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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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Abstract: Shift workers face a heightened risk of insomnia. Recent research has yielded promising insights; but further progress is necessary to better treat insomnia in this group. The present pilot study evaluates how different personality traits and states impact sleep in shift workers to develop an innovative therapeutic approach. An online survey was administered to an ad-hoc sample of *N* = 225 (112 shift workers), and correlations were calculated between sleep variables and specific characteristics (e.g., psychological impairment, personality traits, sleep-related behavior, attitudes towards sleep and shift work). Group differences between good/poor sleepers and day/shift work were determined using Mann-Whitney U-tests and Kruskal-Wallis H-tests. Regression was used to identify appropriate predictors. All factors (except perfectionism, chronotype, and importance of sleep) yielded significant results in both correlations and group differences (good/poor sleepers). The groups day/shift workers showed only minor differences. Dysfunctional beliefs about sleep, pre-sleep arousal, and depression were identified as predictors of poorer sleep. We conclude that interventions on the factors mentioned can replace those on regularity and will build an innovative therapy for shift workers on this basis. Once the treatment manual is finalized, its efficacy will be assessed through a randomized controlled trial.

Keywords: shift work; insomnia; personality traits; states; tailored treatment

1. Introduction

Despite the prevalence of shift work in developed countries, estimated at 20% [1], and the established association between shift work and an increased risk of sleep disorders [2], this demographic has historically been underrepresented in research [3,4]. One potential explanation for this oversight may be the challenge of implementing standard therapeutic interventions, such as CBT-I, due to the absence of a regular sleep-wake cycle. The objective of this pilot study is to identify other factors influencing sleep in order to develop a new therapeutic approach for the treatment of sleep disorders in shift workers where regularity is not a central factor.

1.1. Definition of "Shift Work"

A standard definition of shift work does not exist [5]. For the purposes of this study, the definition provided by the German Society for Occupational and Environmental Medicine is used: According to this definition, shift work is defined as any work schedule that deviates from the conventional 8-hour workday, including rotating shifts and non-conventional schedules such as continuous late shifts or continuous night shifts [6].

In light of the mounting flexibilization and individualization of working hours [6], it is more appropriate to speak of various shift systems rather than to specify exact hours. The 2-shift system encompasses only early and late shifts, while the 3-shift system includes night shifts as well.

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1.2. General Consequences of Shift Work

The adverse consequences of shift work extend to virtually all aspects of one's well-being. The effects on physical health include an increased risk of cardiovascular disease, stroke, cancer, and an elevated mortality rate [7–9]. The psychological consequences of shift work include enhanced levels of depression and anxiety [7], suicidal ideation, and somatization [10,11]. Irritability, nervousness, and neuroticism are more prevalent, and the use of sedatives and hypnotics is also more frequent [12]. Furthermore, night shifts have been shown to lead to elevated oxidative stress, which in turn impairs cognitive performance [13]. Shift work also results in lower job satisfaction [10], higher absenteeism [12] and an increased risk of burnout, particularly the dimension of emotional exhaustion [14]. It can also reduce alertness with implications for safety at workplace and during commuting [15]. In the private context, greater social isolation is perceived [10]. The proportion of singles among shift workers (30.8%) is higher than in the general population (20.8%) [10]. Unconventional working hours present significant challenges in maintaining a healthy work-life balance, particularly in relation to social and family life [16].

1.3. The Impact of Shift Work on Sleep

In light of these findings, it can be expected that sleep is also affected by shift work. Although the differences in sleep patterns between day- and night-shift workers are not particularly salient, they do attain statistical significance for total sleep time and sleep-onset latency [17]. Night workers and those working in a rotating three-shift system have an elevated risk of a total sleep time of less than six hours (*OR* = 1.7 resp. 1.9) compared to day workers (*OR* = 1.0) [18]. Shift work results in a reduction of the total sleep time by two to four hours per night, increased proportions of REM and NREM2 sleep, as well as more frequent and premature sleep interruptions. These alterations in sleep can be influenced by social factors, such as shared meals with family members [12]. The reduced total sleep time could be caused by more challenging sleep conditions during the day [6].

1.4. Insomnia and Shift Work Disorder

Insomnia per se is defined as dissatisfaction with or concern about one's personal sleep quality and/or quantity, commonly associated with difficulties falling or staying asleep, early waking and daytime complaints [1,19]. In western industrialized countries, the prevalence of insomnia is reported to be 10% [1].

The term "shift work disorder" (SWD) refers to a condition characterized by insomnia and/or excessive sleepiness, as well as a reduction of total sleep time, due to the engagement in shift work [1]. These shift-related sleep problems are also observed to occur on days off from work [20], yet they should subside during extended work-free periods, such as vacation. The estimated prevalence of SWD among shift workers is 26.5% [21], but it varies considerably depending on the specific shift system (38.8% three-shift system, 24.7% two-shift system, 5.5% day work only) [22].

Although primary insomnia and SWD have different etiologies, they are difficult to differentiate, as they often overlap symptomatically and in terms of maintaining factors [23]. It is noteworthy that SWD frequently progresses into chronic insomnia [11,20,23]. In the context of the present study, it therefore appears to be of limited practical value to maintain a clear distinction between SWD and insomnia. Consequently, the term SWD is employed exclusively in instances where extant sources also utilize this designation.

1.5. Circadian Rhythm and Other Potential Causes of Negative Consequences of Shift Work

The human circadian rhythm is strongly linked to daylight. The "internal clock" is known to adjust to a 24-hour rhythm in relation to environmental light exposure. This adjustment regulates not only sleeping and waking times but also numerous physiological processes, including melatonin release and body temperature [24,25].

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Sleep disturbances in shift workers are typically attributed to work-related misalignment of the sleep-wake rhythm with the internal circadian system [26]. This misalignment precipitates the release of melatonin and cortisol during times when their effect is incongruent with the individual's current objective (e.g., working or sleeping) [7]. Long-term night shift workers without sleep problems exhibit an endogenous rhythm adapted to these working hours, whereas those with SWD do not [25]. Such an adaptation is not possible in the case of rotating or irregular working hours.

Another hypothesis posits that the factors that contribute to the development and maintenance of insomnia in general are also important in the context of shift-related sleep disorders. For instance, in a sample of night shift workers, disparities were identified between individuals with adequate sleep and those affected by SWD with respect to negatively toned pre-sleep cognitive activities, dysfunctional beliefs about sleep related to worry/helplessness, and selective attention [7]. Furthermore, a clear correlation exists between the risk of SWD and the severity of depression [27].

Despite the analogous conclusions of many studies, there is strong critique about the study situation [28]. Using the example of different diseases, the authors explain in detail what they consider to be serious methodological shortcomings of the studies, which have led to the widespread view that "shift work makes sick." Their examination of the data reveals only marginal differences between day and (night) shift workers, taking into account confounding variables, whereby the results are partly contradictory. Consequently, the elevated illness rates are attributed to factors such as age (e.g., heightened risk of cancer) and less healthy lifestyles (diet, exercise, nicotine and alcohol consumption), with the latter being more prevalent in (night) shift work [28].

1.6. Standard Treatment of Insomnia and Challenges in Its Application for Shift Workers

The gold standard for the treatment of insomnia is cognitive behavioral therapy for insomnia (CBT-I) [29]. However, the implementation in its original form presents significant challenges for shift workers, as a substantial proportion of its therapeutic interventions are contingent upon regular rhythms, e.g. rules for sleep hygiene and stimulus control or sleep restriction (reduction of time lying in bed). If these components of standard therapy cannot be implemented, the most salient efficacy factors of CBT-I no longer apply. The extant studies on shift work offer scant indications of further reasons for the difficulty in implementing or reduced effectiveness of CBT-I in shift workers. However, personal, unsystematic observations (T.G.) from clinical practice with affected shift workers have led to some assumptions. For instance, the belief that shift work makes people ill and that sleep disturbance is an inevitable fate of this form of work seems to be widespread. This phenomenon is further compounded by the tendency of general practitioners to primarily offer sleeping pills as a solution, thereby exacerbating the issue. This phenomenon can engender a sense of resignation or skepticism regarding the efficacy of traditional therapeutic interventions, which might contribute to the observed decline in compliance [30]. The psychological distress associated with shift work, as previously outlined, and the perceived social disconnection resulting from social desynchronization could also contribute to this phenomenon.

Recent studies have shown an increase in the adaptation of CBT-I to address the specific needs of shift workers (see an overview of current research in our subsequent study [31]). The findings of these studies are ambivalent. While some statistically significant improvements are observed, they often fail to reach clinical significance (e.g., [32]).

The attrition rate is high, yet compliance remains low [30,33]. Consequently, several reviews and meta-analyses have concluded that CBT-I adapted to shift workers is better applicable, but not sufficient for this demographic [see 31].

Therefore, the development of a specifically tailored therapy manual for shift workers is imperative. A completely new approach is to be pursued. The subsequent sections will discuss models and characteristics that may be pertinent. Some of these have previously been mentioned in the context of shift work, while others are known to be involved in the development and maintenance of insomnia in the general population. Additional factors have been identified through a comprehensive review of the extant literature and are presented as potential contributors to the

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development and maintenance of insomnia in this population. The objective of this analysis is to explore the potential of these factors to enhance the efficacy of the therapy to be developed and to better meet the needs of shift workers.

1.7. Derivation of Eligible Models and Features

1.7.1. Insomnia-Related Models and Implications for Shift Workers

The **cognitive insomnia model** encompasses both nighttime and daytime processes, positing that excessive negatively toned cognitive activity (influenced by dysfunctional beliefs and safety behaviors) leads to arousal and distress, selective attention and monitoring, and a distorted perception of sleep/function deficit. The importance of sleep is increasing, accompanied by a rise in anxiety [34]. The **attention-intention-effort pathway** posits that an excessive focus of attention or the intention to force oneself to fall asleep can lead to the development and maintenance of sleep disorders [35].

These two models are also pertinent to shift workers, who exhibit heightened cognitive arousal preceding sleep and more maladaptive beliefs about sleep [7]. This finding aligns with the concept of **hyperarousal disorder,** a term frequently employed in the broader insomnia literature [5]. Hyperarousal disorder describes a state of heightened mental and physical tension, accompanied by an inability to effectively relax or recuperate through sleep. For individuals engaged in shift work, interventions targeting pre-sleep cognitive activity and addressing dysfunctional beliefs are recommended [7].

Sleep hygiene encompasses a series of guidelines, including the maintenance of a consistent sleep routine, the abstinence from daytime naps, the adherence to regular sleep- and wake times, and the avoidance of caffeine after 2 p.m. Sleep hygiene is regarded as an effective intervention in CBT-I [29], although some authors have expressed skepticism regarding its efficacy: Poor sleep hygiene is associated with insomnia, but it is rarely the underlying cause [36]. In middle-aged women, no or only moderate correlations are evident between sleep hygiene and insomnia symptoms [37]. A psychoeducational intervention on sleep hygiene among Japanese factory workers, including shift workers, resulted in improvements in sleep-related behaviors [38]. Nevertheless, no significant changes in sleep quality or daytime sleepiness were observed. Another study [39] also revealed no or only small effects on sleep in shift workers, possibly because regularity is an important component. However, another reason could be that sleep hygiene can promote awareness of healthy sleep practices [39], but, in contrast, the adherence to these rules throughout the day may potentially lead to a heightened focus on sleep, which, according to the attention-intention-effort pathway [35], could result in maintenance of the sleep problem.

1.7.2. Mental Health

Untreated sleep disorders are known to be a risk factor for **depression** [40]. This association can be attributed to the role of sleep in emotional processing. Experimental studies have demonstrated that a single night of sleep deprivation results in an amplified amygdala response to negative stimuli and a heightened evaluation of neutral stimuli [41]. A comparison between individuals with sleep apnea syndrome and healthy sleepers revealed that the impaired emotional processing is not attributable to central nervous processes, but rather to the consequences of sleep deprivation itself [41].

However, sleep disorders also frequently manifest as a symptom of depression. The differentiation between sleep disorders and depression, as well as the establishment of causality, is therefore challenging [5], even independently of shift work.

Nevertheless, not only do shift workers have higher levels of depression, they also have higher levels of **anxiety**, suicidality, and somatization, with insomnia usually being assumed to be a mediator [5–7]. This assumption appears to be substantiated by the evidence that shift workers have reduced total sleep time and REM sleep [18].

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Anxiety symptoms as a state appear to be more of a risk factor for insomnia [42], although indications of increased arousal after sleep deprivation in people with sleep disorders at least do not rule out the reverse possibility [5]. The states of irritability, nervousness and anxiety [12] mentioned as consequences of shift work suggest the possibility that the causality between insomnia and anxiety symptoms also points in both directions, as with depression.

This is supported by the finding that acute sleep deprivation exerts divergent effects on healthy individuals compared to those with sleep disorders. Specifically, healthy individuals typically experience drowsiness and impaired performance following sleep deprivation, while individuals with sleep disorders demonstrate largely unimpaired performance without drowsiness, but with heightened arousal, tension, and a reduced ability to relax [5].

A Canadian survey [43] also identified a clear association between shift work and burnout. Using the "Maslach Burnout Inventory" [44], which was originally developed for helping professions, with its three dimensions of emotional exhaustion, depersonalization, and reduced personal performance, the study examined shift and weekend workers. The analysis revealed that both the shift and weekend workers exhibited significantly higher overall values for burnout and for the emotional exhaustion dimension compared to the control group [43].

1.7.3. Personality Traits

The role of personality traits as predisposing factors in interaction with precipitating and perpetuating factors in chronic insomnia was described in the early literature [45]. An earlier review [40] offers a comprehensive overview of personality traits that could be considered as predisposing factors for insomnia. These traits include general dissatisfaction, sensitivity to anxiety, obsessive worrying, hypochondrical concerns, internalization, and neuroticism. Overconcerned individuals, characterized by a lack of self-confidence and elevated doubts about action, have been associated with perfectionism and self-imposed strain [40].

A number of these factors have been substantiated in recent studies and are also mentioned in most textbooks, including neuroticism, internalization and perfectionism [5,12,42]. However, the extent to which these factors are truly predisposing or rather consequential outcomes of insomnia and its deleterious effects on daytime functioning remains to be elucidated [40].

The association between shift work and its tolerance can be delineated through the theoretical framework of **shift work tolerance.** It is defined as the ability to adapt to shift work without adverse consequences, and has been associated with behavioral and biological dispositions [46]. Shift work intolerance, in contrast, is characterized by persistent sleep changes and fatigue, the use of sleep medication, behavioral changes such as aggression and irritability, and gastrointestinal complaints [47]. Female sex, older age and early chronotype have been identified as risk factors for shift work intolerance [48]. In contrast, factors associated with resilience include lower levels of inertia and neuroticism, and higher levels of flexibility, extraversion, and internal locus of control [46]. A longitudinal study presents findings that challenge previous assumptions: While neuroticism is a predictor of insomnia symptoms in shift workers, insomnia is not a predictor of neuroticism. Additionally, high morningness correlates with low insomnia levels, as well as older age predicts fewer insomnia symptoms [49]. The authors posit that this is attributable to a decline in tolerance for shift work at 45–50 years of age, which may not fully account for the observed phenomenon in the study's younger sample. Additionally, they hypothesize that as individuals age, they may become more likely to opt out of shift work, resulting in a higher prevalence of those who are more tolerant of shift work [49]. Therefore, this could be considered as a form of self-selection, a phenomenon that has been previously postulated [50].

1.7.4. Occupational Factors

In comparison with conventional work schedules, shift work has been demonstrated to result in lower job satisfaction, less perceived support from management, and constrained access to social and preventive health services offered by employers due to the nature of the work schedule [10].

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These consequences bear similarities to the risk factors associated with burnout, which include an imbalance between excessive effort and inadequate reward, an excessive willingness to expend effort beyond one's capacity, perfectionism, and a limited ability to disengage from work-related demands [51].

The **effort-reward imbalance model** (Siegrist, as cited in [52]), which was referred to in the last paragraph [51], states 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. A significant correlation between effort-reward imbalance and sleep disorders was found, though the direction of causality remains undetermined. It is conceivable that sleep disturbances might lead to an overestimation of the perceived imbalance [52].

These consequences bear similarities to the risk factors associated with burnout, which include an imbalance between excessive effort and inadequate compensation, excessive demands on oneself, perfectionism, and a limited ability to disengage [51].

The capacity to psychological detachment is pivotal in determining whether occupational or social stress at work has a negative impact on sleep and well-being [53]. 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 [54]. Psychological detachment is also a component of the Effort-Reward-Imbalance model and the measurement instrument developed therefore [55].

The relationship between burnout and shift work has been delineated in section 1.7.2. In addition to emotional exhaustion, irritability, depression, anxiety, and other symptoms, burnout is also characterized by sleep disorders, an inability to recover, and fatigue [56].

Attitudes toward shift work have also been identified as a significant factor influencing sleep. Individuals expressing dissatisfaction with their work hours tend to exhibit diminished sleep quality, despite their objective sleep duration remaining unaltered [57]. Conversely, characteristics of the shift schedule (e.g., length of shifts, rotation), as well as the consequences of shift work (sleep disturbances, social difficulties), are predictors of attitudes toward shift work [58]. The authors highlighted that further investigation is required to better understand the influence of attitudes toward shiftwork [57,58].

1.7.5. Psychosocial Factors

The unconventional scheduling of work hours has been shown to lead to "social desynchronization" within the private context, which hinders participation in social activities due to work shifts [16].

Consequently, a greater proportion of the population experiences elevated levels of social isolation, with 31% of evening shift workers and 27% of night shift workers reporting such experiences, compared to 9% of the general population [10]. Additionally, a higher percentage of shift workers are unmarried compared to the general population, with 30.8% of shift workers reporting this status, compared to 20.8% of the general population [5]. Social isolation has also been found to be negatively associated with sleep, with a significantly higher prevalence of general sleep problems among shift working singles (53.2%) compared to shift workers who are in a relationship (32.8%). In day workers, there are no differences in the prevalence of sleep problems between those living alone or in a partnership [59]. Family conflicts are more frequent in shift workers, less time is spent with the children, a condition that persists even on days off [5]. These findings, which are based on the notion that social connectedness is crucial for mental well-being, suggest that the aforementioned consequences of shift work are likely to exert an additional negative influence on mood.

Social stressors in the workplace (and probably not only there) are particularly detrimental [53]. Unsatisfied needs for belonging and self-esteem protection lead to a range of psychological and physical impairments, including sleep problems [53]. A dearth of social support in the workplace or in general is also a risk factor for sleep complaints [60] (see also [10] on social isolation). As described

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in section 1.2, increased social isolation was observed in shift workers due to social desynchronization [16], so the causality seems to point in both directions here as well.

1.8. Research Questions and Hypotheses

The objective of this pilot study was to examine the factors derived from the extant literature with regard to their relevance for the sleep of shift workers. Despite a thorough review of the extant literature, it remains challenging to assess the relevance of these factors for the inclusion of shift workers into the new treatment. To the best of our knowledge, there is no research with a comparable approach. So the following questions were investigated:

(Qu1) Which of the factors and models derived from literature are associated with insomnia severity, sleep quality, total sleep time, sleep onset latency, and daytime sleepiness in shift workers? It was hypothesized that there would be correlations between poorer sleep outcomes and higher levels of psychological impairment (anxiety and depression, state), the traits anxiety, concern, tension, emotional instability, perfectionism, the sleep-related characteristics pre-sleep arousal, early chronotype, dysfunctional beliefs about sleep, importance of sleep, and the occupational factors effort-reward imbalance, and reluctance to work shifts, as well as lower perceived social integration.

(Qu2) Do good/poor sleepers and day/shift workers differ with regard to the aforementioned factors? We hypothesized that the group of poor sleeping shift workers would demonstrate the highest values for factors representing psychological stress, as previously discussed.

(Qu3) Which of the so far identified characteristics are suitable predictors for sleep outcomes? Do these predictors exhibit disparities between the groups or the respective sleep outcomes?

2. Results

2.1. Qu1: Which of the Factors and Models Derived from Literature Are Associated with Insomnia Severity, Sleep Quality, Total Sleep Time, Sleep Onset Latency, and Daytime Sleepiness in Shift Workers? (See Legend at the End of This Article)

The majority of the correlations between the sleep of shift workers and the analyzed characteristics demonstrated significant results, particularly for severity of insomnia (ISI [61]) and sleep quality (PSQI total, [46], see Table 1). The effect sizes ranged from moderate to high, with the most pronounced effects observed in total psychological impairment, emotional stability, and total pre-sleep arousal.

No significant correlations were found between the sleep of shift workers and either perfectionism or the perceived importance of sleep. Later chronotypes exhibited a longer sleep onset latency, all other correlations between chronotype and sleep variables were not significant.

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

	ISI [61]	***PSQI Total [62]***	***SOL [62]***	***TST [62]***	***ESS [63]***
Anxiety state (HADS-D anx) [64]	r_s = .53, p = .002	r_s = .44, p = .002	r_s = .34, p = .002	r_s = –.15, p = .158	r_s = .14, p = .174
Depression state (HADS-D depr) [64]	r_s = .58, p = .002	r_s = .51, p = .002	r_s = .51, p = .002	r_s = –.21, p = .047	r_s = .15, p = .158
Psychological impairment (HADS-D total) [64]	r_s = .62, p = .002	r_s = .53, p = .002	r_s = .48, p = .002	r_s = –.20, p = .053	r_s = .15, p = .158
Anxiety (trait, 16PF-R [49]) *Pearson*	r = .52, p = .002	r = .50, p = .002	r = .32, p = .002	r = –.23, p = .022	r = .30, p = .004
Concern (16 PF-R [65], O)	r_s = .45, p = .002	r_s =.40 , p = .002	r_s = .28, p = .004	r_s = –.14,p = .188	r_s = .25, p = .013
Emot. instability (16 PF-R [65], C)	r_s = .58, p = .002	r_s = .59, p = .002	r_s = .44, p = .002	r_s = –.33, p = .002	r_s = .21, p = .040

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Tension (16 PF-R [65], Q4)	r_s = .30, p = .002	r_s = .30, p = .002	r_s = .11, p = .284	r_s = –.13, p = .205	r_s = .25, p = .013
Perfectionism (16 PF-R [65], Q3)	r_s = .09, p = .387	r_s = .00, p = .982	r_s = .02, p = .845	r_s = –.13, p = .223	r_s = .12, p = .252
Social Integration (F-SozU) [66]	r_s = –.34, p = .002	r_s = –.36, p = .002	r_s = –.42, p = .002	r_s = .08, p = .436	r_s = –.04, p = .734
Effort ERI [55]	r_s = .21, p = .047	r_s = .18, p = .080	r_s = .15, p = .158	r_s = –.06, p = .563	r_s = .09, p = .408
Reward ERI [55]	r_s = –.35, p = .002	r_s = –.29, p = .004	r_s = –.16, p = .129	r_s =.22, p = .033	r_s = –.28, p = .006
Overcommitment ERI [55]	r_s = .37, p = .002	r_s = .37, p = .002	r_s = .26, p = .011	r_s = –.19, p = .072	r_s = .18, p = .089
Imbalance ERI [55]	r_s = .32, p = .002	r_s =.27, p = .008	r_s = .19, p = .072	r_s = –.14, p = .171	r_s = .20, p = .052
Dysfunctional beliefs about sleep (MZS) [67]	r_s = .64, p = .002	r_s = .50, p = .002	r_s = .33, p = .002	r_s = –.17, p = .095	r_s = .30, p = .002
Pre-Sleep-Arousal total (PSAS total) [68]	r_s = .64, p = .002	r_s = .64, p = .002	r_s = .61, p = .002	r_s = –.34, p = .002	r_s = .20, p = .051
Pre-Sleep-Arousal somatic (PSAS soma) [68]	r_s = .57, p = .002	r_s = .53, p = .002	r_s = .51, p = .002	r_s = –.24, p = .019	r_s = .13, p = .197
Pre-Sleep-Arousal cognitive (PSAS cogn) [68]	r_s = .56, p = .002	r_s = .57, p = .002	r_s = .56, p = .002	r_s = –.30, p = .002	r_s = .19, p = .064
Chronotype (rCSM) [69]	r_s = –.08, p = .425	r_s = –.20, p = .058	r_s = –.30, p = .004	r_s = –.00, p = .982	r_s = –.06, p = .575
Sleep hygiene (SHI) [70] *Pearson*	r = .25, p = .014	r = .30, p = .002	r = .27, p = .008	r = –.17, p = .093	r = .22, p = .036
Importance of sleep	r_s = .04,p = .368	r_s = .05,p = .599	r_s = .12, p = .254	r_s = .19, p = .067	r_s = –.01,p = .924
Like/dislike shiftwork *biserial*	r_s = .31, p = .002	r_s = .23, p = .023	r_s = .14, p = .170	r_s = –.24, p = .019	r_s = .14, p = .163

α-corrected [71,72].

2.2. Qu2: Do Good/Poor Sleepers and Shift/Day Workers Differ with Regard to the Aforementioned Factors?

Irrespective of shift or day work, good and poor sleepers differed significantly on all factors tested, again with the exception of perfectionism, chronotype, and importance of sleep. The effect sizes for the differences in insomnia severity and sleep quality were of course large, as these scores were used for median dichotomization (see section 4.1). Large effects were also found for total sleep time, psychological stress in general, and all facets of pre-sleep-arousal. Medium effect sizes were found for sleep onset latency, the states anxiety and depression, emotional instability, and dysfunctional beliefs. All other examined variables show moderate or medium effects (Table 2).

In contrast, for all variables analyzed, the groups shift/day work only differed from each other with a small to medium effect size for the total sleep time, Z = –4.08, p = .026, η^2 = 0.07. The results in detail are provided in the supplementary material.

Table 2. Group differences (Mann-Whitney-U-Tests, good vs. poor sleepers).

Variable	Good Sleepers (n = 113)	Poor Sleepers (n = 112)	Test Statistic
	M, SD	*M, SD*	*(Z, p, η²)*
Insomnia severity (ISI [61])	4.70, 2.51	14.62, 4.04	–12.95, .001, 0.75
Sleep quality (PSQI [62])	4.36, 1.83	9.80, 3.17	–11.46, .001, 0.58

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Sleep onset latency (SOL [62], min)	20.26, 14.79	39.46, 27.51	–6.13, .001, 0.17
Total sleep time (TST [62], h)	7.11, 0.94	5.71, 1.21	–8.84, .001, 0.35
Daytime sleepiness (ESS [63])	7.82, 3.42	10.10, 4.56	–3.82, .001, 0.07
Anxiety state (HADS-D anxiety) [64]	5.24, 2.73	8.29, 4.03	–5.90, .001, 0.16
Depression state (HADS-D depression) [64]	3.65, 3.14	6.68, 3.60	–6.50, .001, 0.19
Psychological stress (HADS-D total) [64]	8.88, 4.97	14.96, 6.86	–6.98, .001, 0.22
Anxiety (trait, 16 PF-R global scale) [65]	61.12, 12.58	69.71, 13.63	–4.59, .001, 0.09
Concern (16 PF-R, O) [65]	22.73, 6.02	25.32, 6.18	–3.09, .002, 0.04
Emotional instability (16 PF-R, C) [65]	17.54, 4.16	21.04, 5.27	–4.96, .001, 0.11
Tension (16 PF-R, Q4) [65]	20.84, 5.21	23.35, 5.05	–3.57, .001, 0.06
Perfectionism (16 PF-R, Q3) [65]	23.00, 5.67	24.13, 5.02	–1.41, .170, 0.01
Social Integration (F-SozU) [66]	47.29, 6.99	44.06, 7.52	–3.08, .003, 0.04
Effort (ERI [55])	7.85, 2.04	8.68, 2.27	–2.72, .008, 0.03
Reward (ERI [55])	20.94, 3.27	18.54, 4.02	–4.74, .001, 0.10
Overcommitment (ERI [55])	12.83, 3.25	14.62, 3.88	–3.67, .001, 0.06
Imbalance (ERI [55])	0.90, 0.30	1.16, 0.44	–4.72, .001, 0.10
Dysfunct. beliefs about sleep (MZS) [67]	54.35, 22.06	78.46, 26.46	–6.67, .001, 0.20
Pre-Sleep-Arousal total (PSAS) [68]	20.68, 5.57	30.84, 10.48	–7.77, .001, 0.27
Pre-Sleep-Arousal somatic (PSAS) [68]	9.65, 2.46	13.27, 4.67	–7.17, .001, 0.23
Pre-Sleep-Arousal cognitive (PSAS) [68]	11.03, 4.14	17.57, 7.28	–6.99, .001, 0.22
Chronotype (rCSM) [69]	19.25, 4.53	18.99, 4.03	–.10, .923, < 0.001
Sleep hygiene (SHI) [70]	16.25, 6.56	18.53, 6.92	–2.33, .023, 0.02
like/dislike shiftwork (n = 112)	0.15, 0.36 (n = 48)	0.44, 0.50 (n = 64)	–3.28, .001, 0.10
Importance of sleep	3.20, 0.89	3.39, 0.74	–1.85, .065, 0.02

α-corrected [71,72].

The multiple group comparison (Table 3) also shows predominantly significant group differences, with the exception of perfectionism, chronotype, sleep hygiene, and importance of sleep. Large effect sizes were found for total sleep time, insomnia severity, sleep quality, dysfunctional beliefs about sleep and pre-sleep arousal. Sleep onset latency, psychological well-being, and the traits anxiety and emotional instability showed medium effects, all others small effects.

Subsequent post-hoc tests (see supplementary material) revealed that the manifestation of the characteristics differed between the poor (groups 1, 3) and the good sleepers (groups 2, 4); the day (groups 1, 2) vs. shift workers (groups 3, 4) did not.

The distribution of the means shows a clear pattern. The factors examined as possible risk factors, or at least having a negative impact on sleep, are more pronounced in groups 1 and 3, while groups 2 and 4 are less affected, as shown by the color coding.

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Table 3. Multiple group comparisons between the four groups (Kruskal-Wallis H-Test, *df* = 3).

		Goups: M, SD			
	H, p, η²	***Group 1: Poor Sleeping Day Workers n = 48***	***Group 2: Good Sleeping Day Workers n = 65***	***Group 3: Poor Sleeping Shift Workers n = 64***	***Group 4: Good Sleeping Shift Workers n = 48***
Insomnia severity (ISI [61])	168.00, .001, 0.75	14.33, 4.14	4.54, 2.63	14.83, 3.99	4.92, 2.35
Sleep quality (PSQI total [62])	131.98, .001, 0.58	9.83, 2.96	4.17, 1.58	9.78, 3.34	4.62, 2.12
Sleep onset latency (SOL [62], min)	38.66, .001, 0.16	35.02, 23.87	20.28, 14.48	42.78, 29.71	20.23, 15.36
Total sleep time (TST [62], h)	86.32, .001, 0.38	5.98, 1.34	7.35, 0.88	5.51, 1.08	6.79, 0.92
Daytime sleepiness (ESS [63])	15.41, .003, 0.06	9.73, 4.44	7.95, 3.65	10.37, 4.67	7.65, 3.10
Anxiety state (HADS-D anxiety) [64]	40.28, .001, 0.17	9.35, 4.10	5.48, 2.72	7.48, 3.82	4.92, 2.74
Depression state (HADS-D depression) [64]	42.30, .001, 0.18	6.50, 3.51	3.68, 3.27	6.81, 3.69	3.60, 2.99
Psychological stress (HADS-D total) [64]	50.32, .001, 0.21	15.85, 6.67	9.15, 5.17	14.30, 6.97	8.52, 4.71
Anxiety (trait, 16 PF-R global scale) [65]	27.68, .001, 0.11	71.90, 13.29	63.60, 11.23	68.08, 13.76	57.75, 13.60
Concern (16 PF-R, O) [65]	20.72, .001, 0.08	26.54, 6.19	24.18, 5.70	24.41, 6.06	20.77, 5.94
Emotional instability (16 PF-R, C) [65]	30.82, .001, 0.13	21.25, 5.51	18.43, 3.92	20.89, 5.12	16.33, 4.22
Tension (16 PF-R, Q4) [65]	14.70, .003, 0.05	24.10, 4.57	20.98, 4.47	22.78, 5.34	20.65, 6.12
Perfectionism (16 PF-R, Q3) [65]	2.17, .559, -0.00	24.25, 4.77	23.12, 6.13	24.03, 5.24	22.83, 5.03
Social Integration (F-SozU) [66]	17.98, .001, 0.07	42.42, 7.59	46.12, 7.07	45.30, 7.28	48.87, 6.62
ERI: effort [55]	10.01, .023, 0.03	8.31, 2.34	7.63, 2.07	8.95, 2.19	8.15, 1.98
ERI: reward [55]	23.22, .001, 0.09	18.87, 4.23	20.82, 3.67	18.30, 3.87	21.10, 2.68
ERI: overcommitment [55]	15.52, .001, 0.06	14.88, 4.35	13.20, 3.37	14.42, 3.51	12.33, 3.03
ERI: imbalance [55]	23.72, .001, 0.09	1.097, 0.42	0.89, 0.32	1.21, 0.46	0.92, 0.28
Dysfunctional beliefs about sleep (MZS) [67]	46.88, .001, 0.20	74.87, 28.00	56.43, 23.09	81.14, 25.12	51.54, 20.48
Pre-Sleep-Arousal total (PSAS) [68]	62.87, .001, 0.27	32.21, 9.87	21.12, 5.51	29.81, 10.88	20.08, 5.65
Pre-Sleep-Arousal somatic (PSAS) [68]	54.14, .001, 0.23	13.56, 4.67	9.80, 2.35	13.05, 4.70	9.46, 2.62
Pre-Sleep-Arousal cognitive (PSAS) [68]	51.67, .001, 0.22	18.65, 6.91	11.32, 4.21	16.77, 7.50	10.63, 4.04
Chronotype (rCSM) [69]	.02, .999, -0.1	19.00, 4.50	19.20, 4.78	18.98, 3.68	19.31, 4.22
Sleep hygiene (SHI) [70]	6.93, .084, 0.02	18.83, 6.03	16.57, 7.22	18.30, 7.57	15.81, 5.60
Importance of sleep	5.86, .129, 0.01	3.50, 0.72	3.28, 0.82	3.31, 0.75	3.10, 0.97

α-corrected [71,72]. Color coding: less / more pronounced risk factor.

2.3. Which of the so Far Identified Characteristics Are Suitable Predictors for Sleep Outcomes? Do These Predictors Exhibit Disparities Between the Groups or the Respective Sleep Outcomes?

Integrating the results of Qu1 and 2, perfectionism, chronotype, and importance of sleep showed negligible or nonsignificant group differences or correlations with the sleep variables. Therefore, these variables were not included in the regression analyses, as were variables that would lead to redundancies, as explained in the methods section. The independent variables that were ultimately

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included are the sleep related dysfunctional beliefs about sleep, cognitive and somatic pre-sleep arousal, and sleep hygiene; the states depression and anxiety; the traits emotional instability, tension, concern; the work-related factors imbalance, overcommitment, attitudes toward shift work; and social integration. The requirements for multiple linear regression were met; no outliers needed to be excluded.

The ten regressions calculated for five sleep variables, with separate analyses for day and shift workers, yielded significant models (Table 4). Insomnia severity and sleep quality exhibited a high variance explanation in both groups, for sleep onset latency this was only true for the shift workers. The models for all other sleep variables explain moderate to medium variance. For insomnia severity and sleep quality, three independent variables each were integrated, while sleep onset latency consists of two and only one independent variable was used in the models for total sleep time and daytime sleepiness.

The comparison between day and shift workers reveals numerous similarities, as well as several notable differences. Imbalance was incorporated into the model exclusively for day workers, manifesting in insomnia severity, sleep quality, and total sleep time. Instead, for shift workers, depression state manifests in the regression model for insomnia severity, and emotional instability in sleep quality and total sleep time. Depression plays a role in the sleep onset latency model for shift workers, but not for day workers. Dysfunctional beliefs are the only model components for daytime sleepiness in both groups.

Table 4. Multiple linear regressions, forced entry, forward: Models and coefficents, separate for shift and day workers for the sleep variables.

Insomnia Severity	**Shift Workers**						**Day Workers**					
Model	$R^2_{adj.}$ = 0.55, F (3, 108) = 46.64, p < .001						$R^2_{adj.}$ = 0.46, F (3, 109) = 32.52, p < .001					
= –0.97 + 0.10 x (dys. beliefs) + 0.23 x (cogn. arousal) +0 .30 (depression)							= –4.27 + 0.08 x (dys. beliefs) + 0.31 (cogn. arousal) + 3.35 (imbalance)					
coefficients	*b*	*SE*	*β*	*t*	*p*	$CI_{95\%}$	*b*	*SE*	*β*	*t*	*p*	$CI_{95\%}$
(constant)	–0.97	1.09		–0.89	.377	–3.13; 1.20	–4.27	1.45		–2.94	.004	–7.14; –1.39
dysf. beliefs	0.10	0.02	0.45	5.95	<.001	0.07; 0.13	0.08	0.02	0.37	4.72	<.001	0.05; 0.12
Cogn. arousal	0.23	0.07	0.26	3.21	.002	0.09; 0.37	0.31	0.07	0.35	4.44	<.001	0.17; 0.45
Depression, state	0.30	0.13	0.19	2.23	.028	0.03; 0.57						
ERI imbalance							3.35	1.12	0.21	2.99	.003	1.13; 5.56
Sleep quality	Shift workers						Day workers					
Model	$R^2_{adj.}$ = 0.47, F (3, 108) = 33.14, p < .001						$R^2_{adj.}$ = 0.43, F (3,109) = 28.55, p < .001					
=–0.97 + 0.18 x (cogn. arousal) + 0.19x (emot. instability) + 0.04 x (dys. beliefs)							= –0.91+ 0.25 x (cogn. arousal) + 0.03 x (dys. beliefs) + 2.03 x (imbalance)					
coefficients	*b*	*SE*	*β*	*t*	*p*	$CI_{95\%}$	*b*	*SE*	*β*	*t*	*p*	$CI_{95\%}$
(constant)	–0.97	1.01		–0.97	.336	–2.97; 1.02	–0.91	0.91		–1.00	.322	–2.72; 0.90
Cogn. arousal	0.18	0.05	0.32	3.79	<.001	0.09; 0.27	0.25	0.04	0.45	5.66	<.001	0.16; 0.33
emot. instability	0.19	0.07	0.26	2.79	.006	0.06; 0.33						
dysf. beliefs	0.04	0.01	0.25	2.80	.006	0.01; 0.06	0.03	0.01	0.22	2.76	.007	0.01; 0.05
ERI imbalance							2.03	.70	.21	2.88	.005	0.63; 3.42

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Sleep onset latency	Shift workers						Day workers					
Model	$R^2_{adj.}$ = 0.39, F (2, 109) = 36.05, p < .001						$R^2_{adj.}$ = 0.11, F (1, 111) = 14.91, p < .001					
Equation	= –1.53 + 1.89 x (cogn. arousal) + 1.47 (depression, state)						= + 11.23 + 1.06 x (cogn. arousal)					
coefficients	*b*	*SE*	*β*	*t*	*p*	$CI_{95\%}$	*b*	*SE*	*β*	*t*	*p*	$CI_{95\%}$
(constant)	–1.53	4.57		–0.34	.738	–10.59; 7.53	11.23	4.36		2.58	.011	2.60; 19.86
Cogn. arousal	1.89	0.36	0.49	5.19	<.001	1.17; 2.61	1.06	0.28	0.34	3.86	<.001	0.52; 1.61
depression (state)	1.47	0.67	0.20	2.18	.031	0.13; 2.80						
Total sleep time	Shift workers						Day workers					
Model	$R^2_{adj.}$ = .11, F (1, 110) = 14.51, p < .001						$R^2_{adj.}$ = .07, F (1, 111) = 14.84, p = .002					
Equation	= +7,53 – 0.08 x (emot. instability)						= + 7.71 – 0.97 x (ERI imbalance)					
coefficients	*b*	*SE*	*β*	*t*	*p*	$CI_{95\%}$	*b*	*SE*	*β*	*t*	*p*	$CI_{95\%}$
(constant)	7.53	0.40		18.80	<.001	6.74 8.33	7.71	0.33		23.69	<.001	7.07; 8.36
emot. instability	–.078	0.02	–0.34	–3.81	<.001	–0.12; –0.04						
ERI imbalance							–0.97	0.31	–0.28	–3.11	.002	–1.58; –0.35
Daytime sleepiness	Shift workers						Day workers					
Model	$R^2_{adj.}$ = 0.11, F (1, 110) = 15.32, p < .001						$R^2_{adj.}$ = 0.15, F (1, 111) = 20.73, p < .001					
Equation	= +5.47 + 0.06 x (dysfunct. beliefs)						= + 4.82 + 0.6 x (dysfu. beliefs)					
coefficients	*b*	*SE*	*β*	*t*	*p*	$CI_{95\%}$	*b*	*SE*	*β*	*t*	*p*	$CI_{95\%}$
(constant)	5.47	1.03		5.33	<.001	3.44; 7.51	4.82	0.92		5.22	<.001	2.99; 6.65
dysf. beliefs	0.06	0.01	0.35	3.91	<.001	0.03; 0.08	0.06	0.01	0.40	4.55	<.001	0.03; 0.00

3. Discussion

A brief summary of the results is given as an introduction to the discussion. In the group of shift workers, the correlations of all investigated characteristics with the sleep variables demonstrated the expected correlations, with the exception of perfectionism, chronotype and importance of sleep.

Group comparisons revealed only negligible disparities between day and shift workers in terms of the characteristics examined, but clear differences between good and poor sleepers.

The regression analyses yielded ambivalent results. Depending on the group or dependent variable, different independent variables were integrated into the models. Roughly summarized, dysfunctional beliefs about sleep, cognitive arousal before falling asleep, and depression contribute to the explanation of variance, while emotional instability, and imbalance should be considered as suitable predictors with reservations.

(Qu1) The objective of the first question was to ascertain whether the factors derived from the extant literature indeed exert a relationship with the sleep of shift workers. The majority of the correlations between the sleep of shift workers and the analyzed characteristics demonstrated significant results. These correlations were particularly pronounced for severity of insomnia and sleep quality.

Some of the correlations for sleep onset latency were also in the range of large effects, whereas the effects were comparatively smaller for total sleep time and daytime sleepiness.

The most pronounced effects were observed in psychological impairment, the states anxiety and depression, pre-sleep arousal, and emotional stability. Attitudes towards shift work and the results for effort-reward imbalance (with the exception of effort, which produced predominantly non-

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significant results) were found to be in the medium range. The same was true for social integration and tension.

All findings align with the anticipated direction, indicating that suboptimal sleep, characterized by more severe insomnia, poorer sleep quality, longer sleep onset latency, and more pronounced daytime sleepiness, as well as shorter total sleep time, is associated with heightened psychological stress, emotional instability, anxiety, and tension. Additionally, increased pre-sleep arousal and a heightened imbalance between perceived effort and reward in professional contexts, more negative attitudes towards shift work, along with lower perceived social integration, have been identified as factors associated with poorer sleep.

Contrary to prevailing assumptions, no substantial correlations were observed for perfectionism, a trait frequently linked to sleep disturbances in the general population [5,42]. The underlying reasons for this phenomenon are unclear and require further investigation.

A correlation between poorer sleep quality in shift workers among early chronotypes was hypothesized, as this characteristic has been identified as a risk factor for shift work intolerance, as previously described in section 1.7.3 [48]. However, these predictions were not substantiated. Apart from the longer sleep onset latency in the late chronotypes, no significant correlations were found. The unexpected nature of this result prompted further investigation into the potential influence of shift type on these outcomes. Specifically, it was examined whether early chronotypes are more prone to sleep difficulties when regularly on night duty.

Subsequent partial correlations of chronotype with sleep variables, with "regularly night shift yes/no" serving as a control variable, yielded no significant results following α-correction, although the significance level was only slightly missed for sleep onset latency, $r_{partial}(109) = -.23$, $p = .053$, and sleep quality, $r_{partial}(109) = -.219$, $p = .053$. However, the invalidity of this assumption is not certain. A mere one sixth of the shift workers did not indicate night work, which could result in an insufficient degree of variation for this calculation.

The investigation into "importance of sleep" was employed as a means to operationalize the tendency to focus excessively on (disturbed) sleep, with the objective of ascertaining the relevance of the attention-intention-effort pathway [35] in shift workers. The absence of significant findings is somewhat unexpected, and it is conceivable that the single item utilized was inadequate in measuring the intended construct. Consequently, the attention-intention-effort-pathway model should not be disregarded as irrelevant for shift workers based on these findings, particularly in light of the significant correlations observed with cognitive pre-sleep arousal, which can be interpreted as an indication of the model's relevance, as well as that of the cognitive-insomnia model [32].

Although the introduction of sleep hygiene (see section 1.7.1) did not specifically posit a particular hypothesis regarding this concept, it nevertheless gave rise to inquiries concerning the underlying assumptions. The efficacy of sleep hygiene as a standalone intervention remains inconclusive in numerous studies. This observation pertains to both the general population [37,38] and shift workers [39]. Two conclusions were derived from these findings: Firstly, sleep hygiene may be less pertinent for shift workers, as the concept's primary focus is on regularity, rendering numerous rules inapplicable to this demographic. Secondly, adhering to the rules throughout the day could further increase the focus on (disturbed) sleep and thus have a negative effect on sleep. However, the study's findings did not confirm either the absence of a correlation or a negative correlation between sleep and the adherence to the rules. Better sleep hygiene correlates significantly positive with better sleep, with a medium effect size.

Here, too, it is possible that this is due to the instrument used. The Sleep Hygiene Index (SHI [70]) contains only two items that inquire about the regularity of the sleep-wake rhythm. Other items ask about longer naps, prolonged time in bed, activating behaviors prior to sleep.

(Qu2) The calculations for the second question were intended to test whether the four groups—that is good or poor sleeping day or shift workers—differ from each other. Statistically significant differences were identified between good and poor sleepers, here too with the exception of perfectionism, chronotype and importance of sleep. Corresponding to the observed correlations, the

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effect sizes for psychological stress and attitudes toward shift work were found to be medium to high, while personality characteristics were predominantly in the lower range of effect sizes, pre-sleep arousal levels predominantly in the higher range.

A surprising result is that day and shift workers do not differ significantly with regard to the variables examined, with the exception of total sleep time, which exhibited a small effect. These findings were confirmed in subsequent multiple group comparisons. Sleep hygiene now also yielded non-significant differences, as perfectionism, chronotype, and importance of sleep do. The post-hoc tests confirmed that the significance was almost exclusively due to the differences between good and poor sleepers, which also explains the large effects in the sleep variables. Here, too, there were no statistically significant differences between day and shift workers.

However, two points warrant further attention:

Despite the fact that four groups of equivalent size were targeted in the acquisition, the distribution is not uniform. The day/shift work groups were roughly the same size, as were the good/poor sleep groups due to the median dichotomization based on insomnia severity. Although no prevalence may be derived from this because of the controlled acquisition process, it is nevertheless striking that the groups including the most participants are good sleeping day workers (65) and poor sleeping shift workers (64).

The distribution of the mean values across the four groups exhibits a clear pattern. Poor sleepers are more affected by the characteristics assumed to be risk factors than good sleepers. Initially, it may appear counterintuitive that day and shift workers do not differ significantly from each other, with the exception of the moderate difference in total sleep time. It is assumed that shift workers are not inherently more vulnerable; rather, shift work is believed to be responsible for the known higher risks (see section 1 and [6,12,18]). The objective of the present study was to identify factors that could be therapeutically manipulated and are associated with sleep, particularly in shift workers, to replace the previous interventions based on regularity. The absence of a significant difference between the day and shift work groups does not negate the necessity for a novel therapeutic approach. Our primary arguments, that standard-CBT-I is challenging to implement for shift workers and interventions on regularity could compromise compliance, remain valid.

The absence of these group differences may also be attributed to the assumption of self-selection [50] 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 finding could be interpreted as a refutation, given that some individuals are compelled to maintain shift work due to the necessity of bonuses or the shared responsibility of childcare with their partner [50]. In our sample, 27 individuals indicated that their profession necessitates shift work, four cited an employer requirement, and three stated the need for bonuses. These two effects could potentially cancel each other out, leading to the observed lack of group differences.

Integrating the results from Qu1 and 2, the hypothesis that the investigated characteristics are indeed negatively associated with sleep (with the exception of the non-significant characteristics mentioned above) can be regarded as confirmed. Conversely, the hypothesis that day and shift workers vary with respect to these characteristics or the sleep variables must be rejected.

(Qu3) The regression analyses conducted to answer the third question sought to provide a more robust foundation for the findings obtained in the preceding analyses. The results indicate that the independent variables dysfunctional beliefs about sleep, cognitive pre-sleep arousal, depressive state, imbalance, and emotional instability make the greatest contribution to explaining variance. This finding does not contradict the results from Qu1 and 2; but it does not correspond to the expectation that, for example, attitudes toward shift work, anxiety state or the traits worry and tension would play a greater role. The observed discrepancy between the groups in the regression models is noteworthy. Specifically, the ERI imbalance was observed to be exclusively relevant to day workers, while emotional instability was solely integrated in the models for shift workers. The underlying explanations for these observations require further investigation.

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The results of the regression analyses should not be overinterpreted, as they were calculated with numerous independent variables, and the inclusion method (forced entry, forward) is not without controversy [73,74]. Nevertheless, the hypothesis that dysfunctional beliefs about sleep, cognitive pre-sleep arousal, and depression symptoms serve as effective predictors of poor sleep quality is confirmed, while the relevance of emotional instability and ERI imbalance in explaining variances must be considered with certain reservations. Accordingly, only emotional instability is important for the objective of this study, as it appears in the regression model of shift workers.

What does this mean for the planned project? Is it still necessary to develop a new, tailored therapy? The answer is clearly yes. This study was not designed to test the necessity of a customized treatment for shift workers, as this has been proven by several studies (see Introduction). Instead, the objective was to ascertain which therapeutically manipulable factors are actually pertinent with regard to sleep—including, but not limited to—shift workers. The objective is to integrate these factors into a customized treatment that is more applicable to shift workers, replacing challenging interventions such as on regularity.

The integration of the present findings and the literature review from the introduction resulted in the decision to select the following factors: Dysfunctional beliefs about sleep, (specifically cognitive) pre-sleep arousal, depression, and emotional instability. ERI Imbalance was not selected, as its pertinence is confined to the population of day workers. Potential interventions may include psychoeducation, relaxation exercises, cognitive restructuring, methods to address concerns and apprehensions, and acceptance. While the assumptions derived from the extant literature regarding attitudes towards shift work and social integration were only confirmed to a limited extent and did not appear as predictors at all, these two factors seem to be important on the basis of theory. Consequently, interventions focused on daily structure could be integrated to accentuate the opportunities for social participation despite shift work, while concurrently enhancing attitudes towards shift work.

Limitations. The most fundamental limitation is that it is a survey study with an ad hoc sample, meaning that the sample is not stratified 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, sleep problems as well as pre-existing conditions could only be assessed on the basis of information provided by the participants. The survey instrument, which required a considerable 30 minutes to complete, may have introduced selection bias, as only those who were particularly attentive would have completed it.

These limitations must be taken into account when interpreting the results. 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, it seems justified to have accepted these restrictions. This is particularly the case given the planned testing of the efficacy of the resulting treatment manual with a randomized controlled trial, see [31,75].

Strengths. Contrary to the approach of many other studies, our investigation examined a range of characteristics in a cohort comprising diverse occupational groups. This approach addresses the valid criticism that the results of studies on single occupational groups (e.g., nurses) cannot be generalized [18]. The comparison of the four groups of good/poor sleepers and day/shift workers can also be considered as a strength, as it yielded some revealing results. Another notable strength of the present study is the inclusion of an attitude towards shift work component, which was required for future research [57,58].

The objective of establishing a sustainable foundation for the development of an innovative therapeutic approach for the treatment of insomnia in shift workers can therefore be regarded as accomplished.

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4. Materials and Methods

4.1. Study Design, Recruitement, Participants, and Group Allocation

An online survey was conducted with an ad hoc sample from the general population. An attempt was made to obtain four groups of approximately equal size: good/poor sleepers and day/shift workers. To this end, participants were requested to indicate their perceived group affiliation at the commencement of the survey. In instances where the desired group had reached maximum capacity, a message was displayed indicating that further participation was not 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, a multifaceted recruitment strategy was employed, encompassing the utilization of mailing lists and social media platforms. The acquisition of participants via companies and physicians proved challenging due to the ongoing effects and after-effects of the SARS-CoV-2 pandemic during this period.

The inclusion criteria encompassed individuals between the ages of 18 and 65 years, with a minimum of 30 hours of employment per week, and adequate German language proficiency. Both day workers and good sleepers were included in order to identify group differences or potential vulnerability/resilience factors.

Individuals with a history of diagnosed physical illnesses affecting sleep (e.g., restless legs syndrome, sleep apnea syndrome, chronic pain) or other primary disorders (acute substance dependence, severe affective or anxiety disorders, psychoses) were excluded from the study.

An a priori power analysis was conducted using G*Power 3.1 [76]. Assuming a medium effect size, a power of $(1–\beta) = .95$ can be achieved with a total sample size of $N = 200$ in all planned evaluation procedures.

The final sample size comprised 225 participants (59.11% female) with a mean age of 34.88 years ($SD = 12.92$). The criterion for assignment to the shift work group was the regular performance of at least two different shifts (e.g., early and late shift); but most participants also indicated night or split shifts.

The assignment of subjects to the good and poor sleep groups was based on a median dichotomization of the ISI value ($Md = 9$). This approach is substantiated by the inability of the online format to support the delivery of an accurate diagnosis. Consequently, the notion of diagnosing insomnia based on these criteria appears to be somewhat questionable. Furthermore, the threshold value would be set at an ISI of >15, resulting in significantly different group sizes.

The group sizes of the final sample and the distribution measures of the sleep variables are provided in Table 5.

Table 5. Sample description: Group sizes and distribution measures of the sleep variables.

	Shift Work (n = 112)	***Day Work (n = 113)***
Good sleepers ($n = 113$)	*48*	*65*
Poor sleepers ($n = 112$)	*64*	*48*
Insomnia severity (ISI)	$M = 10.58$, $SD = 5.97$	$M = 8.70$, $SD = 5.90$
Sleep quality (PSQI total)	$M = 7.57$, $SD = 3.85$	$M = 6.58$, $SD = 3.61$,
Sleep onset latency (min; PSQI item 2)	$M = 33.12$, $SD = 26.95$	$M = 26.54$, $SD = 20.31$
Total sleep time (h; PSQI item 4)	$M = 6.06$, $SD = 1.19$	$M = 6.77$, $SD = 1.29$
Daytime sleepiness (ESS)	$M = 9.21$, $SD = 4.28$	$M = 8.71$, $SD = 4.08$

4.2. Method and Instrument

The survey study was conducted online via LimeSurvey, and a standardized instrument was compiled from various validated questionnaires and a few in-house developed items. The survey commenced with questions regarding demographics and previous illnesses, and a question

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regarding attitudes toward shift work was included ("Do you like working shifts?" "yes, I don't mind", "no, but I have to").

Sleep. The total score of the PSQI (Pittsburgh Sleep Quality Index [62]) was employed to assess overall sleep quality, while single items were used to assess sleep onset latency (item 2), and total sleep time (item 4).

The ISI (Insomnia Severity Index [61]) was utilized as an indicator of the severity of insomnia, while the ESS (Epworth Sleepiness Scale [63]) was employed to assess daytime sleepiness. The German version of the DBAS-16 (dysfunctional beliefs about sleep; Ger.: MZS, Meinungen-zum-Schlaf-Fragebogen [67]) was used to gather data on sleep-related dysfunctional beliefs, and the rCSM (reduced Composite Scale of Morningness [69]) was used to assess chronotype. The PSAS (Pre-Sleep Arousal Scale [68]) was utilized to evaluate cognitive and physiological arousal before sleep. To assess sleep hygiene behavior, the SHI (Sleep Hygiene Index [70]) was employed. Finally, a self-developed item regarding sleep importance was presented ('How important is your sleep to you?') to gather evidence for the attention-intention-effort-pathway [35].

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 [64]) was employed to assess psychological well-being, in particular anxiety and depression. The 16 PF-R (16 Personality Factor Test, revised version [65]) was also employed, with subscales measuring emotional instability, tension, concern, and perfectionism as well as the global scale anxiety. The Social Integration subscale from the F-SozU (Questionnaire on Social Support [66]) was also integrated, as well as the ERI (effort-reward-imbalance [55]) to measure work-related personality traits (effort, reward, overcommitment, also contains questions on psychological detachment). All tests exhibited acceptable to good test quality, as displayed in [75].

The survey instrument took approximately 30 minutes on average to complete.

4.3. Statistical Analyses

The statistical significance of the findings was assessed 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 the sleep variables insomnia severity, sleep quality, sleep onset latency, total sleep time, and daytime sleepiness (Qu1).

Group comparisons (Qu2) were calculated using Mann-Whitney U-tests and Kruskal-Wallis H-tests, as effect size η^2 was calculated.

Finally, factors that have proven to be significant are subjected to multiple linear regression. The method forced entry, forward was used, because stepwise has major disadvantages [see 73,74]. Hierarchical entry would have also been difficult to implement, because this study is exploratory, it is not known which factors are most important for the explanation of variance in shift workers. One potential approach would be to prioritize the correlations with the highest effect sizes. However, given the discrepancies between the observed results and existing literature in some cases, this method may lack precision. Consequently, the forced entry, forward method was preferred.

For the sleep variables insomnia severity, sleep quality, sleep onset latency, total sleep time and daytime sleepiness, individual regressions were calculated for shift and daytime workers, i.e. ten regressions in total (Qu3).

The prerequisites for the implementation of multiple linear regression were verified in a variety of ways. Scatterplots were utilized to ascertain the linear relationships between the variables, and the presence of homoscedasticity. P-P plots were employed to verify normal distribution of the residuals. The Durban-Watson statistic (approximately 2.0) was employed to assess the autocorrelation of the residuals. Multicollinearity was assessed using correlations less than 0.7, tolerance values greater than 0.1, and VIF values less than 10. The presence of outliers was determined through a case-by-case

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analysis, with studentized deleted residuals (< ±3), leverage values (limits according to [77,78]), and Cook distances <1 being utilized.

A preselection had to be made from the eligible independent variables to avoid over- or under-adjustment of the resulting model [79]. On the one hand, this concerns the number of predictors in relation to the sample size [80] and, on the other hand, content-related logical considerations. In order to circumvent redundancies, the total scores of the HADS-D and the PSAS were not integrated, but rather their subscales. The ERI effort and reward subscales are included in the ERI Imbalance measure, so this scale that was used, overcommitment subscale was included separately. Further exclusions of variables were then made on the basis of the results for Qu1 and 2.

The decision to initiate the whole analysis of the study with bivariate procedures (correlations, group differences), followed by multivariate analyses (regression), may initially appear to be redundant. However, this approach was adopted due to the exploratory nature of the study. While recent research has focused more on 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. The restriction of the analysis to regressions might have precluded the identification of unexpected outcomes.

For Qu1 and 2, the α-level of the results was adjusted [71,72]. The interpretation of the correlation coefficients and effect sizes follows the recommendations of Cohen [81]. All calculations were conducted using SPSS 30 [82].

5. Conclusions

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

The results of the study suggest integrating the following factors and interventions: psychoeducation to cognitively restructure dysfunctional attitudes toward 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; and relaxation methods to reduce tension and emotional instability.

The advantage of these components is that they do not require regularity, making them well-suited for developing a treatment 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.

Outlook. Following the development of a tailored therapy manual based on this approach, a randomized controlled trial will be conducted to assess its efficacy. The newly developed therapy for shift workers will be compared with the standard therapy (CBT-I) [31,75].

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Informed Consent Statement: All participants were informed on the survey start page and had to agree to the conditions in order to start the survey.

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Abbreviations

The following table presents the abbreviations utilized in the manuscript.

SWD	Shift work disorder
CBT-I	Cognitive behavioral therapy for insomnia
REM	Rapid-eye movement
NREM2	Non-Rapid-eye movement sleep phase 2

Legend

Abb.		High values
TST	Total sleep time	longer
SOL	Sleep onset latency	longer
SSQ	Subjective sleep quality	poorer
DS/ESS	Daytime sleepiness/ Epworth sleepiness scale	more severe
ISI	Insomnia severity index	more severe
PSQI	Pittsburgh sleep quality index	poorer sleep
MZS	sleep-related dysfunctional beliefs	More pronounced
PSAS	Pre-sleep arousal scale	Higher arousal
SHI	Sleep hygiene index	Poorer sleep hygiene
HADS-D	Anxiety, Depression, Total	Poorer psychological well-being
16 PF-R	16-Persönlichkeits-Faktoren-Test Anxiety global O: concern C: emotional instability (recoded) Q4: tension Q3: Perfectionism	personality traits, more pronounced: more anxiety more concerned more instability more tension more perfectionism
ERI	Effort-reward-imbalance (occupational) ERI_Effort ERI_reward ERI_Overcommitment ERI_Imbalance: > 1: more effort than reward; = 1: 1:1 balanced; < 1: less effort than reward	 More perceived effort More perceived reward Tendency to exert more effort when perceived reward is insufficient More perceived imbalance
F-SozU	Fragebogen zur sozialen Unterstützung	Better social integration
rCSM	Reduced composite scale of morningness	early chronotype
	Importance of sleep	Higher importance

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