Short and long-term effects of unguided internet-based cognitive behavioral therapy for chronic insomnia in morning and evening persons: A post-hoc analysis

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Abstract

A post-hoc analysis comparing morning and evening persons with insomnia on sleep and mental health characteristics was conducted in order to investigate whether an Internet-based cognitive behavioral therapy for insomnia (ICBTi) was effective both for morning and evening persons. Adult patients (N=178, mean age= 44.9, 67% females) with insomnia were randomized to either ICBTi (N=92; morning persons = 41; evening persons = 51) or a web-based patient education condition (N=86; morning persons = 44; evening persons = 42). All patients were assessed with sleep diaries, the Insomnia Severity Index (ISI), the Bergen Insomnia Scale (BIS), the Dysfunctional Beliefs and Attitudes about Sleep Scale (DBAS-16), the Hospital Anxiety and Depression Scale (HADS) and the Chalder Fatigue Scale (CFQ). Patients were characterized as morning or evening persons based on a median split on the Horne-Östberg Morningness Eveningness Questionnaire. Short and long-term effects of treatment were examined with mixed model repeated-measures analyses. Morning and evening persons did not differ in terms of age, gender or educational status. At baseline, morning persons had more wake time after sleep onset (d=0.54, p<.001) and more early morning awakening (d=0.38, p<.05) compared to evening persons, while evening persons reported longer sleep onset latency (d=0.60, p<.001), more time in bed (d=0.56, p<.001), longer total sleep time (d=0.45, p<.01), more fatigue (d=0.31, p<.05) and more dysfunctional beliefs and attitudes about sleep (d=0.47, p<.01). Despite these differences at baseline, both morning and evening persons receiving ICBTi benefitted more across most measures compared to morning and evening persons who received patient education. For morning persons in the ICBTi group, ISI scores were reduced from 17.3 at baseline to 8.8 ($d_{pre\text{-}post}$=2.48, p<.001) at post assessment, and to 10.0 at 18-month follow up ($d_{pre\text{-}post18m}$=2.13, p<.001). Comparable results were found for evening persons in the ICBTi group, with a reduction in ISI scores from 17.4 at baseline to 8.6 ($d_{pre\text{-}post}$=2.24, p<.001) at post assessment, and to 8.7 at 18-month follow up ($d_{pre\text{-}post18m}$=2.19, p<.001). Similar results were found on the BIS, DBAS, HADS,

CFQ and sleep diary data. Despite different insomnia symptomatology between the two groups, the current study suggests that ICBTi is effective across scores on the morningness-eveningness dimension. The study was pre-registered at: ClinicalTrials.gov Identifier: NCT02261272.

Keywords: Insomnia, morningness, eveningness, cognitive behavioral therapy for insomnia, internet intervention, SHUTi

Word count: 5672

Introduction

Morningness is a dimension referring to the individuals' predilection for activities and sleep within the 24-hour period (Freeman and Hovland 1934; Kleitman 1939). The morningness-eveningness dimension has been described as a continuum between two extremes, where the majority in between are classified as intermediate persons (Natale and Cicogna 2002). People with high scores on morningness (early birds/morning larks) prefer to go to bed relatively early in the evening and rise early in the morning, while people with low scores on morningness (night owls/evening persons) prefer to go to bed relatively late in the evening/night and rise late in the morning (Natale and Cicogna 2002). These differences in sleep/wake timing are corroborated with data on the timing of biological processes, such as core body temperature (Baehr et al. 2000), melatonin excretion (Gibertini et al. 1999), cortisol profiles (Bailey and Heitkemper 2001), and activity data (Thun et al. 2012).

Morning and evening persons have been shown to differ on several sleep parameters. Evening persons tend to report worse sleep quality (Barclay et al. 2010), more daytime sleepiness (Giannotti et al. 2002), longer sleep onset latency (Yazdi et al. 2014) and more maladaptive beliefs about sleep (Adan et al. 2006) compared to morning persons. Evening persons further report greater variability in bed and arise time (Taillard et al. 1999), larger weekday-weekend differences in their sleep timing (Taillard et al. 1999; Wittmann et al. 2006) and more irregular social rhythms (Monk et al. 2004), compared to morning persons. Consequently, evening persons are more prone to social jetlag – which refers to a misalignment between circadian (i.e. biological timing) and social (e.g. work, family commitments) time (Wittmann et al. 2006). Despite these differences, morning and evening persons do not appear to differ in terms of sleep architecture (Mongrain et al. 2005). However, evening persons tend to report more sleep complaints and symptoms of insomnia, and their use of sleep medications is greater than morning persons (Merikanto et al. 2012).

Much research has focused on the morningness-eveningness dimension and sleep in healthy individuals. However, less research has investigated the impact of circadian variables in insomnia patients, although evidence suggests the presence of certain chronological abnormalities in people suffering from chronic insomnia (Lack and Wright 2007; Lack et al. 2008). For example, insomnia patients with sleep initiation difficulties have been shown to display a phase delay in their core body temperature rhythm, implying that part of their predicament may be attributed to difficulties initiating sleep during the "wake maintenance zone" – a period where sleep is typically inhibited (Strogatz et al. 1987; Lack and Wright 2007). Likewise, it has been suggested that insomnia patients with early morning awakening difficulties tend to display a phase advance in their temperature rhythm, where part of their problem may be attributed to difficulties maintaining sleep in the "wake-up zone" preventing them from falling back to sleep and thus curtailing their total sleep time (Lack and Wright 2007). Frequent attempts to initiate or maintain sleep during these periods of rhythm de-synchronizing can potentially lead to the development of chronic insomnia (Lack and Wright 2007).

The development of chronic insomnia is also influenced by other factors, such as cognitive and behavioral components (Morin 1993). In one study, evening persons with insomnia, compared to morning and intermediate persons with insomnia, reported more dysfunctional cognitions related to sleep, more symptoms of depression, more time in bed and greater variability in time out of bed, despite having longer total sleep time (Ong et al. 2007). Another study found that evening persons with insomnia reported worse subjective sleep quality, worse daytime functioning and longer sleep onset latency, compared to morning persons with insomnia (Hasler et al. 2012). In addition, evening persons, compared to morning persons, displayed diurnal patterns characterised by a phase delay and smaller

amplitude in self-reported positive affect (PA) which might be a contributing factor making evening persons more susceptible for developing mood disorders (Hasler et al. 2012).

Cognitive-behavioral therapy for insomnia (CBTi) is the recommended first line treatment for patients suffering from chronic insomnia (Mitchell et al. 2012; Qaseem et al. 2016). The effects of CBTi is well documented in meta-analyses (Smith et al. 2002; Mitchell et al. 2012) with long-term effects that are superior to those of sleep medication (Sivertsen et al. 2006). Between 70-80% of patients achieve significantly improved sleep after CBTi (Morin et al. 1999; Ritterband et al. 2009). In recent years, an increasing number of studies have shown that Internet-delivered CBTi (ICBTi) is an effective tool for making the treatment more accessible (Ritterband et al. 2009; Sivertsen et al. 2013). One current unguided ICBTi treatment program is Sleep Healthy Using the Internet™ (SHUTi), which has demonstrated lasting treatment effects comparable to that of in-person delivered CBTi (Ritterband et al. 2009; Ritterband et al. 2017; Hagatun et al. 2019; Vedaa et al. 2019). Indeed, a recent meta-analysis concluded that the effects of both guided and unguided ICBTi on sleep related outcomes were comparable to that of in-person delivered CBTi (Zachariae et al. 2016). Although only a few studies have assessed the long-term effects (> 6 months) of ICBTi, those who have, report sustained improvements as long as one to three years after treatment completion (Blom et al. 2016; Ritterband et al. 2017; Vedaa et al. 2019).

Knowledge about the morningness-eveningness dimension and effects of ICBTi is important in order to ensure that these interventions can be offered to those who are most likely to benefit from treatment. In addition, knowledge about a potentially differenced effect of ICBTi for morning and evening persons would provide the opportunity to modify the intervention for those who are less likely to respond. This is relevant considering that chronobiological components have previously been shown to affect the development and maintenance of chronic insomnia (Lack and Wright 2007; Lack et al. 2008). In a study of 419

treatment-seeking insomnia patients, Bei et al. (2015) found that group-delivered CBTi significantly improved the patients sleep, but the patient´s score on the morningness-eveningness dimension did not predict their improvements. A stronger evening preference, however, predicted less reduction in depressive symptoms following treatment, compared to patients with stronger morning preference (Bei et al. 2015).

The present study uses data from a recently conducted randomised controlled trial (RCT) on the effects of ICBTi compared to a patient education control group for adult patients with chronic insomnia (Hagatun et al. 2019). The purpose of this study was to conduct post-hoc analyses on these data, in order to explore the insomnia symptomatology of the subgroups of morning and evening persons, and to investigate whether ICBTi is an effective treatment for morning and evening persons with chronic insomnia.

Materials and Methods

Participants

Participants were recruited through advertisements and media appearances by the researchers, inviting people to visit the study website. The website contained information about CBTi and specifics for the present study trial. Individuals who were interested in participating completed an automated screening test that was available on the study webpage. The screening test was anonymous and screened for eligibility based on the following criteria: Participants had to be at least 18 years old, speak fluent Norwegian, have Internet access and meet Diagnostic and Statistical Manual of Mental Disorder (DSM-IV) diagnostic criteria for insomnia (Association AP 2013). Participants were excluded if they had night work, presented symptoms of other untreated sleep disorders (i.e. sleep apnea, hypersomnias) or a severe mental disorder (i.e. schizophrenia, bipolar disorder, major depressive disorder).

Regular use of prescription medicine (including hypnotics) was not an exclusion criterion provided that the medication regimen was stable.

Participants who did not meet the eligibility criteria received an automated generic message informing them about the reason why they could not be included (e.g. "Your answers suggest you may have a different sleep problem than what this program is intended to treat […]"), and they were encouraged to consult their general practitioner with their sleep difficulties. Individuals who were deemed eligible were scheduled for a 15-minute telephone interview, which was performed by a clinical psychologist or trained psychology student, and comprised a semi-structured clinical interview confirming the insomnia diagnosis and participation eligibility.

Procedure

In total, 178 Norwegian adults with insomnia were included and completed a set of online questionnaires. They also kept an online sleep diary for 10 days over a two-week period. After completing the baseline assessments, the participants were randomly assigned to either the ICBTI-program (SHUTi) (n = 92) or to the patient education group (n = 86) for nine weeks. After nine weeks, all participants were asked to complete the online questionnaires and sleep diaries (for 10 days over a two-week period) at post-assessment, and again at 6-month and 18-month follow-up (FU), respectively. Participants had access to their condition program material during the entire study period. The enrolment and participant flow are detailed in **Figure 1**.

SHUTi is a fully automated and interactive self-help program delivered over the internet, designed to help adults with chronic insomnia. The program operationalizes CBTi content for web-delivery (Morin 1993), and consists of six treatment cores including basics of sleep problems, sleep restriction, stimulus control, cognitive restructuring, sleep hygiene, and

relapse prevention. These core concepts are introduced through a combination of informational text for participants to read, video vignettes of fictitious people suffering from insomnia, interactive learning exercises, educational animations, and videos of experts explaining key features of the treatment. Each of the six treatment cores are designed to mimic therapy sessions both in terms of form and content. Each core requires approximately 45-60 minutes to complete, and participants are given homework between the cores. A new core is made available seven days after completing the previous core. Participants in the SHUTi group also received daily e-mail reminders throughout the intervention with instructions to complete the sleep diary, which allowed them to receive individualized recommendations regarding sleep restriction. Participants in the patient education group did not complete any online sleep diaries during the intervention, but could print out a sleep diary form to keep using paper and pencil.

The patient education group received access to a website containing information on sleep hygiene as well as sleep education about insomnia symptoms, cases and strategies to improve sleep. Unlike the participants in the ICBTi group, the information in the education website was presented mostly as static text, and all of the sleep education material was made immediately available. Participants in the patient education group were encouraged to visit the website at the start of the intervention period but received no further email reminders or prompts during the intervention period. They could access the material, however, at any time during the intervention period.

Participants who completed the 18-month FU assessment received NOK 500 (approximately USD 60) as compensation. All participants signed a consent form using electronic signature and were informed that they are fully anonymized and could withdraw from participation at any time without penalty. The study was approved by the Regional

Committee for Medical and Health Research in Western Norway (2012/1934 REK, South East B), and was pre-registered at: ClinicalTrials.gov Identifier: NCT02261272.

Instruments

The Horne-Östberg Morningness Eveningness Questionnaire (MEQ) is the most widely used morningness-eveningness inventory (Adan et al. 2012), and aims to determine preferred time (rather than when it actually occurs) for sleep and other activities (Horne and Ostberg 1976). The MEQ reduced version (rMEQ) consists of five items (no. 1, 7, 10, 18 and 19) from the original (Adan and Almirall 1991). The rMEQ yields a score ranging from 4 to 25 (from "eveningness" to "morningness") where a higher score indicates greater "morningness". The MEQ is a valid and reliable instrument (Adan et al. 2012), and the rMEQ correlates closely with the original MEQ (Adan and Almirall 1991). For the present analyses, participants were classified as morning and evening persons based on a median split of the composite score of the rMEQ. Cronbach alpha of the rMEQ scale was .73.

The Insomnia Severity Index (ISI) consists of seven questions that specifies the overall severity of the participant's insomnia (i.e. problems related to sleep initiation, sleep maintenance, early morning awakening, interference with daytime functioning) (Bastien et al. 2001). The questions are rated on a 5-point Likert scale (0 = "not at all", 4 = "extremely"), and the composite scores range from 0 to 28. Higher scores indicate greater insomnia severity. The ISI is a valid and reliable self-report measure of insomnia severity (Bastien et al. 2001; Thorndike et al. 2011) and has proven sensitive to treatment induced changes, making it a useful measure in treatment outcome studies (Morin et al. 2011). Insomnia remitters are defined as patients who attain an ISI score of less than 8 (Morin and Espie 2003), whereas responders achieve a reduction of ≥8 ISI points relative to baseline assessment (Morin et al.

2011). Cronbach alphas at pre-, post-, 6-month FU and 18-month FU in the present study were .51, .73, .86 and .87, respectively.

The Bergen Insomnia Scale (BIS) contains six questions that assess the participants´ insomnia symptoms (Pallesen et al. 2008) according to the insomnia inclusion criteria of the DSM-IV (Association AP 1994). Each item is scored using a scale from 0 to 7, which indicates how many days a week during the last month the participant has been struggling with various insomnia symptoms. The first four items measure participants' nocturnal sleep impairment and the last two items assess daytime impairment and sleep dissatisfaction. In this study, the scale was used as a continuous measure where higher scores indicate more symptoms of insomnia. The BIS has shown good psychometric properties with Cronbach´s alpha of. 58 at baseline, .82 at post-assessment, .79 at 6-month FU, and .85 at 18-month FU, respectively (Pallesen et al. 2008).

The 16 item version of the Dysfunctional Beliefs and Attitudes about Sleep (DBAS-16) is a self-report questionnaire designed to identify maladaptive beliefs and attitudes about sleep (Morin et al. 2007). The DBAS-16 items are rated on a scale from 0 to 10. Higher scores indicate more dysfunctional beliefs and attitudes. The scale has shown adequate internal consistency both in clinical and research samples (Morin et al. 2007). Also in the present study, the internal consistency of the DBAS-16 was high, where Cronbach´s alphas were .81 at baseline, .89 at post-assessment, .90 at post 6-month FU and .89 at 18-month FU, respectively.

The Hospital Anxiety and Depression Scale (HADS) was used to assess the participant's general psychological distress (Zigmond and Snaith 1983). The scale comprises 14 items, seven for anxiety and seven for depression, where higher scores indicate higher symptom severity. The HADS can be used to separately assess symptom severity of anxiety and depression. In this study, a composite score of the scale was used as a measure of general

psychological distress. Cronbach´s alphas at the different assessment points were .82 at pre, .83 at post, .84 at 6-month FU, and .82 at 18-month FU.

The Chalder Fatigue Scale (CFQ) is a self-administered questionnaire used to measure the extent and severity of fatigue complaints (Chalder et al. 1993). The CFQ contains 13 items, and is answered on a 4-point scale ranging from asymptomatic to maximum symptomatology. A composite score including all 13 items was used in the present study ranging from 0 to 39. The CFQ has shown good psychometric properties (Morriss et al. 1998; Cella and Chalder 2010). In the present study, Cronbach´s alphas for the CFQ at the different assessment points were .84 at pre, .85 at post, .91 at 6-month FU, and .86 at 18-month FU, respectively.

The consensus sleep diary consisted of 11 questions pertaining to the time the person went to bed, the time it took them to fall asleep, number of and length of awakenings during the night, time of final awaking and rise time in the morning, number of and length of naps during the day, use of medication and alcohol consumption, etc. (Morin 1993; Carney et al. 2012). Sleep parameters derived from the sleep diary include wake after sleep onset (WASO), sleep onset latency (SOL), sleep efficiency (SE), early morning awakening (EMA), time in bed (TIB), and total sleep time (TST). Sleep diaries are considered useful measures in treatment studies (Lichstein and Riedel 1994), and insomnia patients self-report tend to correlate significantly with objective sleep measures, such as polysomnography (PSG) (Coates et al. 1982). To increase the reliability, data analyses were based on the average scores of the recording from the 10 days of diaries at each assessment point.

Data analysis

Data analyses were conducted using IBM © SPSS Statistics (version 23) (IBM SPSS Statistics, New York, USA). Participants were classified as morning or evening persons based

on a median split of the scores on the rMEQ. The ICBTi group consisted of 41 morning persons and 51 evening persons, while the web-based patient education group consisted of 44 morning persons and 42 evening persons. For descriptive purpose, t-tests and chi-square tests were conducted to examine differences between morning and evening persons at baseline. Separate linear mixed models for repeated-measures analyses were performed for morning persons and evening persons, respectively, in order to assess the effects of the ICBTi intervention compared to the patient education intervention. Separate linear mixed models were also performed for the within-subject effects and the between subject effects. Linear mixed models use the intention-to-treat principle where all participants with baseline data are included in the analysis. No constraints were imposed on the covariance structure for repeated measures (type = unstructured). Mixed model analysis uses maximum likelihood estimation and can handle data that are missing at random (MAR) on dependent variables. Although there are no conclusive tests to prove the assumption of MAR, it is generally considered a more realistic assumption as compared to missing completely at random (MCAR). Under the assumption of MAR (missing at random), the estimates are still valid, and provide valuable information about the extent to which the changes from baseline to post-treatment in the present study are maintained at 6- and 18-month FU, respectively.

This study was originally powered to be able to detect a difference (Cohens d) between Internet-delivered CBTi and a patient education intervention at posttreatment of approximately 0.45 (Hagatun et al. 2019). However, the between group effect sizes on several of the primary measures (e.g. ISI, BIS, DBAS) were >1 in the original study (Hagatun et al. 2019), which can justify exploratory analyses on smaller subgroups as in the present study. Effect sizes (Cohen´s d) were calculated on the basis of the results from the mixed model analyses (estimated values), and in concordance with suggested guidelines (Carlson et al. 1999). The between-group effect size was calculated as the difference between within-group

effect size at post-treatment of the ICBTi group and the within-group effect size at post-treatment for the patient education group. As a guideline for interpreting effect sizes, $d = 0.8$ is regarded as large, $d = 0.5$ as medium and $d = 0.2$ as small, respectively (Cohen 1988).

Results

Baseline differences

Baseline characteristics for morning and evening persons can be found in Table 1. Mean rMEQ scores was 17.7 (*SD*= 2.0) for morning persons and 10.6 (*SD*= 3.0) for evening persons. There were no significant differences between morning and evening persons regarding age, sex and education level. Most participants were female (64.7% for morning persons and 68.8% for evening persons), and mean age was 44.3 years (*SD*=12.5) for morning persons, and 45.2 years (*SD*=13.4) for evening persons. Mean years of education was 16.4 (*SD*=3.2) for morning persons, and 16.5 (*SD*=2.8) for evening persons. At baseline, morning persons had significantly more WASO (*d*=0.54, p<.001) and EMA (*d*=0.38, p<.05), compared to evening persons, while evening persons had significantly longer SOL (*d*=0.60, p<.001), TST (*d*=0.45, p<.01), TIB (*d*=0.56, p<.001) and a higher score on the DBAS-16 (*d*=0.47, p<.01) and the CFQ (*d*=0.31, p<.05), compared to morning persons. There were no significant differences between morning and evening persons in terms of ISI, BIS, HADS or sleep efficiency (SE).

Morning and evening persons were divided into five insomnia subtypes based on their pre-treatment score on the BIS. 81 morning persons and 88 evening persons fulfilled the criteria for “a mixture of nightly symptoms”. 1 morning person and 5 evening persons fulfilled the criteria for “only complaints of unrefreshing sleep”, while 3 morning persons and none evening persons fulfilled the criteria for “only early morning awakening difficulties”.

None of the morning and evening persons fulfilled the criteria for “only sleep onset difficulties” nor “only sleep maintenance difficulties”.

Effects of the treatment on the questionnaire data

Table 2 presents the results from the linear mixed models on the effects of ICBTi compared to Patient Education (PE) for morning persons and evening persons. For morning persons who got access to the SHUTi intervention; 98% completed Core 1, 93% completed Core 2, 90% completed Core 3, 85% completed Core 4, 85% completed core 5 and 81% completed Core 6. For evening persons; 92% completed Core 1, 80% completed Core 2, 69% completed Core 3, 63% completed Core 4, 57% completed Core 5 and 47% completed Core 6. Both morning and evening persons scored in the range of moderately to severe clinical insomnia on the ISI. There were significantly better effects of ICBTi than of PE on the ISI, with large effect sizes both for morning and evening persons. This was also the case on the BIS. The within-effects on the ISI and the BIS for morning and evening persons in the ICBTi group remained large from baseline to post-assessment, 6-month FU and 18-month FU. As shown in Table 3, 11 morning persons (34.4 %) and 15 evening persons (53.6%) in the ICBTi group achieved an ISI score below 8 points at 18-month FU, indicating remission from clinical insomnia (Morin and Espie 2003). At 18-month FU, 14 morning persons (43.8%) and 15 evening persons (55.6%) in the ICBTi group experienced clinically significant improvements.

Results on the DBAS-16 and the CFQ indicated large effect-size improvements from baseline to post-assessment for the ICBTi group compared to the patient education group, both for morning and evening persons, respectively. Furthermore, these effects were sustained in both ICBTi groups with medium-to-large effect sizes to 6- and 18-month FU. As for psychological distress (HADS) as outcome, both morning and evening persons benefitted significantly from the ICBTi treatment with small-to-medium between-group effect-size

improvements compared to their respective PE groups. Overall, the within-subject effects for morning and evening persons in the ICBTi treatment on these measures were maintained from baseline to 6- and 18-month FU, with small-to-medium effect-sizes.

Effects of the treatment on the sleep diary data

As for the measures derived from the sleep diary, the linear mixed models showed no significant difference in effect of treatment between the ICBTi group and the PE group on SOL and TST, neither for morning persons nor for evening persons. Both morning and evening persons experienced a significantly reduced WASO and EMA in the ICBTi group compared to the PE group, with small-to-medium effect-sizes. The within-subject effects for the two ICBTi groups were also maintained at 6- and 18-month FU, with medium-to-large effect-sizes for morning persons and small-to-medium effect-sizes for evening persons.

Morning and evening persons who received ICBTi reported a significant improvement in their SE compared to the respective PE groups, with large effect-size improvements for morning persons and medium effect-size improvement for evening persons. The within-subject analyses for the ICBTi group indicated that the improvements were maintained from baseline to 6- and 18-month FU, with large effect-sizes both for morning and evening persons. At post assessment, both morning and evening persons achieved a SE above the clinically meaningful threshold of >85%, whereas the respective PE groups were both below this threshold. By and large, the SE values for the two ICBTi groups were maintained for morning persons (84.1%) and evening persons (84.3%) at 18-month FU.

Discussion

The aim of this study was to investigate the nature of insomnia symptomatology in morning and evening persons with insomnia, and whether ICBTi was effective for these two groups.

Our findings show that morning and evening persons had a somewhat different insomnia symptomatology at baseline. Specifically, morning persons experienced greater WASO and EMA than evening persons, while evening persons reported longer SOL, TIB, TST, more fatigue, and higher scores on the DBAS-16 compared to morning persons. These findings suggest that assessing the morningness-eveningness orientation of patients with insomnia may provide useful information about the expected pattern of complaints, which can be considered during treatment. However, in spite of different insomnia symptomatology at baseline between morning and evening persons, both groups showed comparable improvements in terms of sleep and daytime functioning following ICBTi compared to their respective control group, both short- and long-term.

The baseline differences in insomnia symptoms between morning and evening persons seem to correspond to chronobiological differences that have previously been identified among those who have early morning awakening difficulties and those who have sleep initiation difficulties. In particular, people with early morning awakening insomnia have been shown to have more advanced core body temperature than those with sleep onset insomnia (Lack et al. 2008), and early morning awakening is in line with this regarded as a biological marker of morningness (Adan et al. 2012). Conversely, people with sleep onset insomnia have been shown to have more delayed core body temperature rhythms (Morris et al. 1990) which corresponds to biological indicators of eveningness (Adan et al. 2012). The results of the present study – where morning persons displayed more EMA and evening persons displayed more SOL at baseline – can thus be considered coherent with previous observations.

It is well known that both people suffering from sleep initiation difficulties and those suffering from difficulties maintaining sleep benefit from CBTi. However, from a theoretical point of view, there are other important differences between morning and evening persons that might moderate the effect they obtain from CBTi, and especially of unguided ICBTi. For

example, in the present study, evening persons reported more fatigue, DBAS, TST and TIB than morning persons, which suggest that evening and morning persons with insomnia differ in their pattern of complaints beyond the core symptoms of insomnia (i.e. SOL, WASO and EMA). These findings are in line with the results from a cross-sectional study that showed that evening persons with insomnia reported more dysfunctional thoughts about sleep, TIB, TST, symptoms of depression, and a greater variability in time out of bed compared to morning and intermediate persons with insomnia (Ong et al. 2007). In addition, despite that morning and evening persons showed comparable improvements following ICBTi in this study, more morning persons completed all six treatment cores (81%), compared to evening persons (47%). This may reflect that morning and evening persons have been found to differ on personality traits that may be of importance in terms of adherence to treatment. For example, evening persons tend to score lower on conscientiousness (Adan et al. 2012), which may have implications for the risk of dropping out of treatment (Melville et al. 2010).

Both morning and evening persons in the present study showed improved sleep and daytime functioning after receiving ICBTi, with comparable effects of the treatment between the two groups. These were further well maintained at 6-month and 18-month FU. The findings of the present study are in line with the results from a study on group-delivered CBTi, where both morning and evening persons appeared to benefit from the treatment in terms of improved sleep (Bei et al. 2015). The findings from the present study add to the literature by being the first to demonstrate beneficial effects of unguided ICBTi for both morning and evening persons compared to corresponding control groups, and also by being the first to show that these effects were maintained long-term for both groups.

In the present study, small to very large effect size improvements were observed for both morning and evening persons from baseline to 18-month FU on all sleep-related parameters, as well as on symptoms of psychological distress and fatigue. On most

parameters, the patients displayed the greatest improvements immediately after the intervention period, where the mean values appeared to recede somewhat at 18-month FU. This was the case for the SOL, WASO, EMA, SE and for the scores on the ISI and the CFQ. Both morning and evening persons reduced SOL, WASO and EMA below the clinically meaningful threshold of 30 minutes at post-assessment, and remained below or slightly above this threshold also at 18-month FU. As for SE, both groups improved to above the clinically meaningful threshold of 85% post-assessment, and the effects were by and large maintained at 18-month FU, with SE of 84.1% and 84.3% for morning and evening persons, respectively.

Regarding general psychological distress (i.e. HADS), no differences were found between morning and evening persons at baseline. Results from previous studies, however, suggest that evening persons report more depressive symptoms both when they have insomnia (Ong et al. 2007) and when they do not (Kitamura et al. 2010) as compared to morning and intermediate persons. In one study investigating patients with insomnia, it was found that stronger evening preference predicted less reduction in depressive symptoms following group CBTi, compared to patients with stronger morning preference (Bei et al. 2015). However, the results from the present study suggest comparably positive effects of ICBTi for morning and evening persons on general psychological distress, with small-to-medium effect size improvements to post assessment and at 18-month FU. It should also be noted that moderate to severe cases of depression were excluded from the present study, thus participants in the present study generally reported low levels of psychological distress at baseline. Nonetheless, the significant effects of ICBTi on psychological distress for both groups support the notion that ICBTi can be valuable as part of the treatment of comorbid conditions – something that also has been reported by other studies on the SHUTi intervention (Christensen et al. 2016; Hagatun et al. 2018).

Limitations and strengths

The present study has some limitations that should be noted. One important limitation is the relatively small sample size, which precludes direct comparison of the treatment effects obtained by morning and evening persons due to lack of power. Another important limitation is that there was no control group at 6-month and 18-month FU. Thus, we cannot rule out other possible explanations to the sustained effects in the intervention groups. Overall, the response rate in this study was similar to that obtained in other studies on ICBTi (Christensen et al. 2016; Ritterband et al. 2017). Notably, fewer participants completed the 6-month FU than the 18-month FU in the present study. One possible explanation for this is that participants were offered a compensation of NOK 500 (approximately USD 60) for completing the 18-month FU, whereas no compensation was offered for completing the 6-month FU.

It can further be considered a limitation that all measures were based on self-report. Future studies might consider including objective measures (actigraphy or polysomnography recordings) and clinician rated outcomes in the study protocol, although sleep diaries have been shown to be a reliable and valid way to measure sleep, and comparable to more objective measures (Coates et al. 1982). A strength of the current study is that sleep diaries were used to assess the patients' sleep at all assessments points, since day-to-day records are less affected by recall bias and usually considered more accurate than questionnaire assessments alone.

It is also a limitation that morning and evening persons were identified with a median split of the rMEQ. This is an approach that does not take into consideration that most people identify themselves as intermediate persons (Adan et al. 2012). However, differentiating between smaller groups would not have been possible in the present study due to the limited

sample size. The ‘morning’ and ‘evening’ categories in the present study should, therefore, be considered as proxies to the two extremes, and the two groups may be more similar to each other in terms of sleep characteristics than otherwise, because they both include persons that could be classified as intermediates. Reliability analyses showed that the ISI and the BIS both had low internal consistency at baseline assessment, which can be due to restricted range of scores at that time point. A final limitation was that participants in the present study were self-recruited, which could imply that they represent a more motivated group of patients than those usually referred from general practice. A unique feature of the present study is the 18-month FU assessment, where the current study is among very few that have assessed how well the improvements of CBTi are maintained long term (>6 months).

Conclusion

In conclusion, this study explores individual characteristics that might influence whether a person will benefit from unguided ICBTi or not. Our results indicate that the effects of ICBTi are substantial and lasting beyond the intervention period for both those broadly defined as morning and evening persons, with up to large effect size improvements on standard sleep and daytime functioning outcomes. In spite of different insomnia symptomatology at baseline for morning and evening persons, the two groups obtained comparable effects by the ICBTi treatment. Future studies should replicate these findings in larger samples where it would also be possible to distinguish between more standardized definitions of morning persons, intermediates, and evening persons; and where there is also a control group on the follow-up measurements to corroborate the long-term effects of the treatment.

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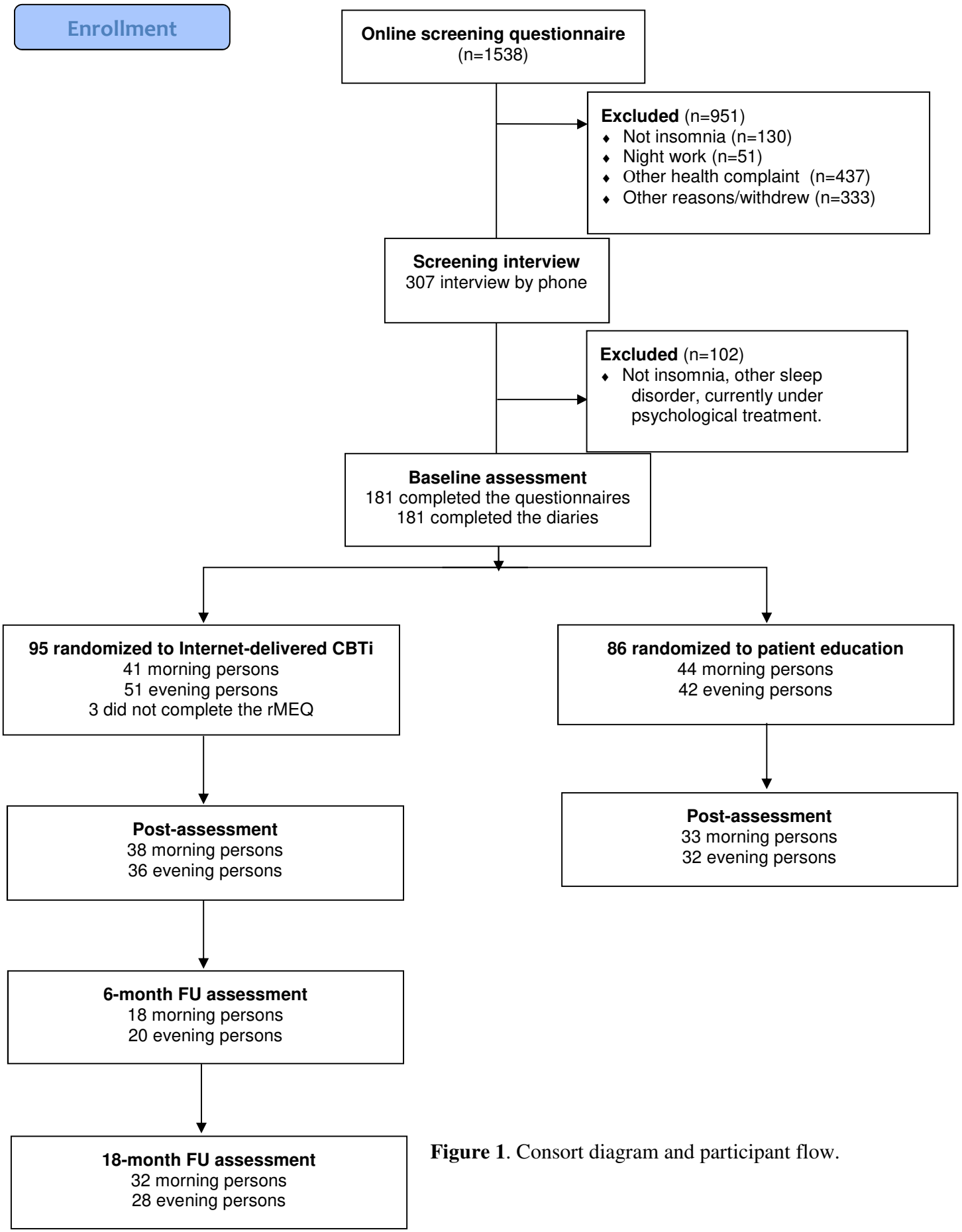

Figure 1. Consort diagram and participant flow.

Table 1. Baseline characteristics for morning persons (N = 85) and evening persons (N = 93).

	Morning persons	Evening persons	Baseline differences
	Mean (95% CI)	Mean (95% CI)	$d_{between}$[1]
rMEQ-score	17.7 (17.3-18.1)	10.6 (10.0-11.2)	2.78***
Age (years)	44.3 (41.6-47.0)	45.2 (42.4-48.0)	0.07
Education level (years)	16.4 (15.7-17.1)	16.5 (15.9-17.0)	0.02
Sleep onset latency (min)	39.3 (29.9-48.7)	68.0 (57.4-78.6)	0.60***
Wake after sleep onset (min)	51.7 (44.8-58.6)	35.2 (29.2-41.3)	0.54***
Early morning awakening (min)	43.9 (37.6-50.2)	33.5 (28.3-38.7)	0.38*
Sleep efficiency	70.8 (68.2-73.5)	71.7 (69.1-74.4)	0.07
Total sleep time (hour)	5.3 (5.1-5.6)	5.8 (5.6-6.1)	0.45**
Time in bed (hour)	7.6 (7.4-7.8)	8.1 (7.9-8.3)	0.56***
Insomnia Severity Index	17.8 (17.1-18.6)	17.5 (16.8-18.3)	0.08
Bergen Insomnia Scale	26.2 (24.6-27.9)	25.5 (24.1-27.0)	0.10
DBAS-16	4.8 (4.5-5.1)	5.4 (5.2-5.7)	0.47**
Chalder Fatigue Scale	18.4 (17.2-19.7)	20.2 (19.0-21.3)	0.31*
HADS-total	9.8 (8.7-11.0)	10.6 (9.5-11.6)	0.14

Note. [1] Effect sizes here refer to the between group effects at baseline.
* p<.05; ** p<.01; *** p<.001

Table 2. Results from the linear mixed models on the effects of ICBTi compared to Patient Education (PE) for morning persons and evening persons.

	Morning persons						Evening persons					
	Internet CBT-I (N = 41)		Patient education (N = 44)		Time x group		Internet CBT-I (N = 51)		Patient education (N = 42)		Time x group	
	Mean (95% CI)	d_{within}[1]	Mean (95% CI)	d_{within}[1]	t	$d_{between}$[2] (95%CI)	Mean (95% CI)	d_{within}[1]	Mean (95% CI)	d_{within}[1]	t	$d_{between}$[2] (95%CI)
Questionnaires:												
Insomnia Severity Index												
Baseline	17.3 (16.2 – 18.4)		18.3 (17.3 – 19.4)				17.4 (16.4 – 18.4)		17.7 (16.5 – 18.8)			
Post-assessment	8.8 (7.1 – 10.5)	2.48***	16.4 (14.6 – 18.3)	0.52*	5.6	1.89***	8.6 (7.0 – 10.2)	2.24***	15.0 (13.3 – 16.8)	0.75***	5.9	1.64***
6-month FU	9.6 (7.4 – 11.8)	2.25***				(1.12–	7.6 (5.7 – 9.5)	2.46***				(1.01–
18-month FU	10.0 (8.0 – 12.1)	2.13***				2.48)	8.7 (6.7 – 10.7)	2.19***				2.15)
Bergen Insomnia Scale												
Baseline	26.1 (23.7 – 28.5)		26.4 (24.1 – 28.7)				25.4 (23.4 – 27.3)		25.6 (23.5 – 27.8)			
Post-assessment	15.3 (12.5 – 18.1)	1.55***	22.9 (20.1 – 25.8)	0.41**	4.6	0.96***	13.9 (11.5 – 16.4)	1.60***	21.8 (19.1 – 24.4)	0.58***	5.5	1.08***
6-month FU	14.4 (10.8 – 18.0)	1.68***				(0.49–	10.3 (7.6 – 13.1)	2.07***				(0.67–
18-month FU	15.3 (11.7 – 18.9)	1.55***				1.31)	11.3 (8.3 – 14.3)	1.92***				1.51)
DBAS-16												
Baseline	4.5 (4.1 – 5.0)		5.0 (4.6 – 5.5)				5.3 (4.9 – 5.6)		5.6 (5.2 – 6.0)			
Post-assessment	2.9 (2.4 – 3.4)	1.04***	4.9 (4.4 – 5.5)	0.08	4.8	1.02***	3.6 (3.0 – 4.1)	1.34***	5.6 (5.0 – 6.2)	-0.01	5.4	1.35***
6-month FU	2.6 (2.0 – 3.3)	1.24***				(0.55–	2.8 (2.2 – 3.4)	1.93***				(0.82–
18-month FU	2.7 (2.1 – 3.2)	1.21***				1.41)	2.8 (2.2 – 3.4)	1.92***				1.85)
Chalder Fatigue Scale												
Baseline	17.8 (16.0 – 19.6)		19.0 (17.3 – 20.7)				19.6 (18.1 – 21.2)		20.8 (19.1 – 22.5)			
Post-assessment	12.3 (10.6 – 13.9)	1.00***	18.7 (17.0 – 20.5)	0.03	4.4	0.91***	13.0 (11.0 – 15.0)	1.33***	19.7 (17.5 – 21.9)	0.19	4.2	0.99***
6-month FU	14.0 (11.5 – 16.4)	0.69**				(0.49–	13.6 (11.4 – 15.7)	1.21***				(0.50–
18-month FU	14.7 (12.3 – 17.1)	0.55*				1.33)	13.6 (12.2 – 15.0)	1.20***				1.50)
HADS – total												
Baseline	9.7 (8.0 – 11.3)		10.0 (8.4 – 11.6)				10.0 (8.5 – 11.5)		11.5 (9.8 – 13.1)			
Post-assessment	6.7 (5.1 – 8.4)	0.49***	10.6 (8.9 – 12.3)	-0.12	4.0	0.67***	7.1 (5.5 – 8.6)	0.59***	11.0 (9.3 – 12.7)	0.09	2.9	0.47**
6-month FU	7.8 (5.4 – 10.2)	0.31				(0.33–	7.6 (5.8 – 9.5)	0.47**				(0.16–
18-month FU	6.7 (4.8 – 8.6)	0.50*				1.02)	7.3 (5.6 – 9.0)	0.53**				.79)
Sleep Diary measures:												
Time in bed												
Baseline	7.5 (7.3 – 7.8)		7.7 (7.4 – 7.9)				8.1 (7.8 – 8.3)		8.2 (7.9 – 8.5)			
Post-assessment	6.8 (6.5 – 7.1)	0.84***	7.5 (7.2 – 7.8)	0.15	3.3	0.70**	7.3 (7.0 – 7.6)	0.73***	8.1 (7.8 – 8.4)	0.13	3.4	0.66**
6-month FU	7.2 (6.9 – 7.4)	0.42**				(0.26–	7.9 (7.5 – 8.2)	0.20				(0.24–
18-month FU	7.3 (7.1 – 7.6)	0.23				1.14)	7.7 (7.4 – 8.1)	0.32*				1.04)

Sleep onset latency												
Baseline	35.9 (22.3 – 49.5)		42.5 (29.4 – 55.6)				59.6 (45.6 – 73.7)		78.2 (62.7 – 93.8)			
Post-assessment	15.4 (5.2 – 25.6)	0.67***	35.6 (24.7 – 46.6)	0.14	1.7	0.31	27.9 (18.0 – 37.8)	0.71***	55.2 (43.7 – 66.8)	0.42**	0.9	0.18
6-month FU	16.0 (8.4 – 23.7)	0.63***				(-0.05–	35.9 (24.0 – 47.8)	0.53***				(-0.20–
18-month FU	19.9 (7.9 – 31.9)	0.49**				.68)	31.1 (21.2 – 41.1)	0.60***				.56)
Wake after sleep onset												
Baseline	50.7 (40.7 – 60.7)		52.7 (43.0 – 62.3)				37.2 (28.9 – 45.4)		33.5 (24.4 – 42.6)			
Post-assessment	19.4 (10.0 – 28.9)	1.08***	43.7 (33.6 – 53.7)	0.26	3.6	0.69**	19.1 (12.0 – 26.2)	0.61***	27.1 (18.9 – 35.2)	0.21*	2.3	0.39*
6-month FU	17.8 (11.0 – 24.6)	1.12***				(0.25–	18.9 (10.5 – 27.4)	0.62**				(0.05–
18-month FU	29.7 (20.3 – 39.2)	0.71***				1.12)	24.3 (15.6 – 33.1)	0.44*				.75)
Early morning awakening												
Baseline	43.4 (34.3 – 52.5)		44.3 (35.5 – 53.1)				34.9 (27.9 – 41.9)		31.9 (24.2 – 39.7)			
Post-assessment	19.5 (11.2 – 27.8)	0.93***	38.8 (29.9 – 47.8)	0.11	3.2	0.63**	14.3 (8.2 – 20.4)	0.73***	31.0 (23.9 – 38.1)	0.05	4.0	0.78***
6-month FU	15.0 (8.6 – 21.3)	1.09***				(0.25–	17.5 (10.4 – 24.7)	0.62***				(0.40–
18-month FU	21.1 (13.6 – 28.5)	0.86***				1.00)	19.3 (11.9 – 26.8)	0.54***				1.15)
Sleep efficiency												
Baseline	71.8 (67.9 – 75.6)		70.0 (66.3 – 73.7)				72.7 (69.1 – 76.3)		70.4 (66.4 – 74.3)			
Post-assessment	87.0 (83.6 – 90.3)	1.34***	74.5 (70.9 – 78.1)	0.34*	-4.7	0.86***	86.4 (83.2 – 89.6)	1.10***	76.6 (72.8 – 80.3)	0.47**	-3.1	0.59**
6-month FU	88.1 (85.4 – 90.8)	1.42***				(0.44–	84.7 (81.4 – 87.9)	0.96***				(0.21–
18-month FU	84.1 (80.2 – 88.0)	1.07***				1.20)	84.3 (80.8 – 87.7)	0.93***				.94)
Total sleep time												
Baseline	5.4 (5.1 – 5.7)		5.3 (5.0 – 5.6)				5.9 (5.5 – 6.2)		5.8 (5.4 – 6.2)			
Post-assessment	5.9 (5.6 – 6.2)	0.59***	5.6 (5.2 – 5.9)	0.20*	-1.9	0.31	6.3 (6.0 – 6.6)	0.35***	6.2 (5.9 – 6.6)	0.36*	-0.2	0.03
6-month FU	6.3 (5.9 – 6.6)	0.97***				(-0.01–	6.6 (6.3 – 6.8)	0.59***				(-0.35–
18-month FU	6.1 (5.9 – 6.4)	0.83***				.63)	6.5 (6.3 – 6.8)	0.54***				.43)

Note. [1]Cohen`s d effect sizes show within effects and are specified relative to baseline. Separate linear mixed models were performed for the within-subject effects and the between subject effects. [2]Effect sizes here refer to the between group effects at post assessment. Positive Cohen`s d reflect an improvement. 95% CI intervals for the between group effect sizes were calculated in Mplus version 8. * p<.05; ** p<.01; *** p<.001

Table 3. Number of participants (and %) who classified as remitters and responders based on the Insomnia Severity Index (ISI) after the intervention period.

	Morning persons		Evening persons	
	Internet CBT-I	Patient education	Internet CBT-I	Patient education
ISI remitters (<8)				
Post-assessment	17 (44.7%)	2 (6.1%)	20 (55.6%)	3 (9.4%)
6-month FU	10 (55.6%)		13 (65.0%)	
18-month FU	11 (34.4%)		15 (53.6%)	
ISI responders				
Post-assessment	20 (52.6%)	4 (12.1%)	21 (58.3%)	3 (9.4%)
6-month FU	12 (66.7%)		14 (70.0%)	
18-month FU	14 (43.8%)		15 (55.6%)	

Note. Insomnia remitters are patients who attain an ISI score of less than 8, whereas responders are patients who achieve a reduction of ≥8 ISI points relative to baseline assessment.