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Are sleep hygiene practices related to the incidence, persistence and remission of insomnia? Findings from a prospective community study

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Abstract The purpose was to examine whether sleep hygiene practices are associated with the course of insomnia (incidence, persistence and remission) over 1 year in the general population. This longitudinal study was carried out in the general population. After excluding anyone with other primary sleep disorder than insomnia, 1638 participants returned a baseline and a 1-year follow-up survey. Questions regarding sleep hygiene practices were administered at baseline, and the status of insomnia was assessed at baseline (T1) and at the 1-year follow-up (T2). Age, gender, mental ill-health, and pain were used as covariates in the analyses. Nicotine use, mental ill-health and pain were independently associated with an increased risk for concurrent insomnia at T1, while mental ill-health was the only risk factor for incident insomnia at T2. Relative to not reporting insomnia at the two time-points, nicotine use, light or noise disturbance, mental ill-health, and pain significantly increased the risk for persistent insomnia over 1 year. In comparison with those whose insomnia had remitted at the follow-up, reporting an irregular sleep schedule was a significant risk factor for persistent insomnia. Of the nine sleep hygiene practices examined in this study, only three were independently linked to concurrent and future insomnia, respectively; using nicotine late in the evening, light or noise disturbance, and having an irregular sleep schedule. This may have implications for the conceptualization and management of insomnia as well as for future research.

Keywords Insomnia · Sleep hygiene · Nicotine · Sleep timing · Epidemiology · Longitudinal

Introduction

Insomnia is a chronic condition that involves difficulties initiating and maintaining sleep (American Psychiatric Association, 2013). It is one of the most prevalent health problems with approximately 10% of the population reporting recurring insomnia and about 25% reporting occasional insomnia (Ancoli-Israel & Roth, 1999; Ohayon, 2002). The consequences for the sufferer are severe and include functional impairment, absenteeism, impaired concentration and memory, increased use of medical services, and an elevated risk of subsequently developing a psychiatric disorder (Breslau et al., 1996; Ford & Kamerow, 1989; Roth & Ancoli-Israel, 1999). Insomnia is therefore viewed as a serious public health problem, and while identified risk factors include poor mental health, illness, lifestyle and working conditions, the impact of sleeping habits on insomnia is relatively unknown (Hartz et al., 2007; Irish et al., 2015; Singareddy et al., 2012).

Sleep hygiene is a term that is commonly used to describe a set of behaviors or habits that may influence sleep quality. Sleep hygiene has often been viewed as having a contributing role for insomnia, which is for example apparent in diagnostic systems. The International Classification of Sleep Disorders (ICSD-II; American Academy of Sleep Medicine, 2005) describes inadequate sleep hygiene as a unique diagnostic entity highly relevant

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to sleeping problems. In the ICSD-II, inadequate sleep hygiene is defined as engaging in behaviors such as improper sleep scheduling, using sleep disturbing products, activating or arousing activities close to bedtime, using the bed for activities other than sleep, and maintaining an uncomfortable sleep environment. The notion of inadequate sleep hygiene as a contributor to insomnia is also evident in that cognitive behavioral therapy (CBT-I), an evidence-based psychotherapeutic intervention for insomnia, typically incorporates sleep hygiene as a treatment modality (Morin et al., 2006). Further, experimental studies in individuals without insomnia have revealed that a variety of sleep hygiene behaviors, e.g., drinking alcohol and smoking, disturb sleep (Riedel, 2000; Stepanski & Wyatt, 2003). While it is unclear whether sleep hygiene, when provided as a sole treatment modality, reduces insomnia symptomatology (Morin et al., 2006), the idea that sleep hygiene is influencing insomnia has resulted in a large number of studies since the 1970's that have investigated the link between sleep hygiene and insomnia using cross-sectional designs.

Cross-sectional studies, both in people with and without insomnia, have demonstrated a significant association between poor global sleep hygiene practices and poor sleep (Irish et al., 2015; Lacks & Rotert, 1986; Mastin et al., 2006). The link between sleep hygiene practices and insomnia has also been explored by comparing the frequency of sleep hygiene behaviors in good and poor sleepers. Earlier studies that have focused solely on sleep-incompatible behaviors associated with the bed and the bedroom, such as reading or watching TV in bed, have reported inconsistent findings (Haynes et al., 1974; Kazarian et al., 1978). Newer studies have examined a broader range of sleep hygiene practices in good and poor sleepers. In these investigations, poor sleepers, relative to good sleepers, used the bed for activities other than sleep more frequently (Harvey, 2000), consumed less caffeine (Cheek et al., 2004), and reported more napping, and smoking (Jefferson et al., 2005; McCrae et al., 2006). However, the results may be influenced by different sample selection procedures and in one of the cited studies (McCrae et al., 2006) where the researchers also recruited a sample of older adults from North Central Florida, there was not a single sleep hygiene behavior that significantly discriminated good sleepers from poor sleepers. It is also worth noting that concerning at least one of the sleep hygiene practices, alcohol use, there has been mixed results (Cheek et al., 2004; Jefferson et al., 2005). Besides different lifestyle behaviors, one study has shown that poor sleepers display increased cognitive activity in the bed, while controlling for anxiety and depression (Gellis & Lichstein, 2009). In this study, poor sleepers also reported enhanced excessive noise in the bedroom, uncomfortable nighttime temperature as well as activities that were perceived as exciting, emotional or requiring high concentration near bedtime. Taken together, studies that have used cross-sectional designs have reported mixed results concerning the relative frequency of sleep hygiene practices in good and poor sleepers.

The impact of sleep hygiene behaviors on insomnia remains unclear. If sleep hygiene behaviors are associated with insomnia, they could constitute an important maintaining factor. However, the mixed findings reported above indicate that sleep hygiene practices are perhaps not critically related to insomnia. For example, Lacks and Rotert (1986) noted that adherence to sleep hygiene was generally high in both good and poor sleepers, and concluded that sleep hygiene behaviors are not a primary cause of insomnia. Another interpretation of the inconsistent results may be that they are a result of the employed methodology. A first methodological caveat is the relatively small samples in some of the studies cited above which may have been under-powered to detect actual differences in sleep hygiene behaviors between good and poor sleepers. Another potential methodological issue is that in some of the community studies (e.g., Gellis & Lichstein, 2009) the attrition rates were high, making it difficult to generalize the findings. Furthermore, the method for assessing sleep hygiene behaviors has varied across studies and, perhaps more importantly, in only one of the studies (Gellis & Lichstein, 2009) a full array of sleep hygiene practices, as reflected in ICSD-II criteria for inadequate sleep hygiene, was assessed. A final methodological weakness with the research cited above is that all studies have used a cross-sectional design. This methodological approach enables investigation of associations at a given time point but does not provide insight into the development of insomnia over time. A prospective study in which individuals were followed over time would make it possible to investigate whether sleep hygiene practices are related to the incidence, persistence and remission of insomnia and have important clinical implications.

To our knowledge, only one prospective investigation has explored the role of sleep hygiene for future insomnia (Gellis et al., 2014). In the study, 548 college students were recruited and their data was used to examine cross-sectional associations between risk factors and insomnia. After controlling for covariates (i.e., gender, anxiety, depression, and morning/evening preference), improper sleep scheduling was the only variable that remained significantly associated with insomnia. One hundred and fifty-seven college students were then followed over 2 months to enable prospective analyses. Baseline improper sleep scheduling predicted insomnia severity at follow-up after controlling for baseline insomnia severity and other covariates. In short, this study suggests that improper sleep

scheduling is a sleep hygiene practice that is associated with the risk of future insomnia severity. Though this investigation was unique by using a prospective design, there are several methodological caveats that hamper the conclusions. First, both subsamples were convenience samples and included only young college students. Second, a related problem was that participants in the prospective part of the study had to report that they had consumed alcohol in the last 30 days; the findings from the prospective analyses may therefore not be generalizable to infrequent alcohol users and abstainers. Third, the investigation did not assess and exclude other primary sleep disorders than insomnia. Fourth, the study did not explore different development patterns between sleep hygiene practices and insomnia. While the investigation did examine the associations between sleep hygiene practices at baseline and changes in insomnia severity the study did not specifically explore whether sleep hygiene practices were related to the incidence, persistence and remission of insomnia.

The current prospective investigation is therefore an attempt to advance from some of the methodological shortcomings of previous studies and to examine the link between sleep hygiene behaviors and insomnia using a representative sample from the general population, assessing and excluding other primary sleep disorders, using well-established risk factors as covariates in the analyses and pinpointing the association between sleep hygiene practices and future insomnia in a detailed manner.

The overall aim of this investigation was to examine whether sleep hygiene practices are associated with the course of insomnia over 1 year in the general population. More specifically, the purpose was to investigate whether sleep hygiene practices were related to insomnia at baseline, to the incidence of insomnia, and to the persistence and remission of insomnia over time.

Methods

Overview of the design

This longitudinal, survey study was carried out in the general population. The status of insomnia was assessed both at baseline [Time 1 (T1)] and at the 1-year follow-up [Time 2 (T2)], while questions pertaining to sleep hygiene practices were administered only at T1. The study participants were those who returned the baseline and follow-up postal questionnaire as well as did not report other primary sleep disorders than insomnia. The Örebro Hospital's Board on Research Ethics approved this study. Informed consent was obtained in a written format.

Participants

This study is a population-based investigation from a random sample of 3000 residents, 20–60 years old, from 3 out of 25 counties in Sweden (see also Jansson-Fröjmark & Linton, 2008). The three counties are representative of all Swedish counties in terms of socio-economic status, gender, age, and living areas. From public records of the three counties, in which all residents are listed, the sample was obtained via random sampling. The age range (20–60 year) was chosen as to provide a sample of the workforce in the general population.

Of the 3000 residents, 2076 participants (69%) returned the baseline questionnaire. To assess whether the baseline non-responders differed from the responders, an attrition analysis in two steps (register data and telephone interview) was performed (for details see Jansson-Fröjmark & Linton, 2008). The attrition analysis showed that the baseline non-responders and responders were similar in terms of age and gender. Also, the analysis demonstrated that there were significantly more responders (35%), compared to the non-responders (29%), who reported a sleep problem during the past 3 months at baseline.

In all, 1746 (84%) of the 2076 baseline responders also returned the follow-up questionnaire 1 year later. For the purpose of the current paper, all participants who reported other primary sleep disorders than insomnia at baseline (n = 108, 6.2%) were excluded (see Primary sleep disorders below). This pertained to the following primary sleep disorders: apnea (n = 33), circadian rhythm disorder (n = 2), restless legs syndrome (n = 54), and periodic limb movement disorder (n = 19). The current paper focuses on the 1638 remaining participants, and descriptive statistics for the study participants are depicted in Table 1. To estimate whether there were significant differences in terms of insomnia prevalence and sleep hygiene behaviors at baseline between the 330 individuals who returned the baseline but not the follow-up questionnaire and the 1638 study participants who responded to both questionnaires, a Chi square analysis and t-tests were conducted. The results showed that there were no significant differences at baseline regarding reported insomnia prevalence (χ^2 = 1.17, p = .322) nor on the sleep hygiene items ($p \geq .400$) between the two groups.

Measures and procedure

The questionnaire used in this study was based on existing and validated surveys, and was constructed to assess a variety of factors, including demographic variables (T1), sleep hygiene practices (T1), sleep (T1 and T2), daytime symptoms (T1 and T2), and daytime functioning (T1 and T2). The following demographic parameters were assessed:

Table 1 The 1638 study participants: demographic parameters

	The study participants
Mean age (years)	41.4 (11.3)
Gender (female)	53.6%
Civil status (married or cohabitant)	77.1%
Occupational status	
Employed	78.3%
Student	8.4%
Unemployed	7.1%
Sick leave or pension	6.2%

Means are presented with standard deviations in parenthesis

age, gender, civil status (married or cohabitant—living alone), and occupational status (employed—student—not employed—sick leave or pension). The baseline questionnaire was sent to the 3,000 residents, along with a letter of introduction, information about the project and a stamped return-envelope. The follow-up questionnaire was then mailed 1 year later to the 2076 individuals who returned the baseline questionnaire. At both baseline and follow-up, if a response was not received within 2 weeks a reminder was mailed. If an additional 2 weeks elapsed without a response a second reminder was sent.

Primary sleep disorders

To screen out possible cases of other primary sleep disorders than insomnia, the questionnaire at T1 contained items based on the DSM-IV symptom criteria. These items were only administered to participants who reported problems sleeping during the past 3 months. An affirmative response on the following items was used to screen out other primary sleep disorders than insomnia: "noticed by someone else often or very often: breathing pauses or snoring during your sleep" (apnea), "often or very often: an unusual or undesirable sleep schedule or different from most other people" (circadian rhythm disorder), "often or very often in the evening or at night: strong urge to move your legs accompanied with an unpleasant sensation in your legs" (restless legs syndrome), and "noticed by someone else: your legs jerk or twitch repeatedly during your sleep" (periodic limb movement disorder).

Insomnia

To assess insomnia, the following three domains were determined at T1 and T2: sleep, daytime symptoms, and daytime functioning (American Academy of Sleep Medicine, 2005; American Psychiatric Association, 2013). The three domains of sleep, daytime symptoms, and daytime functioning were investigated with the Basic Nordic Sleep Questionnaire (Partinen & Gislason, 1995) and the Uppsala Sleep Inventory (Liljenberg et al., 1988). These measures are psychometrically sound and suitable to be employed in epidemiological research on insomnia (Liljenberg et al., 1988).

To assess sleep problems, the initial questionnaire item in Basic Nordic Sleep Questionnaire was "Have you had problems sleeping during the past three months?" with response alternatives: yes–no. The second item assessed the frequency of sleep difficulties during the past 3 months: "How often have you experienced problems sleeping during the past 3 months?" with response alternatives: never or less than once per month—less than once per week—1 or 2 days per week—3, 4 or 5 days per week—every day. Further, three items were used to assess difficulties with sleep onset, sleep maintenance, and early morning awakening: "On average: How many minutes are you awake before you fall asleep?", "On average: If you wake up at night, how many minutes are you awake?", and "On average: How many minutes do you wake up too early (i.e. earlier than desired) in the morning?".

To assess daytime symptoms, the Uppsala Sleep Inventory (Liljenberg et al., 1988) was used and the overall question was asked: "What daytime symptoms have you experienced during the past three months due to poor sleep?". The participants were then asked to assess ten daytime symptoms due to poor sleep from the following list of symptoms: concentration problems, memory problems, headache, low energy, tiredness, aching muscles, tenseness, sleepiness, irritability, and low mood with response alternatives: not at all = 1, somewhat = 2, relatively large = 3, and very large = 4.

To determine daytime functioning, the Uppsala Sleep Inventory (Liljenberg et al., 1988) was used and the following overall question was asked: "What consequences have you experienced during the past three months due to poor sleep?" More specifically, the participants were asked to assess potential, negative consequences of poor sleep in three functional domains: occupational, leisure, and social functioning with response alternatives: no negative consequences = 1, small negative consequences = 2, marked negative consequences = 3, large negative consequences = 4, and very large negative consequences = 5.

Insomnia was assessed based on proposed research criteria (Edinger et al., 2004) and a participant who reported all five of criteria a–e were considered to have *insomnia*: (a) problems sleeping during the past 3 months, (b) problems sleeping for three nights or more per week during the past 3 months, (c) problems with daytime symptoms (i.e., one or more symptoms scored as "relatively large", or higher) or daytime functioning (i.e., one or more functional domains scored as "marked negative consequences", or higher), (d) sleep onset difficulties (i.e. 30 min or more),

sleep maintenance difficulties (i.e. 30 min or more), or early morning awakening difficulties (i.e. 30 min or more), and (e) report no other primary sleep disorders (i.e., apnea, circadian rhythm disorder, restless legs syndrome, and periodic limb movement disorder), as described above under Primary sleep disorders. This methodology for determining insomnia follows the guidelines for determining insomnia diagnosis but the exact self-report procedure has not previously been validated (Buysse et al., 2006).

Sleep hygiene

The sleep hygiene items at T1 were based on recommendations by Posner and Gehrman (Posner and Graham 2010). The instruction for the sleep hygiene items was: "Below is a list of behaviors and circumstances that captures what people might do during the day, evening or night. Please report how much you have engaged in these behaviors and circumstances during the past month by indicating how much you agree with the statements from 1 (strongly disagree) to 5 (strongly agree)." The nine sleep hygiene items were: "I have been taking naps during the day", "I have had an irregular sleep schedule, i.e., using differing set times for going to bed and getting up from bed", "I have been drinking alcohol late in the evening", "I have been using nicotine late in the evening", "I have been drinking caffeinated drinks late in the evening", "I have gone to bed hungry or too full or I have been drinking liquids late in the evening", "I have been exercising late in the evening", "I have been disturbed by light or noise while in bed", and "I have had an uncomfortable sleep environment in my bedroom, e.g., uncomfortable bed or temperature". In the current study, the nine sleep hygiene items correlated with each other at a low strength (r = .01–.29), except for late exercise with late alcohol use (r = .43) and light or noise disturbance in bed with an uncomfortable sleep environment (r = .36).

Covariate variables

Two demographic parameters (age and gender) were collected at T1 and used as covariates in the statistical analyses based on previous research showing that both age and gender might be related to insomnia (Ohayon, 2002). Since mental ill-health and pain might also have an impact on insomnia (e.g., LeBlanc et al., 2009; Ohayon, 2002), those two domains were also employed as covariates. To assess mental ill-health and pain at T1, two of the subscales from the Duke Health Profile (DHP) were used (Parkerson et al., 1990). The subscale 'mental ill-health' consists of five items (i.e., 'I like who I am, 'I give up too easily', 'I have difficulty concentrating', 'During the past week—How much trouble have you had with: Feeling depressed or sad', and 'During the past week—How much trouble have you had with: Nervousness'). All the five items were recoded so that a high score indicates poor mental health. The subscale 'pain' contains only one item (i.e., 'During the past week—How much trouble have you had with: Hurting or aching in any part of your body'). A high score on the pain subscale indicates more trouble with pain. For both DHP subscales, the scores can range from 0 (very good mental health/no trouble with pain) to 100 (very poor mental health/extreme trouble with pain).

Statistical analysis

The data was first summarized with descriptive statistics. An analysis of outliers was conducted employing various forms of detection (e.g. univariate and multivariate) and outlier profiling, but no outliers were identified. Binary logistic regressions were used for the main analyses. The thirteen independent variables were the following: age, gender, mental ill-health, pain, and the nine sleep hygiene items. All the continuous independent variables were transformed into z-scores to enable comparisons between odds ratios and confidence intervals. The logistic regression analyses were based on a hierarchical, multivariate approach, i.e., including age, gender, mental health, and pain in step 1 and all sleep hygiene items in step 2. Since some cells in the analyses contained a limited number of participants, univariate analysis was used as a first, preparatory step in which each independent variable was individually analyzed in relation to the dependent variables insomnia at T1, insomnia at T2, persistence of insomnia and remission from insomnia. Beta values and standard errors are presented in the tables, and odds ratios are presented with 95% confidence intervals. Nagelkerke R^2 is reported for the logistic regressions. A two-tailed p value smaller than .05 was considered statistically significant.

Results

Baseline sleep hygiene practices and insomnia

As can be seen in Table 2, 8.1% of the participants met criteria for insomnia at T1 while 91.9% did not. In a preparatory step, the significant independent variables in univariate analyses were: age (p = .028), gender (p = .006), mental ill-health (p < .001), pain (p < .001), irregular sleep schedule (p < .001), nicotine use (p < .001), caffeinated drinks (p = .037), and light or noise (p = .001). As is displayed in Table 2, a hierarchical, multivariate logistic regression analysis demonstrated that

reporting a higher level of mental ill-health, pain, and nicotine consumption late in the evening increased the risk of reporting insomnia at T1. The model was significant and explained 27% of the variance in insomnia status.

Sleep hygiene practices at baseline and the incidence of insomnia at T2

Of those who did not fulfill criteria for insomnia at T1, 2.4% met criteria for incident insomnia at T2 (Table 3). In a preparatory step, the significant independent variables in univariate analyses were: mental ill-health ($p < .001$), pain ($p = .010$), and nicotine use ($p = .047$). As is displayed in Table 3, a hierarchical, multivariate logistic regression analysis demonstrated that reporting a higher level of mental ill-health increased the risk of incident insomnia at T2. The model was significant and explained 11% of the variance in incident insomnia status.

Sleep hygiene practices at baseline and persistence of insomnia

As can be seen in Table 4, 3.5% of the sample met criteria for insomnia at both T1 and T2 (i.e., persistent insomnia), whereas 89.7% did not fulfill criteria for insomnia at any of the two assessment points. In a preparatory step, the significant independent variables in univariate analyses were: age ($p = .008$), mental ill-health ($p < .001$), pain ($p < .001$), nicotine use ($p < .001$), and light or noise ($p = .013$). A hierarchical, multivariate logistic regression analysis (Table 4) showed that reporting a higher level of mental ill-health, pain, nicotine consumption late in the evening, and light or noise disturbance increased the risk of persistent insomnia from T1 to T2. The model was significant and explained 32% of the variance in persistent insomnia status.

Sleep hygiene practices at baseline and the persistence/remission of insomnia

In Table 5, descriptive statistics and a logistic regression analysis for the risk of persistence and remission of insomnia is presented. Of those who did fulfill criteria for insomnia at T1, 43.2% met criteria for persistent insomnia and 56.8% fulfilled criteria for remission from insomnia at T2 (Table 5). In a preparatory step, the two significant independent variables in univariate analyses were pain ($p = .008$) and irregular sleep schedule ($p = .037$). In the final model (Table 5), it was displayed that reporting an irregular sleep schedule at T1 was associated with an increased risk for persistent insomnia from T1 to T2 compared to remission from insomnia. The full model was significant and explained 17% of the variance in persistent insomnia status.

Discussion

The aim of this investigation was to explore whether sleep hygiene practices are associated with the course of insomnia over 1 year in the general population while controlling for demographic parameters, mental ill-health,

Table 2 Sleep hygiene practices at baseline and insomnia at baseline: descriptive statistics and multivariate logistic regression analysis

Not insomnia at T1 ($n = 1506$)—insomnia at T1 ($n = 132$)					
	M (SD)	B (SE)	OR	95% CI	R^2
Step 1					
Mental ill-health	NI: 24.7 (19.2) I: 45.9 (21.0)	.84 (.11)***	2.33	1.87–2.89	.22
Pain	NI: 23.8 (31.6) I: 55.9 (42.1)	.55 (.10)***	1.74	1.43–2.12	
Step 2					
Mental ill-health	NI: 24.7 (19.2) I: 45.9 (21.0)	.79 (.12)***	2.20	1.76–2.77	.27
Pain	NI: 23.8 (31.6) I: 55.9 (42.1)	.56 (.10)***	1.76	1.43–2.15	
Nicotine	NI: 1.0 (0.2) I: 1.3 (0.7)	.36 (.08)***	1.43	1.22–1.68	

The full model was significant ($p < .001$) and predicted 93.0% of cases (99.4% correct for those without insomnia and 14.8% for those with insomnia)

I insomnia, *NI* not insomnia, *T1* Time 1

*** $p < .001$

Table 3 Sleep hygiene practices at baseline and the incidence of insomnia: descriptive statistics and multivariate logistic regression analysis

Not insomnia at T1 (n = 1506): not insomnia at T2 (n = 1470)—insomnia at T2 (n = 36)					
	M (SD)	B (SE)	OR	95% CI	R^2
Step 1					
Mental ill-health	NI: 24.3 (19.0) I: 39.2 (21.3)	.73 (.18)***	2.07	1.46–2.94	.09
Step 2					
Mental ill-health	NI: 24.3 (19.0) I: 39.2 (21.3)	.69 (.18)***	1.99	1.40–2.83	.11

The full model was significant ($p < .001$) and predicted 97.5% of cases (100% correct for those without insomnia and 0% for those with insomnia)

I insomnia, *NI* not insomnia, *T1* Time 1, *T2* Time 2

*** $p < .001$

Table 4 Sleep hygiene practices at baseline and the persistence of insomnia: descriptive statistics and multivariate logistic regression analysis

Not insomnia at T1 and T2 (n = 1470)—insomnia at T1 and T2 (n = 57)					
	M (SD)	B (SE)	OR	95% CI	R^2
Step 1					
Mental ill-health	NI: 24.3 (19.0) I: 47.1 (21.9)	.89 (.17)***	2.43	1.73-3.40	.25
Pain	NI: 23.4 (31.5) I: 67.0 (40.4)	.79 (.16)***	2.20	1.61-3.00	
Step 2					
Mental ill-health	NI: 24.3 (19.0) I: 47.1 (21.9)	.82 (.18)***	2.26	1.58-3.24	.32
Pain	NI: 23.4 (31.5) I: 67.0 (40.4)	.86 (.18)***	2.36	1.69-3.29	
Nicotine	NI: 1.1 (0.3) I: 1.3 (0.7)	.57 (.12)***	1.77	1.39-2.24	
Light or noise	NI: 1.8 (1.2) I: 2.2 (1.5)	.38 (.17)*	1.46	1.05-2.03	

The full model was significant ($p < .001$) and predicted 97.1% of cases (99.8% correct for those without insomnia and 14.0% for those with insomnia)

I insomnia, *NI* not insomnia, *T1* Time 1, *T2* Time 2

* $p < .05$, *** $p < .001$

and pain. In all, three forms of sleep hygiene practice—late evening nicotine use, light or noise disturbance, and having an irregular sleep schedule—had a significant association with concurrent and future insomnia, respectively.

Nicotine use late in the evening was significantly associated with insomnia at baseline and increased the risk for persistent insomnia over 1 year. In clinical terms, these results indicate that the reduction of nicotine use late in the evening may potentially result in decreases in insomnia symptomatology and lower the risk for persistent insomnia; note, however, that the directionality of the association is unknown and that no study has yet investigated if nicotine reduction has an impact among patients with insomnia. While the association between nicotine use and insomnia is well-established (Jaehne et al., 2009), insomnia is also one of the most common nicotine withdrawal symptoms and this may increase the risk of relapse among nicotine abstainers (Garcia & Salloum, 2015; Short et al., 2017). The recommendations to reduce nicotine use among patients with insomnia may therefore meet with resistance and may need to be addressed with more comprehensive interventions.

Reporting light or noise disturbances, together with nicotine use, was significantly associated with reporting persistent insomnia over 1 year compared to reporting no problems of insomnia at the two time points. This indicates

Table 5 Sleep hygiene practices at baseline and the remission of insomnia: descriptive statistics and multivariate logistic regression analysis

Insomnia at T1 (n = 132): not insomnia at T2 (n = 75)—insomnia at T2 (n = 57)					
	M (SD)	B (SE)	OR	95% CI	R^2
Step 1					
Pain	NI: 46.4 (41.4) I: 67.0 (40.4)	.34 (.16)*	1.39	1.02-1.95	.08
Step 2					
Irregular sleep schedule	NI: 2.0 (1.4) I: 2.6 (1.5)	.48 (.23)*	1.62	1.03-2.53	.17

The full model was significant (p = .011) and predicted 61.9% of cases (77.4% correct for those with remission and 39.5% for those with insomnia)

I insomnia, *NI* not insomnia, *T1* Time 1, *T2* Time 2

*$p < .05$

that sleeping environment may be an important factor in long-term sleeping problems that, compared to nicotine use, the affected person may have relatively limited control over. While bright light exposure may be a component in treatment for sleeping problems associated with circadian rhythm disturbances, involuntary night time light exposure seems to have negative effects on both sleeping and general health that have recently started to draw attention (Chepesiuk, 2009). In contrast, nighttime noise disturbances have long been identified with sleeping problems in community samples (e.g., Langdon & Buller, 1977). However, the relative importance of environmental disturbances among people with chronic insomnia is unclear and previous research has indicated that excitatory behaviors or states may be more important for sleep than the physical sleep environment in this group (Yang et al., 2010).

Reporting an irregular sleep schedule was the only sleep hygiene practice that was significantly and independently associated with an increased risk for persistent insomnia compared to remission after 1 year. The results are in line with those of a previous longitudinal study which also identified improper sleep schedule as a risk factor for insomnia (Gellis et al., 2014). These findings suggest that, among those with insomnia, reducing irregular sleep schedule could lead to an increased possibility of remitting from insomnia. Irregular sleeping patterns have previously been associated with poor sleep but the exact mechanisms are largely unknown (Buysse et al., 2010). Establishing regular sleep patterns is a component of sleep restriction in CBT for insomnia but the unique effect of sleep scheduling has, to our knowledge, never been studied (e.g., Harvey et al., 2014). The impact of giving this advice to people not in insomnia treatment is also unknown.

Importantly, two of the four covariates demonstrated a significant association with concurrent and future insomnia. Reporting a higher level of mental ill-health was a significant risk factor for concurrent insomnia, incident insomnia and persistent insomnia. Also, having a higher level of pain was identified as a risk factor in the analysis for concurrent insomnia and in one of the two analyses focusing on persistence of insomnia. The associations between these two covariates on the one hand and concurrent and future insomnia on the other hand have previously been documented (Smith & Haythornthwaite, 2004; Ford & Kamerow, 1989).

Although this investigation has shown that three sleep hygiene practices are related to concurrent and future insomnia, this does not necessarily imply that these practices are causally linked to insomnia. The longitudinal design of the present investigation cannot demonstrate causality between variables and both sleep hygiene practices and insomnia could be affected by other unknown variables. As mentioned above, nicotine use, light or noise disturbance, and irregular sleep schedule may have complex associations to insomnia that are more pronounced in some subgroups than others. For example, the degree and chronicity of the three sleep hygiene practices may be important factors that partly explain why these associations are found in some studies but not all. These notions are worth exploring in future epidemiological research but also in experimental and clinical studies.

The current investigation has some methodological shortcomings that must be kept in mind when interpreting the results as well as when considering future research. First, the use of self-report measures should impose some caution about the comparability to results obtained by objective measures. A related shortcoming was that the sleep hygiene and insomnia severity measures were retrospective in nature, which is vulnerable to biased or inaccurate responding. Future research may, for example, assess sleep hygiene behaviors and insomnia using daily measurements. A second problem in this study was the baseline participation rate of 69%. Although this level is not uncommon in this type of research, it may restrict the

generalizability of the findings. A third possible shortcoming of this study is that the sample of non-responders contacted via telephone was relatively small (5.3%) and therefore possibly not representative of the non-responders in this study. A related limitation of this study was that a selection bias was demonstrated in that more women than men returned the baseline questionnaire and the responders complained more frequently about a sleep problem than the non-responders.

Some additional disadvantages in this study should also be mentioned. Chronicity of insomnia was not assessed at baseline. The course of insomnia may have been affected by whether or not the condition was chronic or acute at the initial assessment, which could influence rates of persistence and remission at subsequent assessments. Hypothetically, individuals with chronic insomnia at baseline might be more likely to report insomnia again at follow-up and participants with acute insomnia at baseline might have a higher probability of following a course of remission over time. Another limitation is that the assessment of insomnia at baseline was based on whether the individuals fulfilled current criteria for insomnia, but not on whether the individuals had prior history of insomnia beyond the 3-month reference period. This precludes estimating the true incidence of new cases of insomnia, suggesting that the findings on incidence in this study should be interpreted cautiously. Future research might investigate true incidence (i.e. first onset in individuals with no prior history of insomnia) of insomnia as a complaint. Also, since full information about co-occurring disorders (e.g. psychiatric, sleep, or medical) was not assessed in this study, it is likely that the sample consisted of both participants with only insomnia and participants with co-morbid insomnia. As a consequence, it is difficult to specifically generalize the findings of this study to either insomnia only or co-morbid insomnia. For example, sleep hygiene practices may affect insomnia differently in patients with comorbid pain (Martinez et al., 2014). Another limitation with the current investigation is that the possibility of a bidirectional association between sleep hygiene practices and insomnia could not be tested (i.e., whether insomnia increases the risk of reporting changes in sleep hygiene behaviors over time) since sleep hygiene practices were not assessed at both time-points. Finally, this study is correlational in nature and thus we cannot draw conclusions about any cause-and-effect relationships among the study variables. We found that T1 improper sleep schedules predicted persistent insomnia at T2 after controlling for other risk factors; however, other variables that were not controlled for in this study may have explained the relationship.

For instance, few studies have assessed emotional or physically arousing behaviors at bedtime. In one study, Buman et al. (2014) showed that while people who exercised in the morning reported better sleep than others, evening exercise did not negatively affect reported sleep quality. The cross-sectional design of the study makes it impossible to draw firm conclusions regarding the effects of evening exercise but at least it seems that it need not be generally discouraged. In contrast, Harvey (2000) assessed environmental conditions that may affect sleep in adults and found that late night cognitive arousal was reported as one of the most disturbing factors among people with poor sleep. In a later study, Gellis and Lichstein (2009) could confirm that poor sleepers report more frequent cognitive and emotional arousal near bedtime than good sleepers. Both these studies used cross-sectional designs so the causality between arousal and sleep problems is still uncertain.

In the current study, the use of caffeinated drinks was not a significant risk factor for insomnia but this may have been affected by the wording of the question which specifically asked for consuming caffeinated drinks late in the evening. Other studies (e.g., Drake et al., 2013) have shown that caffeine taken long before bed time may still affect sleep and in the current study, some participants may have had a large intake earlier in the day but were not identified as caffeine consumers in the questionnaire. Also, infrequent caffeine users may be more sensitive to the sleep disturbing effects of caffeine and advice regarding caffeine consumption may need to be tailored to each person's habits.

One common sleep hygiene practice that was not investigated in the current study but is often advised and may have affected the results is to reduce alcohol consumption. Alcohol consumption has been associated with insomnia and specifically with poor sleep quality after episodes of high consumption (Stein & Friedmann, 2006). Similar to nicotine use, long term users of alcohol may experience less disturbed sleep over time but are at increased risk of insomnia when trying to reduce consumption or abstain (Brower, 2003).

Despite the caveats mentioned above, this study shows that only a few sleep hygiene practices seem to affect the incidence, persistence and remission of insomnia in the general population. While there are individual differences and important to consider different contexts, the practices of abstaining from nicotine late in the evening, improving the sleeping environment regarding light and noise and adjusting an irregular sleep schedule should be investigated further as treatment features in adjunct to evidence-based treatments, such as CBT. Instead of exploring sleep hygiene as a multifaceted treatment component, which has been the focus of several previous trials (Chung et al., 2017), these findings may pave way for intervention studies that target one sleep hygiene practice (e.g., nicotine use) among selected risk individuals (e.g. heavy smokers with

insomnia). However, other factors, such as mental health and pain, may be at least as important to address for people who suffer from insomnia. In conclusion, this study suggests that some aspects of sleep hygiene may be beneficiary but more experimental studies are needed, both in the general population and among people in insomnia treatment since the impact of sleep hygiene practices may vary between different populations.

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Compliance with ethical standards

Conflict of interests Markus Jansson-Fröjmark, Jonas Evander and Sven Alfonsson declares that they have no conflict of interests to report.

Human and animal rights and Informed consent All procedures were in accordance with the ethical standards of the institutional research committees and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study.

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