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Insomnia in Shift Workers: Which Trait and State Characteristics Could Serve as Foundation for Developing an Innovative Therapeutic Approach?

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Insomnia in Shift Workers: Which Trait and State Characteristics Could Serve as Foundation for Developing an Innovative Therapeutic Approach?

Running Head: Pilot Study for a Shift-Work Insomnia Therapy

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Abstract: Shift workers are at an elevated risk for insomnia relative to the general population. While recent research has yielded promising insights, there is still room for improvement in the treatment of insomnia in this target group. This pilot study assesses the relevance of various personality traits and states for the sleep of shift workers, with the objective of establishing a basis for the development of an innovative therapeutic approach for shift workers. Data was collected with an online survey from an ad-hoc sample of N = 225 (112 shift workers). Correlations were calculated between sleep variables and specific characteristcs (e.g., psychological impairment, personality traits, sleep-related behavior, attitudes towards sleep and shift work). Whether there were group differences between participants with insomnia (yes/no) and shift work (yes/no) was determined with Mann-Whitney U-tests and Kruskal-Wallis H-tests. A regression approach was used to find suitable predictors for the severity of insomnia. With the exception of perfectionism, chronotype and effort-reward imbalance, all factors produced significant results in correlations and group differences (insomnia yes/no). The groups shift yes/no hardly differed from each other. Four factors were identified as predictors of insomnia severity: dysfunctional beliefs about sleep, pre-sleep-arousal (cognitive and somatic) and depression. Individuals with sleep disorders exhibit differences from healthy sleepers in most of the analysed factors in the expected direction. We conclude that corresponding interventions could establish a foundation for the development of an innovative therapeutic approach for shift workers. When the resulting therapy manual is finalised, its effectiveness will be tested with an RCT.

Keywords: shift work; insomnia; personality traits; states; tailored therapeutical approach

1. Introduction

Approximately 20% of adults are engaged in shift work (ICSD3, American Academy of Sleep Medicine [AASM], 2014). The effects of shift work on health include an increased risk of cardiovascular disease, stroke, cancer, and an elevated mortality rate (Bastille-Denis et al., 2020; Esquirol et al., 2011; Gu et al., 2015). Psychological consequences comprise elevated levels of depression and anxiety (Bastille-Denis et al., 2020), suicidal ideation, and somatization (Cheng & Drake, 2018; Drake et al., 2004). Irritability, nervousness, and neuroticism are more prevalent, and the use of sedatives and hypnotics is also more frequent (Costa, 2010). Furthermore, night shifts lead to higher oxidative stress, which in turn impairs cognitive performance (Özdemir et al., 2013).

Shift work also results in lower job satisfaction (Cheng & Drake, 2018), higher absenteeism (Costa, 2010) and an increased risk of burnout, especially the dimension of emotional exhaustion (Jamal, 2004). It can also reduce alertness with consequences for workplace and safety when commuting to work (Rodenbeck et al., 2015).

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In the private context, greater social isolation is perceived (Cheng & Drake, 2018). The proportion of singles among shift workers (30.8%) is higher than in the general population (20.8%, Cheng & Drake, 2018). Unconventional working hours present significant challenges in maintaining a healthy work-life balance, particularly in relation to social and family life (Nachreiner et al., 2019).

Insomnia per se is defined as dissatisfaction with or concern about ones personal sleep quality and/or quantity, commonly associated with difficulties falling or staying asleep, early waking and daytime complaints (DSM-5, American Psychiatric Association [APA], 2013; AASM, 2014). In western industrialised countries, a prevalence of 10% is reported for insomnia (AASM, 2014).

The term "shift work disorder" (SWD) refers to a condition characterised by insomnia and/or excessive sleepiness and a reduction of total sleep time (TST) due to the engagement in shift work (AASM, 2014). These shift-related sleep problems also occur on days off (Järnefelt & Spiegelhalder, 2022). Distinguishing between insomnia and SWD is often challenging as both can co-exist and since SWD can evolve into chronic insomnia (Drake et al., 2004; Järnefelt et al., 2012; Järnefelt & Spiegelhalder, 2022). The estimated prevalence of SWD among shift workers is 26.5% (Pallesen et al., 2021). However, it varies considerably depending on the specific shift system (three-shift system 38.8%, day work 5.5%, two-shift system 24.7%; Flo et al., 2012).

Although sleep differences between day- and night-shift workers are not particularly pronounced, they do reach statistical significance for TST and SOL (sleep-onset latency, Åkerstedt et al., 2008). The risk of a TST of less than six hours is increased in night workers (OR = 1.7) and those working in a three-shift system (OR = 1.9) compared to pure day workers (OR = 1.0, Ohayon et al., 2010). Shift work reduces the TST by two to four hours (Costa, 2010). Additionally, the proportion of REM and NREM2 sleep increases, and sleep is interrupted more frequently and earlier, in part due to social factors such as eating with the family (Costa, 2010). More difficult sleeping conditions during the day can also result in a reduced TST (Seibt et al., 2006).

The negative effects of shift work on sleep and other health-related factors have so far mostly been attributed to a misalignment between the sleep-wake rhythm and the internal circadian system (Schwartz & Roth, 2006). This misalignment results in the release of melatonin and cortisol at times when their effect is contrary to the person's current goal (working or sleeping; Bastille-Denis et al., 2020). Long-term night shift workers without sleep problems exhibit an endogenous rhythm adapted to these working hours, whereas those with SWD did not (Gumenyuk et al., 2012). Such an adaptation is not possible in the case of rotating or irregular working hours.

It is currently hypothesised that the factors which contribute to the development and maintenance of insomnia in general are also important in SWD. Bastille-Denis et al. (2020) identified differences between good sleepers and those affected by SWD in a sample of night shift workers with regard to negatively toned pre sleep cognitive activity, dysfunctional beliefs about sleep related to worry/helplessness, and selective attention. Furthermore, a clear correlation exists between the risk of SWD and the severity of depression (Chang et al., 2024).

The gold standard for the treatment of insomnia is CBT-I (cognitive behavioural therapy for insomnia, Espie, 2022). The application in its original form is challenging for shift workers, as many of its interventions are based on regular rhythms.

Recently, there has been an increase in the number of studies that have adapted CBT-I to meet the specific needs of shift workers (please refer to the overview of the current state of research in Grünberger et al., 2025). The findings of these studies are ambivalent. While some statistically significant improvements are observed, they often fail to reach clinical significance (z.B. Ito-Masui et al., 2023).

The attrition rate is high (Vallieres et al., 2024), yet compliance is low (Kalkanis et al., 2023). Several reviews and meta-analyses have concluded that CBT-I adapted to shift workers is applicable, but not sufficient for this demographic (see Grünberger et al., 2025).

Consequently, it is still required to develop a specifically tailored therapy manual for shift workers. A completely new approach is to be pursued. The subsequent section will address models and characteristics that are known to be pertinent in the development and maintenance of insomnia

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within the general population. Some of these have already been investigated in the context of shift work – and might be of use for the development of the planned new therapeutic approach.

Shiftwork tolerance, the ability to adapt to shift work without negative consequences, is associated with behavioural and biological dispositions (Saksvik et al., 2011). Shift work *in*tolerance is characterised by persistent sleep changes and fatigue, the use of sleep medication, behavioural changes such as aggression and irritability, and gastrointestinal complaints (Reinberg & Ashkenazi, 2008). Female sex, older age and early chronotypes have a higher risk of shift work intolerance (Natvik et al., 2011). On the other hand, resilience factors are lower levels of inertia and neuroticism along with high levels of flexibility, extraversion and internal locus of control (Saksvik et al., 2011).

A longitudinal study (Larsgård & Saksvik-Lehouillier, 2017) presents findings that challenge previous assumptions. Neuroticism is a predictor of insomnia symptoms in shift workers (but insomnia is not a predictor of neuroticism). High morningness correlates with low insomnia levels. Older age predicts fewer insomnia symptoms. The authors posit that this is due to a decrease in tolerance for shift work at 45-50 years of age, which may not fully account for the observed phenomenon in their sample, which is too young. Additionally, they suggest that more individuals are selected out of shift work at an older age, resulting in a higher prevalence of those who are more tolerant of shift work (Larsgård & Saksvik-Lehouillier, 2017).

The **cognitive insomnia model** (Harvey, 2002) encompasses both nighttime and daytime processes. It posits that excessive negatively toned cognitive activity (influenced by dysfunctional beliefs and safety behaviours) leads to arousal and distress, selective attention and monitoring, and a distorted perception of sleep/function deficit (Harvey, 2002). The importance of sleep is increasing, accompanied by a rise in anxiety. The **attention-intention-pathway model** (Espie et al., 2006) states that an excessive focus of attention or the intention to force oneself to fall asleep leads to the development and maintenance of sleep disorders. These two models are also pertinent to shift workers. They show heightened cognitive arousal preceding sleep and more maladaptive beliefs about sleep (Bastille-Denis et al., 2020). This finding is consistent with the term **hyperarousal disorder,** which is frequently used in the general insomnia literature (e.g., Crönlein et al., 2017) and describes an increased mental and physical tension, accompanied by a lack of ability to relax or catch up on sleep. For shift workers, interventions are recommended that address pre-sleep cognitive activity and dysfunctional beliefs (Bastille-Denis et al., 2020).

Sleep hygiene is regarded as an effective intervention in CBT-I (e.g., Espie, 2022), although it is also questioned by some authors: Poor sleep hygiene is associated with insomnia, but it is rarely the cause (Hermann et al., 2009). In middle-aged women, no or only moderate correlations are evident between sleep hygiene and insomnia symptoms (Cheek et al., 2004). Japanese factory workers (including shift workers) showed improvements in individual sleep-related behaviours following a psychoeducational intervention on sleep hygiene, but no significant changes in sleep quality or daytime sleepiness (Itani et al., 2018). No or only small effects on sleep have been found in shift workers (Tout et al., 2024), possibly because regularity is an important component. Sleep hygiene can promote awareness of healthy sleep practices (Tout et al., 2024). But maybe an adherence to rules throughout the day could increase the focus on sleep, potentially lead to poorer sleep quality, in the sense of the attention-intention-pathway model (Espie et al., 2006).

Siegrist's **effort-reward imbalance model** (cited in Fahlén et al., 2006) posits that the perceived effort invested in the workplace should be in balance with the rewards received (e.g., pay, appreciation, career opportunities). An imbalance has a particularly negative impact on individuals who tend to overcommit as a coping strategy. The results of Fahlén et al. (2006) indicate a significant correlation between effort-reward imbalance and sleep disorders, although the causal direction cannot be determined. It is also possible that sleep problems lead to an overestimation of the perceived imbalance (Fahlén et al., 2006).

Perfectionism and higher anxiety levels. Anxiety symptoms are more likely to be a risk factor for sleep disorders, depressive symptoms rather a consequence; higher anxiety levels are associated with increased insomnia symptoms (Akram et al., 2015). In addition to other personality characteristics, such as increased neuroticism (Costa, 2010) and internalisation, perfectionism is also

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associated with insomnia and has been identified as a predisposing factor (Akram et al., 2015; Crönlein et al., 2017).

Social stressors in the workplace are particularly detrimental (Pereira & Elfering, 2014). Unsatisfied needs for belonging and self-esteem protection lead to a range of psychological and physical impairments, including sleep problems (Pereira & Elfering, 2014). A lack of social support in the workplace or in general is also a risk factor for sleep complaints (Åkerstedt, 2006, see also Cheng & Drake, 2018, social isolation). The capacity to engage in **psychological detachment** is pivotal in determining whether occupational or social stress at work has a negative impact on sleep and well-being (Pereira & Elfering, 2014). The phenomenon of 'problem-solving pondering' is particularly evident when individuals derive enjoyment from their work, with no negative consequences. Conversely, 'affective rumination' can have a detrimental impact (Syrek et al., 2017).

Attitudes towards shift work also appear to be an important factor. Those who are dissatisfied with their working hours tend to experience reduced sleep quality, although their objective sleep duration remains unchanged (Axelsson et al., 2004). Conversely, characteristics of the shift schedule (e.g., length of shifts, rotation) and consequences of shift work (sleep and social difficulties) are predictors of attitudes towards shiftwork (Åkerstedt et al., 2022). Both, Axelsson et al. (2004) and Åkerstedt et al. (2022), have highlighted that further investigation is required to better understand the influence of attitudes towards shiftwork.

The objective of this pilot study was to ascertain which of the factors enumerated here are actually pertinent for shift workers and thus warrant consideration when developing a tailored therapic approach. The following questions were investigated:

(1) Which of the aforementioned factors and models are associated with subjective sleep quality (SSQ), total sleep time (TST), sleep onset latency (SOL), daytime sleepiness (DS) and insomnia severity in shift workers? We anticipated a correlation between poorer sleep outcomes and higher levels of psychological impairment (anxiety and depression, state), anxiety (trait), concern, tension, emotional instability, perfectionism, pre-sleep arousal, early chronotype, dysfunctional beliefs about sleep, importance of sleep, effort-reward imbalance and reluctance to work shifts.

(2) Do the groups insomnia yes/no and shift work yes/no differ with regard to the aforementioned factors? For the group of shift workers with insomnia, we anticipated the highest values for factors that represent psychological stress, as previously discussed.

(3) Which of the characteristics identified are suitable predictors for sleep outcomes?

2. Methods

2.1. Study Design and Participants

An online-survey was conducted with an ad-hoc sample from the general population. To determine group differences, four groups of approximately equal size were obtained: participants with/without insomnia and with regular/irregular working hours. To regulate this, the participants were asked to indicate which of the groups they would assign themselves to. If that group was already full, a message appeared indicating that participation was no longer possible.

Participants were recruited from April to October 2021 in the German-speaking region. Companies and institutions with shift work were contacted and invited to forward the survey to their employees. Furthermore, different mailing lists as well as social media were utilized for the recruitment of participants. As the effects and after-effects of the SARS-CoV-2 pandemic were still clearly noticeable during this period, the acquisition of participants via companies and physicians was challenging.

Inclusion criteria were an age between 18 and 65 years, current employment (≥30h per week) and sufficient knowledge of German. Both day workers and good sleepers were included in order to identify group differences or vulnerability/resilience factors.

Individuals who, according to their self-report, suffered from previously diagnosed physical illnesses that affect sleep (restless legs syndrome, sleep apnea syndrome, chronic pain) or other

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primary disorders (acute substance dependence, severe affective or anxiety disorders, psychoses) were excluded.

An a priori power analysis was conducted using G*Power 3.1 (Faul et al., 2007). Assuming a medium effect size, a power of β = .95 can be achieved with a total sample size of N = 200 in all planned evaluation procedures.

The final sample was N = 225 (female 59.11%) with a mean age of 34.88 years (SD = 12.92). Of the 112 shift workers, 30 actually suffered from insomnia, as determined by procedures explained below. Of the regular working participants, 23 of 113 participants were affected. Further sample descriptions are provided in the supplementary material, table A.

2.2. Method and Instrument

The survey study was conducted online via LimeSurvey. A standardised instrument was compiled from various validated questionnaires and a few own items. The survey started with questions about demographics and previous illnesses, and a question about attitudes to shift work ('Do you like working shifts?') was included.

Sleep. The total score of the PSQI (Pittsburgh Sleep Quality Index; Riemann & Backhaus, 1996) was used to assess overall sleep quality, while items 4, 2, and component 1 were employed to assess TST, SOL, and SSQ, respectively.

The total score of the ISI (Insomnia Severity Index; Gerber et al., 2016) was used as an indicator of the severity of insomnia. The ESS (Epworth Sleepiness Scale; Bloch et al., 1999) was employed to assess daytime sleepiness. The German version of the DBAS-16 (dysfunctional beliefs about sleep; Ger.: MZS, Meinungen-zum-Schlaf, Weingartz & Pillmann, 2009) was employed to gather data on sleep-related irrational beliefs, the rCSM (reduced Composite Scale of Morningness; Randler, 2008) for chronotype. Cognitive and physiological arousal before sleep was evaluated with the PSAS (Pre-Sleep Arousal Scale; Gieselmann et al., 2012), to assess sleep hygiene behaviour the SHI (Sleep Hygiene Index, Mastin et al., 2006) was used. Finally, a self-developed item regarding sleep importance was presented ('How important is your sleep to you?') to gather evidence for the attention-intention-pathway (Espie et al., 2006).

Sleep influencing factors. To examine the factors derived in the introduction for their relationships with sleep and their relevance for shift workers, existing questionnaires were used in whole or in part. The HADS-D (Hospital Anxiety and Depression Scale, Herrmann-Lingen et al., 2011) was employed to assess psychological well-being, in particular anxiety and depression. From the 16 PF-R (16 Personality Factor Test, revised version, Schneewind & Graf, 1998), subscales with the poles emotional instability/stability, relaxation/tension, self-confidence/concern, flexibility/perfectionism were used. The Social Integration subscale from the F-SozU (Questionnaire on Social Support, Fydrich et al., 2007) was integrated, as well as the ERI (effort-reward-imbalance, Siegrist et al., 2019) to measure work-related personality traits (effort, reward, overcommitment, also contains questions on psychological detachment). All tests showed acceptable to good test quality (rf. Grünberger et al., 2024).

In total, the survey instrument took an estimated average of 30 minutes to complete.

2.3. Statistical Analyses

Statistical significance was tested with an error probability of $p < .05$, two-sided. Pearson, Spearman or biserial correlations were calculated with the sub-sample of shift workers (n = 112), depending on data distributions to test which factors showed a significant correlation with different sleep variables (Qu1).

As the PSQI rates sleep *quality*, the cut-off score of the ISI (≥ 15: clinical insomnia, moderate/severe) was used to assign group participants into the groups insomnia (yes/no). Participants who reported working at least a 2-shift system were assigned to the shift-work group.

Group comparisons (Qu2) were calculated using either Mann-Whitney U-tests or t-tests. All four groups (insomnia yes/no; shift yes/no) were included in Kruskal-Wallis H-tests or Anovas. The effect

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size *r* for Mann-Whitney U tests and the pairwise comparisons of the Kruskal-Wallis H test were calculated.

Factors that have proven to be significant are subjected to multiple linear regression with the total score of the ISI as dependent variable (Qu3).

The strategy of first carrying out bivariate (correlations, group differences) and then multivariate (regression) analyses may initially appear to be redundant. However, we elected to pursue this approach due to the exploratory nature of the study. Although recent research has focused more on the sleep of shift workers, the number of studies in this area remains limited. Consequently, it is possible that the observed relationships differ from those assumed based on known effects in the general population. Had we limited our analysis to regressions, we might have failed to detect unexpected results.

For Qu1 and Qu2, the α-level of the results was adjusted according to Benjamini and Hochberg (1995; Hemmerich, 2016). The interpretation of the correlation coefficients (r_s) and effect sizes (r, *Cramer's V*) follows the recommendations of Cohen (1988): small: $|r| \geq .1$; medium: $|r| \geq .3$; large: $|r| \geq .5$. All calculations were conducted using SPSS 29 (IBM, 2022).

3. Results

Qu1: No significant correlations were identified between the sleep of shift workers and either perfectionism or the perceived importance of sleep. Late chronotypes took longer to fall asleep, apart from that there were no correlations between chronotype and sleep variables.

The remaining factors analysed showed significant correlations, particularly for sleep quality (PSQI total) and the severity of insomnia (ISI), but also for many of the other variables (see Table 1). The effect sizes were moderate to high, with the largest effects found for total psychological impairment, emotional stability and pre-sleep arousal (total).

Table 1. Correlations of specific characteristics with sleep variables, shift workers only (n = 112, df = 110).

	SSQ	*SOL*	*TST*	*DS*	*PSQI total*	*ISI total*
Anxiety score (HADS-D anxiety)	r_s = .43, p = .002**	r_s = .34, p = .002**	r_s = –.15, p = .158	r_s = .14, p = .174	r_s = .44, p = .002**	r_s = .53, p = .002**
Depression Score (HADS-D depression)	r_s = .50, p = .002**	r_s = .51, p = .002**	r_s = –.21, p = .047*	r_s = .15, p = .158	r_s = .51, p = .002**	r_s = .58, p = .002**
Psychological impairment (HADS-D total)	r_s = .52, p = .002**	r_s = .48, p = .002**	r_s = –.20, p = .053	r_s = .15, p = .158	r_s = .53, p = .002**	r_s = .62, p = .002**
Anxiety (trait, 16PF-R global scale)*Pearson*	r = .41, p = .002**	r = .32, p = .002**	r = –.23, p = .022*	r = .30, p = .004**	r = .50, p = .002**	r = .52, p = .002**
Concern (16PF-R, O)	r_s = .36, p = .002**	r_s = .28, p = .004**	r_s = –.14, p = .188	r_s = .25, p = .013*	r_s =.40 , p = .002**	r_s = .45, p = .002**
Emotional stability (16PF-R, C)	r_s = –.51, p = .002**	r_s = –.44, p = .002**	r_s = .33, p = .002**	r_s = –.21, p = .040*	r_s = –.59, p = .002**	r_s = –.58, p = .002**
Tension (16PF-R, Q4)	r_s = .26, p = .011*	r_s = .11, p = .284	r_s = –.13, p = .205	r_s = .25, p = .013*	r_s = .30, p = .002**	r_s = .30, p = .002**
Perfectionism (16PF-R, Q3)	r_s = .06, p = .546	r_s = .02, p = .845	r_s = –.13, p = .223	r_s = .12, p = .252	r_s = .00, p = .982	r_s = .09, p = .387
Social Integration (F-SozU)	r_s = –.29, p = .004**	r_s = –.42, p = .002**	r_s = .08, p = .436	r_s = –.04, p = .734	r_s = –.36, p = .002**	r_s = –.34, p = .002**
ERI: effort	r_s = .17, p = .102	r_s = .15, p = .158	r_s = –.06, p = .563	r_s = .09, p = .408	r_s = .18, p = .080	r_s = .21, p = .047*
ERI: reward	r_s = –.35, p = .002**	r_s = –.16, p = .129	r_s =.22, p = .033*	r_s = –.28, p = .006**	r_s = –.29, p = .004**	r_s = –.35, p = .002**

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ERI: overcommitment	r_s = .38, p = .002**	r_s = .26, p = .011*	r_s = –.19, p = .072	r_s = .18, p = .089	r_s = .37, p = .002**	r_s = .37, p = .002**
ERI: imbalance	r_s = .28, p = .006**	r_s = .19, p = .072	r_s = –.14, p = .171	r_s = .20, p = .052*	r_s =.27, p = .008**	r_s = .32, p = .002**
Dysfunctional beliefs about sleep (MZS)	r_s = .48, p = .002**	r_s = .33, p = .002**	r_s = –.17, p = .095	r_s = .30, p = .002**	r_s = .50, p = .002**	r_s = .64, p = .002**
Pre-Sleep-Arousal total (PSAS)	r_s = .51, p = .002**	r_s = .61, p = .002**	r_s = –.34, p = .002**	r_s = .20, p = .051	r_s = .64, p = .002**	r_s = .64, p = .002**
Pre-Sleep-Arousal somatic (PSAS)	r_s = .47, p = .002**	r_s = .51, p = .002**	r_s = –.24, p = .019*	r_s = .13, p = .197	r_s = .53, p = .002**	r_s = .57, p = .002**
Pre-Sleep-Arousal cognitive (PSAS)	r_s = .46, p = .002**	r_s = .56, p = .002**	r_s = –.30, p = .002**	r_s = .19, p = .064	r_s = .57, p = .002**	r_s = .56, p = .002**
Chronotype (rCSM)	r_s = –.15, p = .161	r_s = –.30, p = .004**	r_s = –.00, p = .982	r_s = –.06, p = .575	r_s = –.20, p = .058	r_s = –.08, p = .425
Sleep hygiene (SHI) *Pearson*	r = .25, p = .013*	r = .27, p = .008**	r = –.17, p = .093	r = .22, p = .036*	r = .30, p = .002**	r = .25, p = .014*
Importance of sleep	r_s = .07, p = .518	r_s = .12, p = .254	r_s = .19, p = .067	r_s = –.01, p = .924	r_s = .05, p = .599	r_s = .04, p = .368
Like/dislike shiftwork *biserial*	r_s = .25, p = .016*	r_s = .14, p = .170	r_s = –.24, p = .019*	r_s = .14, p = .163	r_s = .23, p = .023*	r_s = .31, p = .002**

Qu2 (Table 2)**:** Irrespective of shift work, individuals with and without insomnia differed significantly on all factors tested except perfectionism and chronotype, with effect sizes mostly moderate to strong. Among shift workers, people who enjoyed working shifts were disproportionately often not affected by insomnia.

Table 2. Group differences (insomnia yes/no) regarding the specific characteristics examined.

				rank/mean/frequency	
N = 225	*Test statistic*	*p*	*Effect size*	*Insomnia yes (53)*	*Insomnia no (172)*
Anxiety score (HADS-D anxiety)	Z = –6.42	.001**	r = .43	162.98	97.60
Depression Score (HADS-D depression)	Z = –6.54	.001**	r = .44	163.92	97.31
Psychological stress (HADS-D total)	Z = –7.17	.001**	r = .48	169.01	95.74
Anxiety (trait, 16PF global scale) *normal*	$t(223)$ = 5.32	.001**	*Cohens d* = -.84	M = 73.70, SD = 12.904	M = 62.84, SD = 13.037
Worry (16PF-R, O)	Z = –3.59	.001**	r = .24	141.03	104.36
Emotional stability (16PF-R, C)	Z = –5.59	.001**	r = .37	156.65	99.55
Tension (16PF-R, Q4)	Z = –3.28	.001**	r = .22	138.57	105.12
Perfectionism (16PF-R, Q3)	Z = –1.80	.076		127.03	108.68
Social Integration (F-SozU)	Z = –3.42	.001**	r = .23	86.30	121.23
ERI: effort	Z = –2.84	.007**	r = .19	134.94	106.24
ERI: reward	Z = –4.05	.001**	r = .27	81.45	122.72
ERI: overcommitment	Z = –3.84	.001**	r = .26	142.89	103.79
ERI: imbalance	Z = –4.47	.001**	r = .30	147.91	102.24
Dysfunctional beliefs about sleep (MZS)	Z = –7.75	.001**	r = .52	173.59	94.33
Pre-Sleep-Arousal total (PSAS)	Z = –7.36	.001**	r = .49	170.47	95.29

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Pre-Sleep-Arousal somatic (PSAS)	$Z = -6.88$	.001**	$r = .46$	166.05	96.65
Pre-Sleep-Arousal cognitive (PSAS)	$Z = -6.63$	.001**	$r = .44$	164.68	97.08
Chronotype (rCSM)	$Z = -0.83$	.408		106.55	114.99
Sleep hygiene (SHI) *normal*	$t(223) = 2.85$	.007**	*Cohens d* = –.45	$M = 19.68$, $SD = 7.60$	$M = 16.67$, $SD = 6.43$
like/dislike shiftwork *dichotom* ($n = 112$)	$\chi^2(1) = 6.71$	.012*	*Cramers V* = .25	like $f = 15$, dislike $f = 15$	like $f = 62$, dislike $f = 20$
Importance of sleep	$Z = -2.41$	.018*	$r = .16$	130.29	107.67

However, for all sleep variables analysed, the groups shift yes/no only differed from each other with a moderate effect size for the TST, $Z = -4.08$, $p = .026$*, $r = 0.27$, mean rank yes = 95.52, no = 130.33 (table B, supplementary material).

Table 3 indicates that the groups 1 (shift no, insomnia yes) and 3 (shift yes, insomnia yes) exhibited the strongest expressions towards the 'more vulnerable' pole. The strongest expressions towards the 'more resilient' pole were even found slightly more often in shift-workers that did not suffer from insomnia (group 4) than in healthy non shift-workers (group 2).

Table 3. Group differences between four groups regarding the specific characteristics analysed (Kruskal-Wallis-H-Test/Anova, $df = 3$).

			Goups: rank/mean			
	H (χ^2)	p	*Group 1: Shift no Insomnia yes* $n = 23$	*Group 2: Shift no Insomnia no* $n = 90$	*Group 3: Shift yes Insomnia yes* $n = 30$	*Group 4: Shift yes Insomnia no* $n = 82$
SSQ (PSQI comp. 1)	90.76	.001**	182.26	85.83	178.33	99.49
SOL (PSQI item 2)	35.79	.001**	137.11	98.64	171.97	100.43
TST (PSQI item 4)	60.74	.001**	66.91	146.53	55.70	110.09
DS (ESS)	26.03	.001**	151.61	98.66	153.38	103.13
PSQI total	88.72	.001**	184.26	83.88	186.35	98.13
ISI total	124.32	.001**	197.07	78.39	200.48	95.40
Anxiety score (HADS-D anxiety)	44.39	.001**	164.72	105.94	161.65	88.44
Depression score (HADS-D depression)	44.84	.001**	149.30	97.24	175.12	97.39
Psychological impairment (HADS-D total)	53.15	.001**	162.04	100.96	174.35	90.02
Anxiety (trait, 16PF global scale) *normal*	$F(3, 221) = 12.70$	.001**, $\eta^2 = .15$	$M = 73.04$	$M = 65.61$	$M = 74.20$	$M = 59.79$
Concern (16PF, O)	23.95	.001**	145.30	119.96	137.75	87.25
Emotional stability (16PF, C)	37.06	.001**	149.11	110.34	162.43	87.71
Tension (16PF, Q4)	12.75	.006**	132.85	111.27	142.95	98.38
Perfectionism (16PF, Q3)	3.36	.352	128.07	110.33	126.23	106.87
Social Integration (F-SozU)	19.21	.001**	77.70	108.87	92.90	134.79
ERI: effort	12.12	.008**	134.57	96.77	135.23	116.63
ERI: reward	17.12	.001**	81.87	126.73	81.13	118.32
ERI: overcommitment	15.92	.001**	151.37	107.17	136.38	100.08
ERI: imbalance	23.84	.001**	151.78	93.08	144.93	112.30
Dysfunctional beliefs about sleep (MZS)	60.40	.001**	168.72	92.98	177.33	95.80

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Pre-Sleep-Arousal total (PSAS)	55.73	.001**	168.89	101.12	171.68	88.90
Pre-Sleep-Arousal somatic (PSAS)	49.77	.001**	161.33	103.69	169.67	88.93
Pre-Sleep-Arousal cognitive (PSAS)	45.34	.001**	166.46	102.57	163.32	91.05
Chronotype (rCSM)	1.50	.682	114.00	112.49	100.83	117.73
Sleep hygiene (SHI) *normal*	$F(3, 221) = 3.30$	.024*, $\eta^2 = .04$	$M = 18.83$	$M = 17.20$	$M = 20.33$	$M = 16.10$
Shiftwork like/dislike	--	--	--	--	--	--
Importance of sleep	9.15	.029*	146.61	110.24	117.78	104.85

Marked in colour: highest expression to the „more vulnerable“ pole (orange); „more resilient“ pole (green).

In the post-hoc tests (see supplementary material, table C), the groups with insomnia (1, 3) differed from groups without insomnia (2, 4) for most of the characteristics tested, with the exception of the factors SOL, anxiety, emotional stability, tension, social integration, effort-reward imbalance and sleep hygiene. Here, only one or two pairwise group comparisons were significant in some cases. ‚Importance of sleep‘ was also an exception; sleep was most important for participants with regular working hours with insomnia.

Qu3: Based on the previous results, perfectionism, chronotype and importance of sleep were excluded as they showed very little or no significant correlations with ISI (and the variables derived from the PSQI). The results for these variables were also not significant for the group differences or only showed small effects. To avoid multicollinearity, PSAS total and HADS-D total were also excluded.

Stepwise multiple linear regression with the criterion ISI total yields a high goodness of fit and explanation of model variance for the model including the four predictors dysfunctional beliefs about sleep (MZS), cognitive pre-sleep-arousal (PSAS_cogn), depression score (HADS-D depression) and somatic pre-sleep-arousal (PSAS_soma). The included variables significantly predict the ISI score. The regression equation shows significant positive correlations: If the level of dysfunctional beliefs about sleep increases by one *SD*, the ISI increases by 0.37 *SD*, provided that the other factors are held constant (Table 4).

Table 4. Multiple linear regression, stepwise, criterion: ISI total, $n = 111$.

coefficients	*b*	*SE*	*β*	*t*	*p*	*95% CI*	
						upper	lower
(constant)	-1.99	1.10		-1.81	.073	-4.16	0.19
MZS: dysfunctional beliefs	0.08	0.02	0.37	4.82	< .001***	0.05	0.11
PSAS_cogn: cognitive pre-sleep arousal	0.18	0.07	0.21	2.55	.012*	0.04	0.31
HADS-D_depr: Depression score	0.31	0.13	0.20	2.45	.016*	0.06	0.57
PSAS_soma: somatic pre-sleep arousal	0.26	0.13	0.19	2.10	.038	0.02	0.51

Equation: ISI_total = 0.37 x (MZS) + 0.21 x (PSAS_cogn) + 0.20 x (HADS_depr) + 0.19 x (PSAS_soma)

$R = 79$; $R^2 = .63$; $R^2_{adj.} = .62$; $F(4, 106) = 45.10$, $p < .001$***.

4. Discussion

Qu1: People with poorer sleep showed higher scores for psychological impairment, anxiety, concern, tension, pre-sleep arousal, dysfunctional beliefs about sleep and effort-reward imbalance; lower scores for emotional stability, social integration and sleep hygiene. People with a more negative attitude towards shift work also slept worse. It seems interesting that more significant results with stronger effects were found for SSQ and SOL than for TST and DS. As DS is a criterion of SWD (AASM, 2014; Becker et al., 2009) and TST is known to be negatively affected by shift work (Costa,

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2010), stronger correlations were expected for these variables. The underlying cause may be attributed to a delay in falling asleep due to rumination, worrying and increased arousal.

Perfectionism, chronotype and the importance of sleep represent an exception to this general pattern, with the results in these cases being (mostly) not significant. We had expected that higher perfectionism (Akram et al., 2015; Crönlein et al., 2017) and early chronotype (Natvik et al., 2011) would be associated with poorer sleep in shift workers. The question about the importance of sleep was used as an operationalisation of excessive attention to (disturbed) sleep in order to find an indication of the relevance of the attention-intention pathway (Espie et al., 2006) in shift workers. It is somewhat surprising that no significant results were obtained. It is possible that the single item used was insufficient to measure the intended construct.

Sleep hygiene was not expected to be important in shift workers, but it showed moderate effects. This may be due to the instrument used to measure sleep hygiene: Only two of the 13 items of the SHI (Sleep Hygiene Index, Mastin et al., 2006) ask for the regularity of the sleep-wake rhythm.

Qu2: The results for Qu1 were confirmed in the subsequent analyses: The insomnia (yes/no) groups differed from each other in almost all characteristics and the effect sizes were mostly moderate to strong. It was indeed relevant whether someone liked or disliked their working mode: In the group with insomnia there were significantly more people who reported dissatisfaction with shift work. This confirms the assumption of Axelsson et al. (2004) assumption that those who are dissatisfied with their working hours sleep less well, at least subjectively. Nevertheless, according to Åkerstedt et al. (2022), this outcome may also be interpreted to indicate that individuals with insomnia tend to associate it with their working hours, therefore exhibit a more negative attitude towards shift work.

At first glance, it seems surprising that the shift yes/no groups do not differ significantly from each other, with the exception of the moderate difference in TST.

To recruit four groups of equal size, the recruitment process was controlled accordingly. The study design therefore does not permit any inferences to be drawn regarding the risk of sleep disorders in shift workers. We also assume that shift workers are not inherently more vulnerable, but that shift work is responsible for the known higher risks (see Introduction; Ohayon et al., 2010; Costa, 2010; Seibt et al., 2006). Accordingly, the objective was to identify therapeutically manipulable factors that are associated with sleep, also or especially in shift workers, to replace the previous interventions based on regularity. The lack of difference between the shift yes/no groups does not detract from the need for a new therapy. Our primary arguments are that the standard-CBT-I is difficult to implement for shift workers and interventions on regularity could impair compliance.

However, the absence of group differences between participants with regular/irregular working hours may be attributed to the assumption of self-selection (Rosa & Colligan, 1997) in two respects: The results appear to support the hypothesis that individuals who are more intolerant of shift work are more likely to return to regular working hours. However, this could be seen as a refutation given that some individuals are obliged to remain in shift work (Rosa & Colligan, 1997) due to the necessity of the bonuses or the sharing of childcare with their partner. In our sample, 27 individuals indicated that their profession necessitates shift work, four cited an employer requirement, and three need the bonuses. These two effects could potentially cancel each other out, leading to the observed lack of group differences.

Qu3: Dysfunctional beliefs about sleep, pre-sleep arousal (cognitive and somatic) and depression levels have been shown to be significant predictors of insomnia severity. It was rather expected that anxiety (state) and the traits anxiety, emotional stability, tension and concern would be adequate predictors for the severity of insomnia, whereas depression would rather be the result of sleep deprivation (Akram et al., 2015). Given the results of Qu1 and Qu2, it is also surprising that attitudes towards shift work do not appear in the model. This could be interpreted as an indication of the causal direction, as discussed in Qu2: Attitude towards shift work is not a predictor of the severity of insomnia, because the opposite is more likely: those who have a sleep problem attribute it to shift work and therefore have a more negative attitude towards it (Åkerstedt et al., 2022).

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5. Conclusions

The objective of this study was to identify factors that are associated with sleep, particularly in shift workers, that can be manipulated therapeutically, to replace interventions based on regularity.

Our results suggest integrating the following factors and interventions: Psychoeducation to cognitively restructure dysfunctional attitudes towards sleep and shift work; interventions against rumination and concern to reduce anxiety and depression; positive and social activities to reduce depression and to foster social integration; relaxation methods to reduce tension and emotional instability.

These components offer the advantage of not requiring regularity, making them well-suited for developing a therapy manual for shift workers who are unable to maintain stable circadian rhythms. A program explicitly designed for this target group, which excludes elements that are unsuitable for them, should also enhance compliance and reduce attrition rates.

Limitations. The most fundamental limitation is that it is a survey study with an ad hoc sample. Consequently, the sample is not representative, and all data are self-reported. The collection of objective data, including polysomnography and actigraphy recordings, was precluded due to the ongoing presence of the SARS-CoV-2 pandemic. Due to the online format of the study, pre-existing conditions could only be assessed on the basis of information provided by the participants. The length of the survey instrument, which was approximately 30 minutes, could have introduced a selection bias, as only those who were particularly attentive would have completed it.

These limitations must be taken into account. However, given the objective of this pilot study (as part of a larger project) to obtain information for the development of a new therapeutic approach, the limitations appear to be justified. This is particularly the case given the planned testing of the effectiveness of the resulting therapy manual with an RCT (see Grünberger et al., 2024).

Strengths. In contrast to many other studies, our investigation simultaneously examined a range of characteristics in a cohort comprising diverse professional groups. This approach takes into account Ohayon's justified criticism (2010) that the results of studies on single occupational groups (e.g., nurses) cannot be generalised. The comparison of the four groups of insomnia yes/no and shift work yes/no also yielded some revealing results. Another strength is that we have included the attitude towards shift work, which was demanded by Axelsson et al. (2004) and Åkerstedt et al. (2022).

We have therefore achieved our goal of creating a sustainable basis for the development of an innovative therapeutical approach for the treatment of insomnia in shift workers.

Outlook. Once the tailored therapy manual based on this approach has been developed, we will test its effectiveness in an RCT. Therefore, we are planning to compare the newly developed therapy for shift workers with the standard therapy (CBT-I).

Supplementary Materials: The following supporting information can be downloaded at the website of this paper posted on Preprints.org.

Statements: Data are available on demand. As this is an online study, no costs were incurred, therefore no financing is to be indicated. For the same reason, authorisation by the ethics committee was not necessary. None of the authors has a conflict of interest. Patients were informed in detail at the beginning of the survey and agreed to participate by clicking on 'continue'. No materials from other sources have been used that require permission. A clinical trial registration was not necessary as this was not an RCT study.

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