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Original Article

Pre-Sleep Arousal Scale (PSAS) and the Time Monitoring Behavior-10 scale (TMB-10) in good sleepers and patients with insomnia

Juliana Vochem, Christine Strobel, Lena Maier, Kai Spiegelhalder, Elisabeth Hertenstein, Dieter Riemann, Bernd Feige*

Department of Psychiatry and Psychotherapy, Medical Center – University of Freiburg, Faculty of Medicine, University of Freiburg, Germany

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ABSTRACT

Objectives: Pre-sleep arousal and time monitoring behavior are two putative factors involved in the development and maintenance of insomnia. We investigate two questionnaires measuring these factors in good sleepers and patients with insomnia.
Participants: A sample of 96 patients with non-organic insomnia according to ICD-10 and 208 good sleepers completed the Pre-Sleep Arousal Scale (PSAS), the Time Monitoring Behavior-10 scale (TMB-10), the Beck Depression Inventory (BDI)-II, the Pittsburgh Sleep Quality Index (PSQI), the Insomnia Severity Index (ISI) and the State-Trait Anxiety Inventory (STAI).
Methods: In this study, 95% quantile cut-off scores were determined for good sleeper in the age and gender mathed subgroups of the insomnia group. Multiple logistic regression analysis was used to determine variables predicting above-threshold values in the two target questionnaires. Included predictors were age, gender as well as ISI, BDI-II, STAI-1 and -2 total scores.
Results: Good sleepers showed 95% quantiles between 12.2 and 23.8 for PSAS and between 7.5 and 12.7 for TMB-10. Approximately 40% of patients with insomnia had scores above these cut-offs for PSAS and ca. 25% for TMB-10. Female gender and anxiety were variables associated with scores above cut-off on the PSAS. Insomnia severity and anxiety were associated with scores above cut-off on the TMB-10.
Conclusions: These findings underline the importance of PSAS and TMB-10 in the diagnostic investigation of insomnia and indicate that time monitoring is related to increased insomnia severity. Further research may investigate the impact of the corresponding two constructs on response rates to cognitive-behavioral treatment for insomnia.

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1. Introduction

Insomnia disorder according to DSM-5 is defined as difficulties initiating or maintaining sleep, accompanied by impaired daytime functioning [1]. Insomnia is the most prevalent sleep disorder. Occasional insomnia afflicts up to 50% of the general population depending on the applied criteria, whereas up to 4% of the population is affected by insomnia in the absence of comorbid medical diseases or psychiatric disorders [2].

In current models of insomnia, physiological, cognitive and emotional hyperarousal play an important role for the development and maintenance of the disorder (eg, [3]; [4]; [5]).

The Pre-Sleep Arousal Scale (PSAS) [6] German version [7] is the most frequently used self-report instrument for measuring subjective physiological and cognitive pre-sleep arousal (ie, state of arousal as subjects fall asleep). Several studies investigated the effects of cognitive pre-sleep arousal on sleep using the PSAS. In a study by Gross and Borkovec [8], pre-sleep arousal before a nap was induced in good sleepers (GS) by telling them that they would have to give a speech after waking up. Compared to two control conditions, the participants reported longer sleep onset latency (SOL) and a reduced amount of sleep when anticipating to give a speech. In patients with insomnia, PSAS scores are generally higher than in

Abbreviations: BDI, Beck Depression Inventory; GS, Good Sleepers; ISI, Insomnia Severity Index; PSAS, Pre-Sleep Arousal Scale; PSQI, Pittsburgh Sleep Quality Index; STAI, State-Trait Anxiety Inventory; TMB, Time Monitoring Behavior; SO, Sleep Onset; SM, Sleep Maintenance.

* Corresponding author. Department of Psychiatry and Psychotherapy, Medical Center – University of Freiburg, Faculty of Medicine, University of Freiburg, Hauptstraße 5, 79104, Freiburg, Germany. Fax: +49 761 270 66190.
E-mail address: bernd.feige@uniklinik-freiburg.de (B. Feige).

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healthy control participants [9]. In addition, subjective cognitive arousal appears to be more likely to be the main determinant for sleeping problems than physiological [10].

The Time Monitoring Behavior-10 scale (TMB-10) [11] is a questionnaire to measure nocturnal clock watching. This behavior correlates with difficulties initiating [12] and maintaining sleep [11]. Patients with insomnia potentially aggravate their disorder by regularly watching the clock while trying to fall asleep and calculating how much sleep time they have left [11]. In an experiment by Tang et al., [12], good as well as bad sleepers were instructed to monitor the clock while falling asleep and showed a higher pre-sleep arousal and longer SOL than a control group without clock monitoring. Avoiding clock watching is a major component of sleep hygiene [13,14].

The aim of the present study was to evaluate possible predictors of elevated PSAS and TMB-10 scores by using data from a large sample of GS and insomnia patients. First, distribution-based cut-off scores were determined in the GS group. Afterwards, these cut-off scores were used in insomnia patients modelling the influence of insomnia severity, depression and anxiety on the probability of exceeding the cut-off scores.

2. Methods

2.1. Design

The present study is a prospective questionnaire investigation with a sample consisting of 96 insomnia patients and 208 GS recruited from October 2015 to May 2017. The investigation was conducted using self-reported questionnaire data.

2.2. Participants

The participants in the insomnia group were recruited from regular patients referred to our clinic through their general practitioner or other medical specialists and meeting the following inclusion criteria: diagnosis of non-organic insomnia according to ICD-10 (F51.0: difficulties initiating or maintaining sleep, impaired daytime functioning, no evidence of any specific cause [15]), age of at least 18 years and no missing values on any questionnaire. No explicit limit was set for the Pittsburgh Sleep Quality Index (PSQI).

The GS were recruited from the community by advertisements in public and social media. The inclusion criteria for GS were that they regarded themselves as good sleepers, aged at least 18 years with no upper age limit, showed no missing values on any questionnaire and had values <7 on the PSQI (for the cut-off see Ref. [16]) and <13 on the Beck Depression Inventory-II (BDI-II; for the cut-off see Ref. [17]). All participants submitted a written informed consent. The study was approved by the Ethics Committee of the University Medical Centre Freiburg.

2.3. Measures and procedure

All participants filled in a set of questionnaires that were intended to reflect presumed mechanisms in the development and maintenance of insomnia. Insomnia patients completed the questionnaires on a laptop during their consultation (9–11 am), while GS filled them in online at home (at unknown time of day).

The PSAS [6], German version [7] consists of 16 items relating to experiences before falling asleep: half of them refer to physiologic arousal (PSAS 1, eg, heart racing, pounding or beating irregularly; stomach upset), the other half refer to cognitive arousal (PSAS 2, eg, worry about falling asleep; cannot shut thoughts off). All items refer to the past two weeks. The PSAS is rated on a 5-point Likert scale from 1 (not at all) to 5 (extremely) with total scores ranging from 8 to 40 points on both subscales, with higher scores indicating a higher pre-sleep arousal.

The TMB-10 [11] consists of 10 items: five of them refer to clock watching and subsequent negative feelings at sleep onset (TMB-10 SO), whereas the other five items refer to clock watching and subsequent negative feelings at awakening during the night (TMB-10 SM, sleep maintenance). The items do not refer to a particular time interval. The TMB-10 is based on a 4-point Likert scale from 0 (rarely/never/none) to 3 (almost always/always/severe). Total scores range from 0 to 15 on both subscales, with higher scores indicating a higher frequency of nocturnal time monitoring and resulting negative feelings.

The 21-item Beck Depression Inventory-II (BDI-II [18]) is an established questionnaire to capture the severity of depressive symptoms. Scores between 13 and 18 indicate a slight depressive syndrome, scores between 19 and 28 a moderate and scores ≥29 a severe depressive syndrome [17].

The 24-item Pittsburgh Sleep Quality Index (PSQI [19], German version [20]) is a renowned tool to assess the subjective sleep quality and its disturbances. Five items are answered by the partner and have only descriptive value. The other 19 items are divided into seven subscales with total scores ranging from 0 to 21 points. A cut-off point >6 allows a good differentiation between good sleepers and patients suffering from sleep disorders and maximises the specificity of the PSQI with a just moderately reduced sensitivity in comparison to a cut-off point of >5 [16].

The Insomnia Severity Index (ISI) [21] consists of seven items that assess the key symptoms of insomnia. Total scores range from 0 to 28 and can be interpreted as followed: 8–14 = sub-threshold insomnia, 15–21 = moderate insomnia and 22–28 = severe insomnia [22].

The State-Trait Anxiety Inventory (STAI) [23], German version [24] consists of 40 items: half of them refer to state anxiety (STAI-1), whereas the other half refer to trait anxiety (STAI-2). Total scores between 20 and 80 on each subscale can be reached with higher scores indicating a higher intensity of anxiety.

2.4. Statistical analysis

Statistical analyses were conducted with the open source program “R” version 3.4.2 [25]. Means and standard deviations were calculated for descriptive purposes. To determine distribution-based cut-off scores for the PSAS and TMB-10, the GS were divided into six groups by age and gender. Three age groups equal in number of GS were constructed using tertiles (see Table 1). The first (18–25 years) and second age group (25–34 years) contained 70 GS, providing 33.7% of the sample each, whereas the third age group (34–82 years) contained 68 GS, providing 32.7% of the sample.

Cut-off scores were determined using the 95% quantiles in GS. We then computed the percentage of patients with insomnia exceeding the cut-off in their respective age and gender group. 95% quantiles were used because 5% is a standard value for an acceptable error rate. The 95% quantile can also be estimated more reliably than larger quantiles using our group sizes [26].

A multiple logistic regression was run within the insomnia group with the binary variable “above/less or equal to cut-off score” as the dependent and “age”, “gender”, “ISI total score”, “BDI-II total score”, “STAI-1 total score” and “STAI-2 total score” as independent variables. The level of statistical significance was set at $p < 0.05$ for all analyses.

Table 1
Description of the age groups constructed by GS age tertiles.

	Age groups in years	N	% of the sample	Gender[a]	
				F	M
GS	18–25	70	33.7	55 (26%)	15 (7%)
	25–34	70	33.7	48 (23%)	22 (11%)
	34–82	68	32.7	37 (18%)	31 (15%)
PI Patients	18–25	11	11.5	7 (7%)	4 (4%)
	25–34	12	12.5	8 (8%)	4 (4%)
	34–82	73	76.0	40 (42%)	33 (34%)

[a] Indication of *N* and in brackets of the percentage of the sample.

3. Results

3.1. Participant characteristics

Descriptive statistics regarding demographic and baseline data are listed in Table 2. As shown, the group of GS was younger and contained more females than the group of the patients with insomnia.

3.2. Descriptive statistics of the cut-off scores

As shown in Table 3, cut-off scores determined using the 95% quantile depending on age group and gender were between 12.2 and 15.7 for the PSAS 1, with a mean cut-off score of 13.8. For the PSAS 2, the cut-off scores were between 17.0 and 23.8, with a mean cut-off score of 20.9. The cut-off scores for the TMB-10 SO were between 7.5 and 12.7 with a mean cut-off score of 10.2; the ones of the TMB-10 SM between 8.5 and 12.0 with a mean cut-off score of 10.2 as well.

In Fig. 1, every subject is represented in his or her age group either by a circle (GS) or by a triangle (patients with insomnia) indicating the individual total score on the subscales of the PSAS and the TMB-10. The narrow horizontal lines indicate the determined mean cut-off score for each age group. The thick horizontal lines indicate the median of the total scores for each group within the age groups.

Table 4 indicates that 38.5% of the patients with PI exceed the determined cut-off scores for PSAS 1 and 41.7% for PSAS 2. Fewer patients with PI exceed the cut-off scores for TMB-10 SO (29.2%) and for TMB-10 SM (20.8%).

3.3. Multiple logistic regression analysis

The main results of the logistic regression are shown in Table 5.

For the PSAS 1, females had a higher likelihood of scores above the cut-off than men ($p = 0.012$).

Table 2
Demographic and baseline variables for GS and PI patients.

	GS	PI Patients
N	208	96
Gender (F)	67,31%	57,29%
Age	34,98 (15,37)	46,32 (13,81)
ISI	3,63 (3,00)	15,75 (4,38)
BDI-II	3,78 (3,50)	11,46 (9,05)
PSQI	3,27 (1,51)	11,04 (3,74)
STAI-1	32,17 (6,88)	42,54 (11,39)
STAI-2	31,82 (7,30)	43,05 (10,89)

Data are presented as means and standard deviation in parentheses; PSAS, Pre-Sleep Arousal Scale; TMB-10, Time Monitoring Behavior-10; ISI, Insomnia Severity Index; PSQI, Pittsburgh Sleep Quality Index; BDI-II, Beck Depression Inventory-II; STAI-1, State-Trait Anxiety Inventory-1; STAI-2, State-Trait Anxiety Inventory-2.

Table 3
Cut-off scores of the PSAS and TMB-10.

	18–25 years		25–34 years		34–82 years	
	M	F	M	F	M	F
N	15	55	22	48	31	37
PSAS 1	14.6	14.2	13.0	15.7	13.0	12.2
PSAS 2	20.5	20.0	23.8	22.7	17.0	21.2
TMB-10 SO[a]	11.3	11.3	9.0	12.7	7.5	9.2
TMB-10 SM[b]	9.3	10.3	9.0	12.0	8.5	12.0

Data represent the 95% quantiles for the six GS subgroups defined by age tertiles and gender.
[a] Sleep onset.
[b] Sleep maintenance; PSAS, Pre- Sleep Arousal Scale; TMB-10, Time Monitoring Behavior-10.

For both the PSAS 2 ($p = 0.032$) and the TMB-10 SO ($p = 0.026$), increased STAI-2 scores significantly predicted above-threshold scores, whereas no significant association was found for the STAI-1.

For the TMB-10 SO, additionally increased ISI scores predicted above-threshold scores ($p = 0.027$).

For the TMB-10 SM, increased ISI ($p = 0.066$) and STAI-2 scores ($p = 0.090$) were not significant predicting above-threshold scores. Unexpectedly, reduced BDI-II scores predicted above-threshold TMB-10 SM scores ($p = 0.012$). In the multiple logistic regression analysis, the influences of other variables are adjusted. This means that the BDI-II has a significant influence on the scores of the TMB-10 SM in the direction that patients with the same scores on the STAI and ISI but higher BDI-II scores report watching the clock less often during the night.

4. Discussion

The results of the correlational analyses performed in the present study indicate determining factors for the PSAS and the TMB-10 that can be useful in the therapy or prevention of insomnia.

First, the TMB-10 seems to be more specific for insomnia than the PSAS that does not show any significant correlation with the ISI. This finding indicates that subjective pre-sleep arousal alone cannot suffice in explaining insomnia. Some authors suggest that elevated cognitive arousal in insomnia patients is not limited to the pre-sleep period, but that cognitive arousal and worries about sleeping problems during the day also contribute in the maintenance of insomnia [27–29]. Harvey [28] could show that GS experience pre-sleep arousal as well, but sense and interpret it differently than patients with insomnia. GS focused on “nothing in particular” before falling asleep, whereas insomnia patients payed significantly more attention to worries, own problems and noises in the environment. It could be possible that pre-sleep arousal does not “interfere with sleep above a certain level” [30].

In accordance with the findings of Krakow et al., [11], time monitoring behavior displays a significant positive correlation with insomnia severity. This correlation should be investigated further in longitudinal studies in order to verify causality of the relationship.

Until now, nocturnal time monitoring behavior was mainly investigated in the context of insomnia only. In addition, our findings display a correlation between nocturnal clock watching at sleep onset and trait anxiety (measured with the STAI-2). In patients with insomnia who show high scores on the TMB-10, anxiety should be considered as one of the possible causes. As already established in other studies [6,30], trait anxiety correlates as well in the present study with high levels of cognitive pre-sleep. Because of these findings, special attention should be paid on anxiety in the diagnostics and therapy of insomnia.

Female patients with insomnia have a higher risk of experiencing higher physiological pre-sleep arousal. This finding is in line

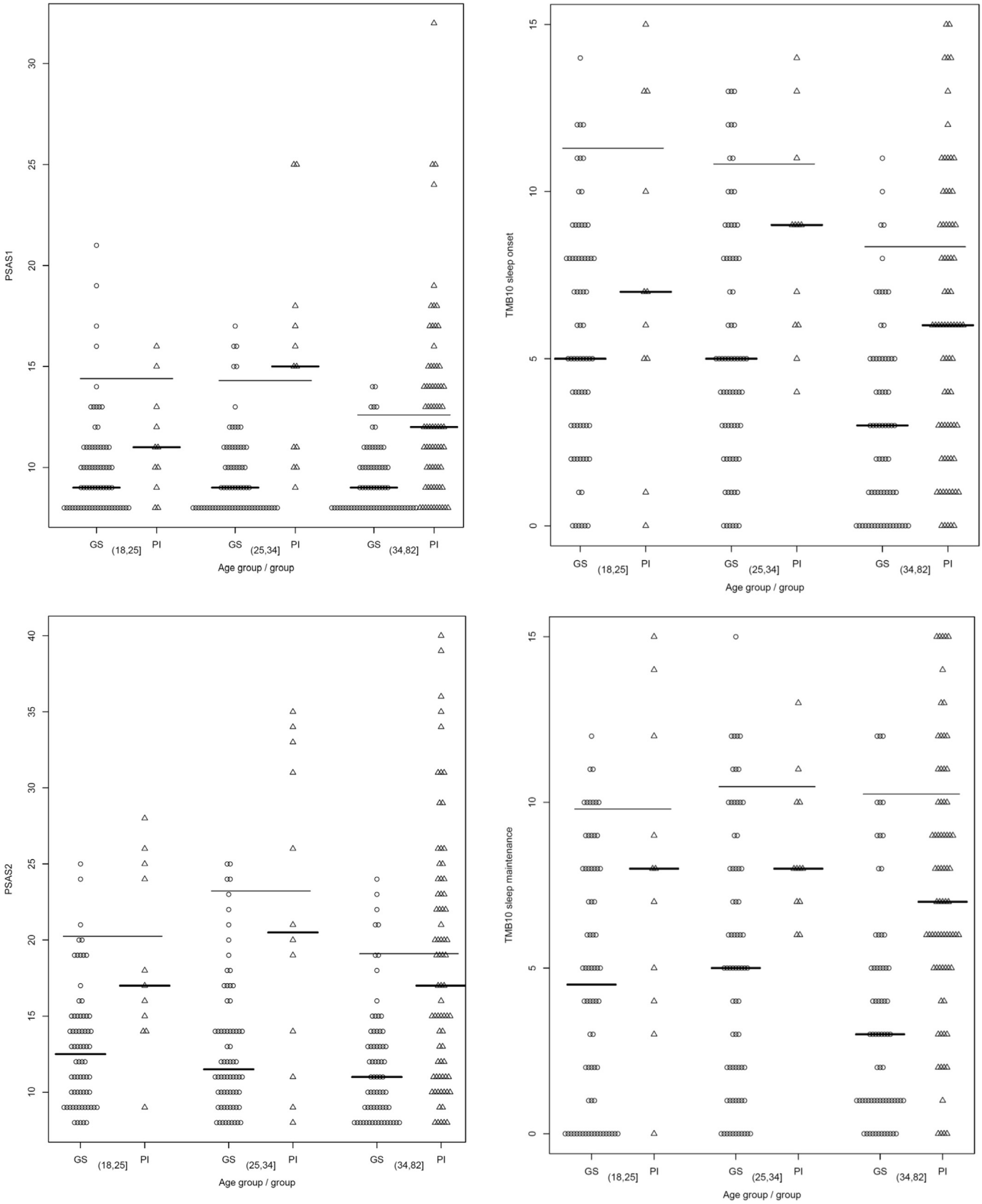

Fig. 1. Individual total score of each subject on the subscales of the PSAS and TMB-10. Each circle represents the total score of a GS, every triangle of a patient with insomnia. The horizontal narrow lines indicate the determined mean cut-off score for each age group. The horizontal thick lines indicate the median of the total scores for each group within the age group. $N = 304$ (208 GS, 96 insomnia patients); PSAS, Pre-Sleep Arousal Scale; TMB-10, Time Monitoring Behavior-10.

Table 4
Percentage of each group exceeding the cut-off scores within their individual age and gender subgroups.

	PI Patients	GS
PSAS 1	38.5	5.8
PSAS 2	41.7	5.8
TMB-10 SO[a]	29.2	5.3
TMB-10 SM[b]	20.8	4.3

Note that the rate in GS is close to 5% by design.
PSAS, Pre- Sleep Arousal Scale; TMB-10, Time Monitoring Behavior-10.
[a] Sleep onset.
[b] Sleep maintenance.

with a study by Chen et al., [31], in which women with different sleep disorders showed higher mean values on the PSAS 1 compared to men.

Given that insomnia, depression and anxiety are often correlated with each other [32,33], it can be assumed that higher scores on the BDI-II tend to display correlations with higher scores on the STAI and ISI as well. This would indicate that the identified negative correlation regarding the BDI-II-scores in the present study do not have clinical relevance. But as fatigue is one of the key symptoms of depression [1], it is also possible that depressed subjects have a reduced drive, even for watching the clock while falling asleep.

Distribution-based cut-off scores for the PSAS and the TMB-10 were determined in the present study. The determination of cut-off scores is important for improvements in the interpretation and clinical use of these questionnaires. Furthermore, the cut-off scores help to identify patients with an abnormal pre-sleep arousal or an abnormal time monitoring behavior. Consequently, these factors can be prioritized in the psychotherapeutic treatment of these patients [13].

The fact that we observed that not all but between 21 and 42% of insomnia patients showed scores above the cut-offs is interesting in itself. It means that using our cut-offs, fractions of PI patients can be identified who express pre-sleep arousal or time monitoring on a level surpassed by only 5% of good sleepers. The presence or absence of these problems may guide clinicians accordingly in their treatment.

The present study has several limitations. One potential limitation is that GS were intentionally not recruited considering all research diagnostic criteria proposed by Edinger et al., [34], for the recruitment of normal sleepers. Particularly, neither the subjects' medication or substance use, such as alcohol or caffeine, was controlled for nor a regular sleep/wake schedule. While we would not expect this to have an influence on time monitoring behavior, there could be an influence on pre-sleep arousal in our GS group. Furthermore, we cannot rule out an influence of the fact that PI patients filled their questionnaires in the morning hours while time of day was uncontrolled in the GS group, and also not a possible effect of the questionnaire medium (computerized vs. paper).

The advantage of not imposing strict selection criteria is that the sample of GS better represents the variance of sleep experiences in the total population without subjective sleep problems.

Nevertheless, it is difficult to define a self-reported normal sleeping control group (GS) because of the wide prevalence of sleep disorders in the total population [35]. Since GS were not objectively screened for sleep disorders, it cannot be ruled out that some individuals in the GS group had a sleep disorder. The 95% quantile and the exclusion of GS with a PSQI- score >6 compensate for this in the present study. Additionally, GS with a BDI-II score >12 were excluded because patients with depression frequently suffer from insomnia [36]. Other psychiatric or somatic diseases affecting sleep were not used as exclusion criteria.

The reason for choosing the 95% quantile of the score distribution to determine the cut-off scores, rather than the usually employed 95% confidence interval of mean ± 2 standard deviations [37] was the fact that the questionnaire data are not normally distributed.

As the GS group consisted mainly of young subjects between 20 and 30 years of age, the age groups were not evenly populated for the PI patients, with the third age group containing 76% of the patients (see Table 1). Therefore, no meaningful differentiation between younger and elderly patients was possible. Due to the large age range from 34 to 82 years in the third age group, influence of the subject's age on the interpretation of the cut-off scores cannot be ruled out.

Despite these limitations, our study provides important knowledge regarding the relationship between pre-sleep arousal/time monitoring behavior and insomnia. For future research, we suggest adding more data of older as well as more extensively screened good sleepers to investigate possible differences, especially for the different age groups. As the present study is a cross-sectional investigation, no conclusions about causal relations can be drawn. Longitudinal studies should be conducted to evaluate if anxiety as a predictor of elevated PSAS scores is cause or effect of a high pre-sleep arousal and if anxiety and insomnia severity as predictors of elevated TMB-10 scores are causes or effects of a high frequency of nocturnal clock watching.

Table 5
Overview of estimates and standard errors of the multiple logistic regression in the PI patient group.

	PSAS 1	PSAS 2	TMB-10 SO[a]	TMB-10 SM[b]
Age	0.04(0.02)	−0.01 (0.02)	0.01 (0.02)	−0.03 (0.02)
Gender (F)	1.32* (0.52)	−0.12 (0.52)	−0.09 (0.54)	−0.76 (0.63)
ISI	−0.06 (0.06)	0.09 (0.07)	0.15* (0.07)	0.15(0.08)
BDI-II	0.00 (0.04)	−0.03 (0.04)	−0.06 (0.04)	−0.13* (0.05)
STAI-1	0.05 (0.04)	0.04 (0.04)	0.01 (0.04)	0.08 (0.05)
STAI-2	0.05 (0.04)	0.09* (0.04)	0.10* (0.04)	0.08 (0.05)

Data are presented as estimates and standard error in parentheses; $N = 96$.
*$p < 0.05$.
PSAS, Pre-Sleep Arousal Scale; TMB-10, Time Monitoring Behavior-10; ISI, Insomnia Severity Index; BDI-II, Beck Depression Inventory-II; STAI-1, State-Trait Anxiety Inventory-1; STAI-2, State-Trait Anxiety Inventory-2.
[a] Sleep-onset.
[b] Sleep maintenance.

Author contributions

JV, CS and LM were responsible for the recruitment of the good sleepers. KS contributed to the study design. JV wrote the first draft of the manuscript and was responsible for the data analysis. BF supervised the data analysis and interpretation. EH and DR supervised JV and contributed to the study design and conception, data interpretation and writing of the manuscript. All authors have reviewed the final version of the manuscript.

Conflict of interest

The authors indicate no financial conflicts of interest.

The ICMJE Uniform Disclosure Form for Potential Conflicts of Interest associated with this article can be viewed by clicking on the following link: https://doi.org/10.1016/j.sleep.2019.01.022.

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