ≤ 9) and affect was not tested. This was not done as less than 10% of our participants slept ≥10 h in our sample (Difrancesco et al., 2019), making it impossible to have enough power to detect such effect. We therefore only used sleep duration as continuous variable in our analyses.

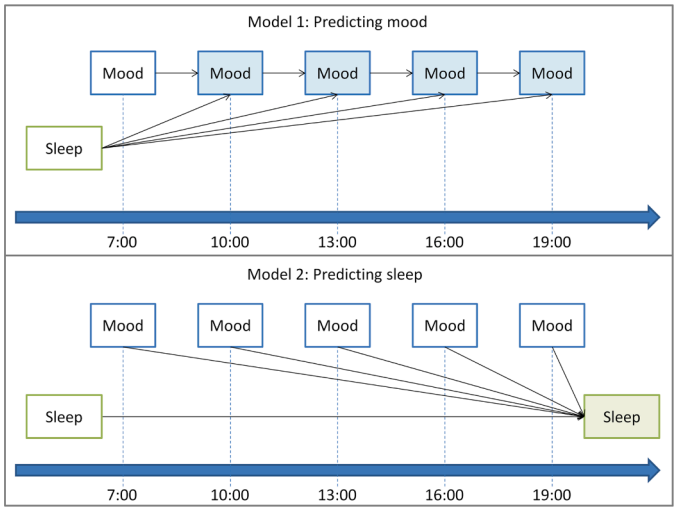

Fig. 1. Summary of the bidirectional longitudinal association between momentary affect states assessed every three hours and (actigraphy actigraphy assessed and EMA-based) sleep. The filled boxes indicate the outcomes. Note Model 1: as we included the previous affect affect state of the same day in the model, this variable is not present for the first assessment of the day and therefore not depicted as an arrow.

Data centring of momentary affect states and sleep variables was performed by within-person mean; therefore, estimates in the models indicate the effect of deviations of affect and sleep from the diurnal person-specific mean. The first-order autoregressive working correlation structure was chosen to take into account the within-person correlation over the 2-week observation period.

The same analyses were repeated to test for the moderating effect of current or remitted depressive and/or anxiety disorders. When moderation terms were significant, stratified analyses by diagnostic group were conducted to interpret and visualize the group effect.

Post-hoc analyses were performed to test the main effect and moderating effect of time of the day on the associations.

All analyses were performed with the statistical software R Studio (R Studio version 1.2.5033, R version 3.5) and the 'gee' library. A p-value < 0.05 was considered statistically significant.

3. Results

3.1. Demographics, ambulatory assessment variables and psychopathology

Table 1 and Fig. 2 show demographics, ambulatory assessment variables and psychopathology in the NESDA EMAA subsample. The average age was 49.5 ± 12.6 years, and 63.7% were females. Of the 16920 total EMA assessments, 32.7% were on work/school days. The median momentary affect states were 5 (IQR 1.5) and 1.3 (IQR 0.9) for positive and negative affect respectively. The median sleep quality was 5 (IQR 2), while the median sleep duration was 7.5 h (IQR 1.5 h) when assessed with EMA and 7.04 h (IQR 1.7 h) when assessed with actigraphy. The median actigraphy-assessed sleep efficiency was 90% (IQR 10%). Moderate significant correlations were found between EMA-based sleep quality and EMA-based sleep duration ($r = 0.41$, $p < 0.001$), and between EMA-based sleep duration and actigraphy-assessed sleep duration ($r = 0.50$, $p < 0.001$). Weak correlation was found between EMA-based sleep quality and actigraphy-assessed sleep duration ($r = 0.09$, $p < 0.001$).

Most of the persons included had a lifetime diagnosis of depressive and/or anxiety disorders: 93 (26.0%) persons had current depressive and/or anxiety disorders, 176 (49.0%) persons had remitted depressive and/or anxiety disorders and only 90 (25.0%) persons had no lifetime depressive and/or anxiety disorders.

3.2. Day-to-day longitudinal association between sleep and subsequent momentary affect states

Better sleep quality was predictive of subsequent higher positive

Table 1
Demographics and psychopathology in the NESDA sample.

	Sample
N	359
Demographic variables	
Age, mean (SD)	49.5 (12.6)
Female, n (%)	228 (63.7 %)
Psychopathology	
Depressive and/or anxiety disorders	
No, n (%)	90 (25.0 %)
Remitted, n (%)	176 (49.0 %)
Current, n (%)	93 (25.1 %)
Antidepressant use, n (%)	71 (19.7%)

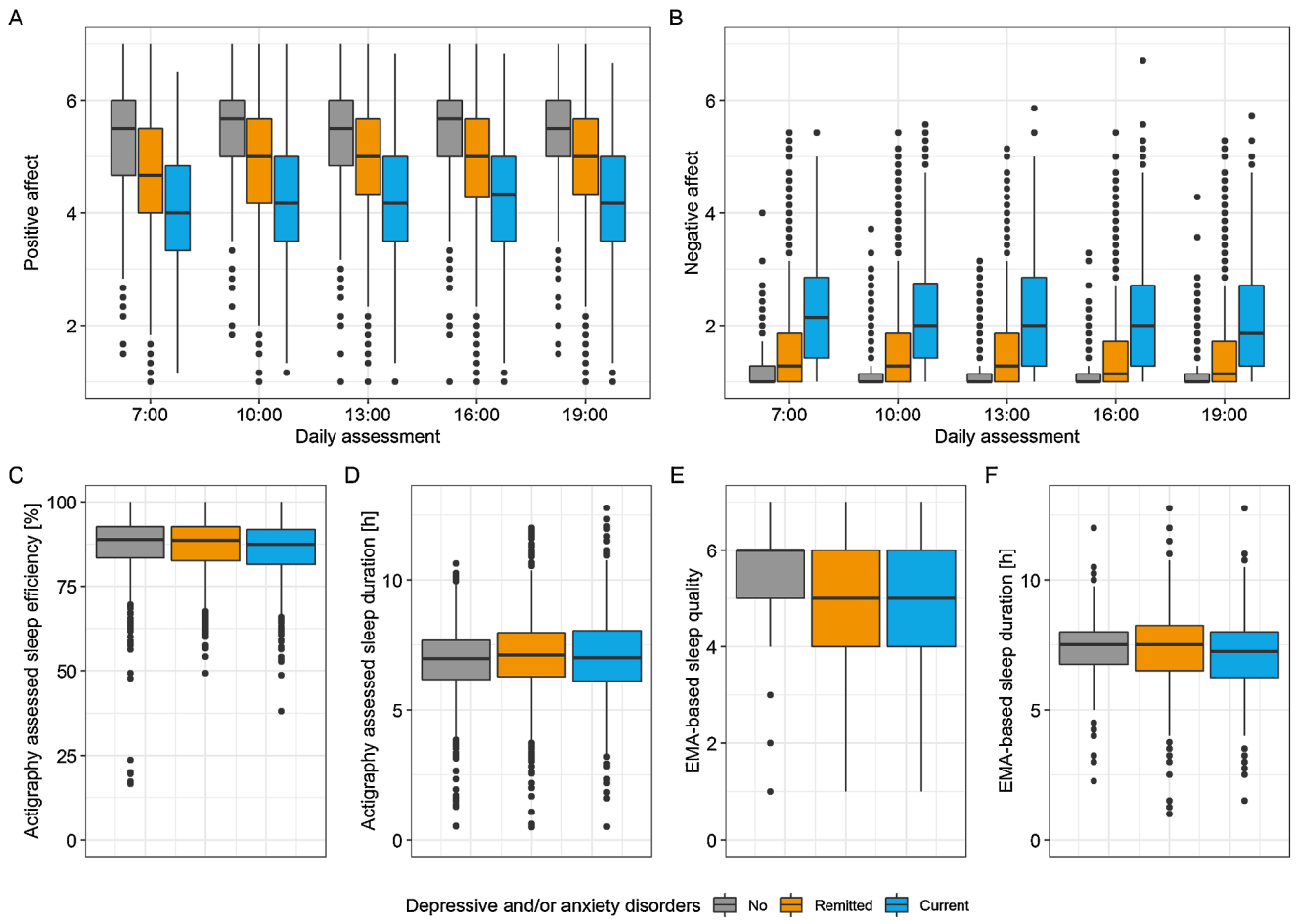

Fig. 2. Distribution of m momentary affect states and sleep variables in the NESDA sample (n = 359): positive (A) and negative (B) affect by daily assessment and by diagnosis, actigraphy assessed sleep variables by diagnosis (C = sleep efficiency, D = sleep duration), EMA E EMA-based sleep variables by diagnosis (E = sleep quality, F = sleep duration).

affect scores and lower negative affect scores the same day (Table 2, both $p < 0.001$). When testing the moderating effect of current or remitted depressive and/or anxiety disorders: having a current depressive and/or anxiety disorder moderated the relationship between better sleep quality and lower negative affect score, as the interaction term was statistically significant ($p = 0.003$, Supplemental Material, Table S1). As the interaction term was significant, we visualize group effects (Fig. 3): a more pronounced negative association was observed between better sleep quality and subsequent negative affect for the groups with current and remitted depressive and/or anxiety disorders. Self-reported and objective sleep duration were not predictive of subsequent affect the same day (Table 2), nor did current/remitted depressive and/or anxiety disorders have a moderating effect (Supplemental Material, Table S1 and Table S2). When adjusting for time of the day, results did not change. Time of the day did not moderate the associations (results not shown).

Table 2
Association between sleep and momentary affect states of the following day (n = 359).

	Positive affect			Negative affect		
	b	se	p	b	se	p
Predictor = EMA assessed sleep quality						
Sleep quality (t-1)	0.035	0.006	<0.001	-0.022	0.005	<0.001
Mood (t-1)						
Positive affect (t-1)	0.327	0.014	<0.001			
Negative affect (t-1)				0.350	0.020	<0.001
Predictor = EMA assessed sleep duration						
Sleep duration (t-1)	0.011	0.008	0.147	-0.008	0.005	0.161
Mood (t-1)						
Positive affect (t-1)	0.334	0.014	<0.001			
Negative affect (t-1)				0.356	0.020	<0.001
Predictor = Actigraphy assessed sleep efficiency						
Sleep efficiency (t-1)	0.198	0.120	0.099	-0.078	0.071	0.273
Mood (t-1)						
Positive affect (t-1)	0.335	0.014	<0.001			
Negative affect (t-1)				0.357	0.021	<0.001
Predictor = Actigraphy assessed sleep duration						
Sleep duration (t-1)	-0.002	0.006	0.785	0.004	0.004	0.256
Mood (t-1)						
Positive affect (t-1)	0.335	0.014	<0.001			
Negative affect (t-1)				0.357	0.021	<0.001

3.3. *Day-to-day longitudinal association between momentary affect states and subsequent sleep*

Higher score on positive affect and lower score in negative affect predicted better sleep quality the next day (Table 3, both $p < 0.01$). No interaction with current/remitted depressive and/or anxiety disorders was observed, suggesting that such associations do not depend on diagnostic group (Supplemental Material, Table S3). Affect states neither predicted self-reported and actigraphy assessed sleep duration (Table 3), nor did current/remitted depressive and/or anxiety disorders have a moderating effect (Supplemental Material, Table S3 and Table S4). When adjusting for time of the day, results did not change. Time of the day did not moderate the associations (results not shown).

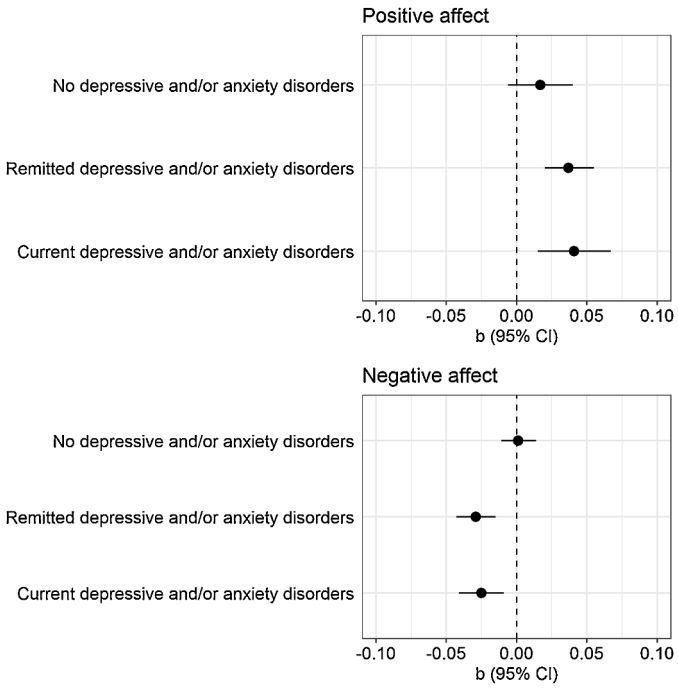

Fig. 3. Longitudinal association between EMA-based sleep quality and subsequent momentary assessment states stratified by diagnostic group.

Table 3
Association between momentary affect states and sleep of the following night (n = 359).

	Sleep			Sleep		
	b	se	p	b	se	p
Outcome = EMA assessed sleep quality						
Mood (t-1)						
Positive affect (t-1)	0.031	0.02	0.128			
Negative affect (t-1)				-0.102	0.031	0.001
Sleep quality (day-1)	-0.063	0.024	0.010	-0.066	0.024	0.006
Outcome = EMA assessed sleep duration						
Mood (t-1)						
Positive affect (t-1)	-0.003	0.019	0.870			
Negative affect (t-1)				-0.047	0.026	0.078
Sleep duration (day-1)	-0.085	0.021	<0.001	-0.086	0.021	<0.001
Outcome = Actigraphy assessed sleep efficiency						
Mood (t-1)						
Positive affect (t-1)	0.001	0.001	0.434	-0.001	0.002	0.523
Negative affect (t-1)						
Sleep efficiency (day-1)	-0.106	0.029	<0.001	-0.106	0.029	<0.001
Outcome = Actigraphy assessed sleep duration						
Mood (t-1)						
Positive affect (t-1)	-0.015	0.016	0.348			
Negative affect (t-1)				0.005	0.025	0.833
Sleep duration (day-1)	-0.111	0.028	<0.001	-0.111	0.028	<0.001

4. Discussion

This study examined the day-to-day bidirectional longitudinal association between self-reported and actigraphy-based sleep measures and momentary affect in a population with and without remitted or current depressive and/or anxiety disorders. Better self-reported sleep quality was predictive of improved affect the same day especially in persons with current depressive and/or anxiety disorders. On the other hand, better affect on the preceding day was predictive of higher self-reported sleep quality. No bidirectional longitudinal association was found between self-reported and actigraphy-based sleep duration and affect. Thus, the bidirectional associations between sleep quality and affect may highlight the potential of improving sleep quality as a target for affect improvement and regulation in patients with depression and anxiety by breaking the vicious circle.

This study supports previous findings on the bidirectional longitudinal relationship between sleep quality and affect. Similarly to our results, better self-reported sleep quality has been linked to subsequent increased positive affect and decreased negative affect (Bouwmans et al., 2017; Triantafillou et al., 2019), and better affect has been linked to improved sleep quality (Triantafillou et al., 2019) in individuals without and with depressive and anxiety disorders when using daily (electronic) diaries and EMA. Both cognitive and biological mechanisms may explain the relationship between poor sleep quality and affect. Sleep deprivation may impact on emotions with alterations in especially the limbic system. Rapid eye movement (REM) sleep has been suggested as a modulator of affective brain processes, offering a regulatory function which restructures experiences in an emotionally adaptive manner (Kahn et al., 2013). Emotional information and memory processing may also be relevant, as a negative remembering bias has been shown, by which individuals tend to remember negative but not positive experiences following loss of sleep (Kahn et al., 2013). Finally, the cognitive-energy model (Zohar et al., 2005) suggests that sleep loss depletes energy levels, thus disrupting adaptive affective responses to stress. On the other hand, there is also data to suggest that an individual's coping style and emotion regulation strategy (e.g., avoidant emotion regulation, rumination) may moderate the relationship between low mood and sleep loss (Kahn et al., 2013)

Interestingly, in our study better sleep quality was found to improve subsequent affect especially in persons with current depression and/or anxiety. Although some studies have found that history of depression and anxiety did not mediate the relationship (Bouwmans et al., 2017; Triantafillou et al., 2019), a possible explanation of our results is that individuals with an already vulnerable emotion-regulation system may experience even more adverse effects from poor sleep quality or more pronounced beneficial effects from better sleep quality (Harvey, 2011).

In contrast, no association was found between self-reported or actigraphy-based sleep duration and affect. These results seem to be consistent with other research which found no bidirectional association between affect and actigraphy-based sleep quality in an elderly population (Parsey and Schmitter-Edgecombe, 2019) and actigraphy-based sleep duration in a population with lifetime diagnosis of unipolar and bipolar depression (Merikangas et al., 2019). In line with our previous findings (Difrancesco et al., 2019), this study showed that the correlation between objective sleep duration and self-reported sleep quality was low and therefore objective and self-reported measures capture different aspects, enhancing the assessment of sleep.

While the current study looking at day-to-day associations did not observe associations between sleep duration and affect, sleep duration may nevertheless impact on affect. Results from meta-analyses on prospective longitudinal studies have shown that insomnia (Baglioni et al., 2011) and, both short and long vs normal sleep duration (Zhai et al., 2015), assessed with self-reported retrospective ratings, are longitudinally associated with increased risk of depression 6 months later. Therefore, self-reported sleep disturbances may have important long-term effects resulting in depression and worsening of depressive symptoms. More research is needed to understand the underlying biological mechanisms.

We observed bidirectional day-to-day effects between sleep quality and affect, possibly pointing to a vicious circle. A question for future studies is whether improving sleep quality may have positive outcomes on daily affect, especially in patients with depression and anxiety. As online psychological interventions have been shown to be effective for psychiatric disorders (Carlbring et al., 2018) and EMA can provide day-to-day assessments, EMA may be an add-on monitoring tool to (online) psychotherapy and Ecological Momentary Interventions (EMI). Specifically for insomnia, digital cognitive behavioral therapy (CBT-I)

can be administered to patients with depression and anxiety; self-reported sleep quality may be an indicator of treatment response. Mobile technologies may also be used to monitor patients more broadly. Similarly to the biofeedback-based treatments for insomnia, integrating mobile technologies with apps summarizing affect and sleep may provide feedback to patients. This may help raise patients' awareness, and may help them to gain control.

This study has limitations. First, the observational study design can only point to areas of interest for monitoring and interventions, but does not allow us to make definitive recommendations on such interventions. Future clinical trials may further investigate the application of mobile technologies to monitor and measure treatment response. While actigraphy is feasible, it only detects sleep based on wrist movement and therefore may not be optimal to measure sleep. As restless REM sleep has been identified as a potential target for treatment of mental disorders (Wassing et al., 2019), REM sleep may be a better indicator of objective sleep disruptions. Although antidepressant use can be seen as a confounder, it is also closely associated with severity of depression and anxiety (the most severe cases use it), therefore, using it as a covariate may be seen as an overcorrection. In addition, as we have previously shown, antidepressant use is not associated with sleep duration (Difrancesco et al., 2019). Important strength of the study is the use of mobile technology to study the bidirectional day-to-day relationships between objective and self-reported indicators of sleep and affect on a relatively large sample with CIDI-based depression and anxiety diagnoses. Another strength of this study is that it strongly supports previous research on the longitudinal association between sleep quality and affect.

To conclude, this 2-week intensive ambulatory assessment study using mobile technology has shown a bidirectional association between better self-reported sleep quality and better affect, while no bidirectional association was found between self-reported and actigraphy-based sleep duration and affect. Mobile technologies may be insightful tools to provide feedback to patients about their sleep and affect. Improving sleep quality may be an important target of treatment to enhance affect in patients with depression and anxiety. Future studies may investigate whether EMA technology measuring sleep quality can be used to monitor treatment outcomes in depression and anxiety.

5. Author Statement Contributors

S. Difrancesco, F Lamers, B. W. J. H. Penninx and H. Riese formulated the research questions. S. Difrancesco performed the data cleaning and the statistical analyses, interpreted the results, wrote the manuscript, and incorporated feedback from all co-authors. B. W. J. H. Penninx, F. Lamers reviewed and provided feedback in all drafts of the manuscript, and critically interpreted the results. H. Riese, A. M. van Hemert, N. Antypa contributed to the interpretation of results and revised the manuscript critically for important intellectual content. All authors approved of the final version of the paper.

Declaration of Competing Interest

None.

Role of Funding Source

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Data Availability Statement

According to European law (GDPR) data containing potentially identifying or sensitive patient information are restricted; our data involving clinical participants are not freely available in a public repository. However, data are available upon request via the NESDA Data Access Committee (nesda@ggzingeest.nl).

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.jad.2021.01.052.

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