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SCIENTIFIC INVESTIGATIONS

Effects of a Workplace-Based Sleep Health Program on Sleep in Members of the German Armed Forces

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Study Objectives: To develop and evaluate a brief manual-based sleep health program within the workplace health promotion of the German Armed Forces.
Methods: The sleep health program comprised four weekly group sessions. Sixty-three members (48 males) were randomly allocated to either a treatment group or a waiting control group matching for age, sex, and baseline Pittsburgh Sleep Quality Index (PSQI). The control group had to wait before participating in the sleep health program until the treatment group finished the intervention. Sleep was assessed by ambulatory polysomnography (PSG) as well as with evening and morning protocols at baseline (t0), directly after the treatment group participated in the sleep health program (t1), and after the control group finished participation (t2). The PSQI, the Insomnia Severity Index (ISI), and the Epworth Sleepiness Scale (ESS) were applied at the same three time points, and during a 3-month follow-up evaluation (t3).
Results: Fifty-seven out of the 63 randomized individuals (42 males, mean age = 40.6 years; complete PSG data: n = 36; complete questionnaire data: n = 39) participated in the sleep health program. Objective wake after sleep onset, sleep efficiency, latency to persistent sleep, self-reported sleep latency, restfulness, PSQI, and ISI scores improved with medium or large effects in both groups. ESS scores decreased with moderate effects in the treatment group only.
Conclusions: The sleep health program had a positive and stable effect on objective and self-reported sleep parameters, and it is suitable as a preventive measure in members of the German Armed Forces.
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Keywords: behavioral intervention, group treatment, home ambulatory polysomnography, insomnia, objective sleep quality, restfulness, restorative sleep, subjective sleep quality, workplace health promotion
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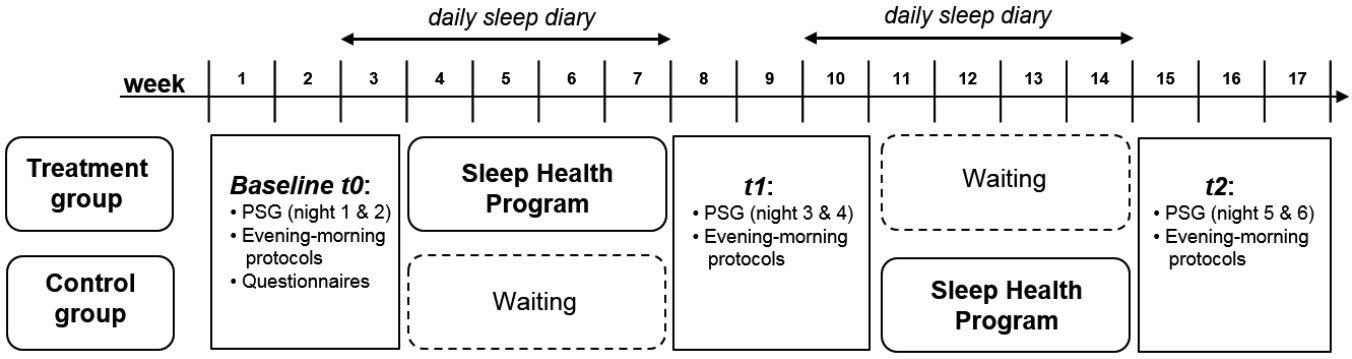
BRIEF SUMMARY
Current Knowledge/Study Rationale: Sleep health programs are rarely offered in workplaces, although the benefit of good sleep on physical and psychological health is unequivocal. The brief manual-based sleep health program presented here addressed persons with minor to moderate sleep impairments to improve sleep and prevent future sleep disorders.
Study Impact: This workplace-based group intervention was beneficial in improving objective and self-reported measures of sleep in members of the German Armed Forces. The program might increase health resilience by providing helpful strategies in the case of impaired sleep quality and strengthen self-efficacy.

INTRODUCTION

Studies in German soldiers have shown high prevalence rates of impaired sleep quality as measured by the Pittsburgh Sleep Quality Index (PSQI), ranging between 29% to 38% in non-deployed young soldiers, up to 35% during deployment,[1] and 41% after deployment.[2] Recently, high rates of sleep apnea (47%) and insomnia (26%) in veterans of the United States were reported,[3] emphasizing the importance of early prevention of these conditions. Impaired sleep and insomnia symptoms prior to deployment are predictors for the development of mental disorders such as posttraumatic stress disorder (PTSD), depression, or suicide.[3–6] Furthermore, in addition to an increased risk of mental health problems, Seelig et al. demonstrated in a study on sleep and health resilience in a large United States military cohort that insomnia symptoms were associated with lower self-rated health and negative effects on work and deployment.[7] Given these negative consequences of impaired sleep in the military context, several attempts to treat sleep disorders in military personnel have been made, but most of them have focused on the treatment of sleep disorders after a return from deployment or in veterans[8–10] or in those with chronic insomnia.[11] Pedersen et al.[12] suggested evaluating sleep health programs to promote physical and psychological health, and resilience to stress after deployment. In the current study, this type of preventive approach was followed. A short-term manual-based sleep health program was developed and evaluated to improve the sleep of military personnel of the German Armed Forces. In a pilot study, the feasibility of the sleep health program in the workplace health promotion

Figure 1—Study design and time schedule.



Both groups underwent evaluations of objective and self-reported sleep parameters at the same time points (t0, t1, t2). The treatment group participated in the sleep health program following t0, and the control group participated following t1. PSG = polysomnography.

of the German Armed Forces was proven and positive effects on well-being and self-care were observed.[13] The sleep health program takes into consideration the participation of military personnel with different causes and levels of impaired sleep. In the current study, the effects of the sleep health program on objective and self-reported measures of sleep were evaluated in a randomized crossover field study.

METHODS

Procedures

Prior to any study procedures, information sessions were held at four different military sites across Germany to describe the sleep health program and to recruit participants for the study. Participants were randomized either to a treatment group or to a waiting control group for each site separately. After the treatment group finished the sleep health program, the waiting control group received the same intervention (**Figure 1**). The number for each group was restricted to eight participants.

Assessments of objective and self-reported sleep parameters occurred in parallel in the treatment and in the waiting control groups: baseline examinations were conducted prior to any intervention (t0), effects of the course were evaluated following participation of the treatment group in the sleep health program (t1), and directly after the end of the participation of the waiting control group in the sleep health program (t2). Questionnaires were applied at the same three time points, and during a 3-month follow-up evaluation (t3).

The study was approved by the Ethics Committee of the Charité – University Medicine Berlin (EA4/115/14). Written informed consent was obtained from all participants prior to any study intervention.

Participants

In total, 81 self-selected employees of the German Armed Forces at four different sites were interested in taking part in the study and signed the informed consent. Inclusion criteria comprised (1) being an employee of the German Armed Forces, (2) adult age (18 years or older), (3) being interested in improving sleep, and (4) being willing and able to attend all four sessions of the sleep health program and undergo the evaluation procedures. Participants with severe depressive and/or somatic symptoms according to the Patient Health-Questionnaire (PHQ)[14,15] were excluded.

Intervention: Face-to-Face Group Sleep Health Program

The sleep health program was provided during regular working hours and consisted of four 90-minute sessions, which were delivered with 1-week intervals between sessions.

The four sessions addressed different sleep-related topics and comprised theoretical parts and practical instructions (**Table 1**). The practical instructions had to be carried out as a type of "homework" between sessions. Guided group discussions, the exchange of experiences between participants and individualized support by a sleep expert, were essential parts of the intervention. All sessions at all sites were conducted by CS, a clinical and health psychologist, who is a certified expert somnologist (European Sleep Research Society and German Sleep Research Society).

Assessment Procedures

Patient Health Questionnaire for Depressive Symptoms

Depressive symptoms were evaluated at baseline by the nine-item subscale for depressive symptoms PHQ-9 of the German version[16] of the Patient Health Questionnaire.[17] Total scores ranging from 0 to 14 represent no to moderate symptoms, whereas scores above 14 are indicative of severe symptoms of depression.[14]

Patient Health Questionnaire for Somatic Symptoms

The self-administered subscale PHQ-15 of the German version[16] of the Patient Health Questionnaire[17] was applied at baseline to screen for somatic symptoms. The total score as well as a cutoff score ≤ 14 for "minimal" to "medium" somatic symptom severity versus > 14 indicative of "high" levels of somatic symptom severity[15] were considered for further analyses.

Measurement of Objective Sleep Parameters by Ambulatory Polysomnography

Sleep was recorded and evaluated according to the standard of the American Academy of Sleep Medicine (AASM).[18]

Objective sleep parameters were measured by ambulatory polysomnography (PSG; Somnoscreen plus, Somnomedics, Randersacker, Germany) at three time points (t0, t1, t2) for 2 consecutive nights each. Electrodes and sensors were attached to the participants at the military sites, and participants slept in their familiar surroundings either at home or at the barracks. The recordings were scored by an external and independent competence center for sleep analysis (The Siesta Group Schlafanalyse GmbH, Vienna, Austria), which provided a validated and Food and Drug Administration-approved sleep scoring under expert human supervision according to the AASM standard criteria.[19] The expert scorer was blind to the group condition. The PSG outcome parameters comprised time in bed (TIB; from "lights out" until "lights on" in minutes), sleep latency (SL; "lights out" to first epoch of any sleep in minutes), latency to persistent sleep (LPS; latency from lights out to the first 10 minutes of consecutive epochs of sleep), stage R sleep latency (sleep onset to the first epoch of stage R sleep in minutes), total sleep time (TST; any sleep stage different from wake; in minutes), wake after sleep onset (WASO; wakefulness during TIB, minus TST and minus SL, in minutes), and percentage sleep efficiency ([TST / TIB] × 100).

Measurement of Self-Reported Sleep Parameters by Evening-Morning Protocols

Each time participants underwent ambulatory PSG, they filled out the standard version of the evening and morning protocol of the German Sleep Society.[20] These protocols are an extended version of the Consensus Sleep Diary, which is recommended by Carney et al.[21] and is intended for use parallel to a polysomnographic recording. The following self-reported sleep parameters, which correspond to the appropriate objective target variables, were analyzed: self-reported time in bed (sTIB in minutes), self-reported sleep latency (sSL in minutes), self-reported total sleep time (sTST in minutes), self-reported wake after sleep onset (sWASO, in minutes), and self-reported percentage sleep efficiency (sTST / sTIB) × 100. In addition, the item restfulness was considered for further analyses (five categories from 1 = very restful to 5 = not at all restful).

To monitor their sleep-wake schedule between assessments and to document the effect of the applied exercises, a short version of the evening morning protocol (sleep diary) of the German Sleep Society[22] was given to the participants. The sleep diary comprised six short questions in the evening and eight questions in the morning. Participants of both groups filled in their sleep diary in parallel, 1 week before and during the time of the sleep health program, resulting in approximately 10 weeks of self-reported data per participant (**Figure 1**). Data are not presented here.

Measurement of Self-Reported Sleep Quality by the Pittsburgh Sleep Quality Index

Self-reported sleep quality was assessed by the PSQI.[23] The 19-item PSQI was applied at all four time points (t0, t1, t2, t3). For further analyses, the global score as well as categorical data (total score > 5 indicative of "poor sleep quality" versus ≤ 5 indicating that sleep quality is "good") were assessed.

Table 1— Sleep health program sessions and content.

Session 1: Good Sleep • How can we measure sleep? (diary and polysomnography) • How does sleep change across the lifetime? • Rules of sleep hygiene • Homework: Choose one or two of the sleep hygiene rules and practice them until the next session.
Session 2: Disturbed Sleep • Sleep diary review, group discussion and individual recommendations • Introduction to the most common sleep disorders • Vicious circle of insomnia • Introduction into nonpharmacological interventions • Introduction to techniques to improve falling sleep (e.g., relaxation training and cognitive strategies) • Homework: Choose one or two of the techniques of Session 2 and practice them until the next session. Continue practicing the sleep hygiene rules.
Session 3: Sleep Within the 24-hour Sleep-Wake Rhythm • Sleep diary review, group discussion and individual recommendations • On morning and evening types • Shift work: consequences and strategies to improve sleep and wakefulness • Jet Lag: consequences and strategies to improve sleep and wakefulness • Homework: Keep on practicing the techniques from Session 2 or try out a new one. Choose one or two of the techniques that were presented in Session 2 and practice them until the next session. Continue practicing the sleep hygiene rules.
Session 4: Daytime Sleepiness • Sleep diary review, group discussion and individual recommendations • Relevance and causes of daytime sleepiness (sleep-related and unrelated) • Strategies to reduce or treat excessive daytime sleepiness • Summary and outlook • Support in case of further questions and need for diagnostic procedures

Measurement of Self-Reported Insomnia Symptoms by the Insomnia Severity Index

The Insomnia Severity Index (ISI)[24] was applied four times (t0, t1, t2, t3) throughout the study to assess insomnia symptoms. A cutoff score ≥ 8[25] was applied to discriminate participants with "no insomnia" from those with "subthreshold" insomnia to moderate or severe insomnia.

Measurement of Self-Reported Daytime Sleepiness by the Epworth Sleepiness Scale

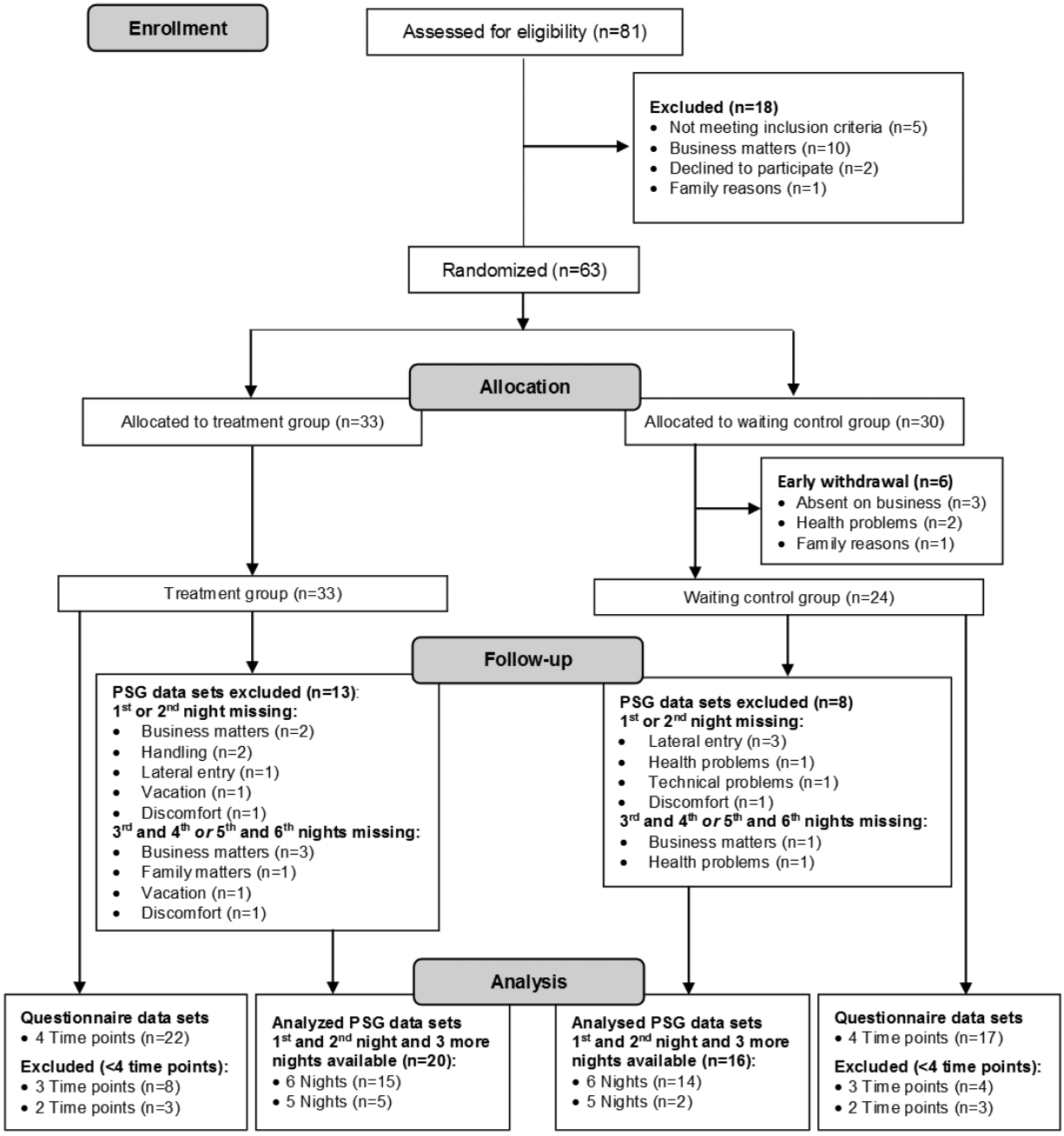
Self-reported daytime sleepiness was evaluated with the Epworth Sleepiness Scale[26] (ESS) at all four times of evaluation. In addition to the total score, the cutoff score > 10 was applied to classify participants with increased daytime sleepiness.

Statistical Analyses

Analysis of Baseline Characteristics

Baseline characteristics between different subsamples were compared by applying unpaired *t* tests in case of normally

Figure 2—Participant flowchart.



PSG = polysomnography.

distributed values and the Mann-Whitney *U* test for nonparametric data. Chi-square tests or Fisher exact test were used for comparisons of categorical data dichotomized at a cutoff score.

Analysis of Objective and Self-Reported Sleep Parameters

All participants, for whom data were available from the first and second night at t0 and from at least 1 night for t1 and t2 were included in the analysis, resulting in a total number of 36 participants with data (treatment group; n = 20; waiting control group: n = 16). The mean of 2 nights was analyzed. The number of participants and available data for all analyses as well as numbers and reasons for dropouts are presented in **Figure 2**.

All objective and self-reported sleep parameters were individually standardized into z-values to control for interindividual differences. Because almost all data were non-normally distributed, nonparametric statistics were applied. Friedman tests were used to test for possible treatment effects within the treatment and the control group separately. *Post hoc* Wilcoxon matched-pairs signed-rank tests were performed to look for pairwise changes between three different times of measurement. In addition to tests of significance (*P* values), effects sizes were considered. Bravais-Pearson correlation coefficients *r* were calculated for comparisons of two groups. In the case of comparisons between three measurement times

Table 2—Baseline (t0) characteristics for all participants (n = 57) and for subsamples of the PSG analysis (n = 36) and of the questionnaire analysis (four time points: n = 39).

	Total Sample (n = 57)			PSG Analysis Group (n = 36)			Questionnaire Analysis Group (4 time points) (n = 39)		
Parameter (t0)	TG (n = 33) mean ± SD	CG (n = 24) mean ± SD	*P*	TG (n = 20) mean ± SD	CG (n = 16) mean ± SD	*P*	TG (n = 22) mean ± SD	CG (n = 17) mean ± SD	*P*
Age, years	41.0 ± 10.8	40.7 ± 10.8	.909	42.1 ± 11.3	42.4 ± 10.3	.916	43.2 ± 8.6	40.1 ± 10.5	.307
BMI, kg/m^2	26.0 ± 3.3	26.4 ± 3.8	.725	26.0 ± 2.4	26.3 ± 3.8	.740	27.1 ± 3.2	25.7 ± 3.7	.228
PSQI score	7.8 ± 3.3	7.4 ± 3.3	.530*	7.7 ± 2.7	7.4 ± 3.7	.798	7.1 ± 2.7	7.3 ± 3.5	.764*
ISI score	11.1 ± 5.9	11.5 ± 4.4	.760	10.5 ± 5.6	11.9 ± 5.0	.431	10.5 ± 5.8	11.5 ± 4.6	.574
ESS score	9.7 ± 4.6	9.5 ± 3.9	.873	9.3 ± 3.9	9.6 ± 3.9	.777	9.7 ± 4.6	8.7 ± 4.0	.493
PHQ-9 score	5.0 ± 3.8	5.6 ± 2.6	.182*	7.6 ± 2.7	5.1 ± 4.1	.304*	4.4 ± 3.0	5.6 ± 2.6	.206
PHQ-15 score	5.6 ± 3.6	5.7 ± 2.9	.919	6.0 ± 3.7	6.0 ± 3.0	.964	5.4 ± 3.1	6.2 ± 2.9	.400
	n (%)	n (%)	*P*	n (%)	n (%)	*P*	n (%)	n (%)	*P*
Male	26 (78.8)	16 (66.7)	.305	16 (80.0)	10 (62.5)	.285†	17 (77.3)	9 (52.9)	.110
Soldiers	27 (81.8)	14 (58.3)	.051	16 (80.0)	8 (50.0)	.058	17 (77.3)	9 (52.9)	.110
PSQI score > 5	26 (78.8)	18 (75.0)	.736	17 (85.0)	12 (75.0)	.675†	17 (77.3)	13 (76.5)	> .999†
ISI score > 7	24 (72.7)	20 (83.3)	.346	15 (75.0)	13 (81.3)	.709†	15 (68.2)	14 (82.4)	.464†
ESS score > 10	11 (33.3)	8 (33.3)	> .999	7 (35.0)	5 (31.3)	.813	6 (27.3)	4 (23.5)	> .999†
PHQ-9 score ≥ 14	1 (3.0)	0 (0.0)	> .999†	1 (5.0)	0 (0.0)	> .999†	0 (0.0)	0 (0.0)	–
PHQ-15 score ≥ 14	0 (0.0)	0 (0.0)	–	0 (0.0)	0 (0.0)	–	0 (0.0)	0 (0.0)	–

Statistical results of unpaired *t* tests and the Mann-Whitney *U* test are shown in the upper part of the table. Statistical results for the categorical data (chi-square test and Fisher exact test) are shown in the lower part of the table. * = Mann-Whitney *U* test. † = Fisher exact test. BMI = body mass index, CG = control group, ESS = Epworth Sleepiness Scale, ISI = Insomnia Severity Index, PHQ-9 = Patient Health Questionnaire for Depression, PHQ-15 = Patient Health Questionnaire for Somatic Symptoms, PSG = polysomnography, PSQI = Pittsburgh Sleep Quality Index, SD = standard deviation, TG = treatment group.

within the groups (Friedman test), Kendall *W* was calculated as an effect size estimate.[27] All effect sizes were interpreted according to Cohen,[28] with values of ≥ 0.1 indicating a "small" effect, ≥ 0.3 "medium" effect, and ≥ 0.5 a "large" effect.

Analysis of Self-Reported Data From Questionnaires

For the longitudinal data analysis of four time points (t0, t1, t2, t3), complete questionnaires from 39 participants were analyzed. Possible differences between the treatment and the control group at baseline were analyzed by using *t* tests, or by Mann-Whitney *U* tests in the case of nonparametric distribution of data. Because of the non-normal distribution of the variables derived from the questionnaires at time points t1 to t3, all further data were analyzed with nonparametric tests. For within-group analyses Friedman tests were performed to measure effects across time, and Wilcoxon matched-pairs signed-rank tests for pairwise comparisons between time points. Chi-square tests or Fisher exact tests were used for the categorical data derived by the corresponding cutoff scores. In addition, Bravais-Pearson *r*, Kendall *W,* and Cramers *V* were calculated to measure magnitude of effects. All effect sizes were interpreted according to Cohen.[28]

Because of the small sample sizes, only effect sizes are reported for objective and self-reported sleep parameters and for questionnaire data. Only results representing medium to large effects across time points are reported and depicted in the figures.

All tests were performed with a double-sided significance level of $P < .05$. Data were processed statistically using IBM SPSS 23 (IBM Corp., Armonk, New York, United States).

RESULTS

Baseline Participant Characteristics

From 81 originally screened potential participants, 63 were randomized, and finally 57 employees (42 men, 15 women; mean ± standard deviation age: 40.9 ± 10.7 years; range: 18–58 years) participated in the sleep health program and underwent the accompanying evaluation. The 57 participants did not differ from all dropouts (n = 24) with regard to age, PSQI, ESS, and ISI and other baseline scores (**Table S1** supplemental material). Reasons for dropouts are presented in **Figure 2**, and basic sample characteristics of the participants are shown in **Table 2**. In none of the analysis groups did the treatment group differ significantly from the control group in any of the baseline characteristics. In all analysis groups, sleep quality measured by the mean scores of the PSQI and the ISI was impaired at t0 according to the applied cutoffs (**Table 2**). Mean values of self-reported daytime sleepiness in the ESS were just below the cutoff score of 10. Mean scores of PHQ-9 and PHQ-15 lay below the cutoff values according to the inclusion cutoff criteria of 14 and even below 10, which indicates "no" or "mild symptoms" of depression or somatic symptoms, respectively.[29] Distribution of military ranks and levels of civil servants between treatment group and control group did not differ significantly (**Table S2** in supplemental material).

Adherence to Sleep Health Program

Although the criteria required the inclusion of only individuals who were able to participate in all four sessions, the participation rate ranged between 91.2% (52 of 57) in the first session, 87.7% (n = 50) in the second, 89.5% (n = 51) in the third, and

Table 3—Results of objective sleep parameters for three time points and results of comparisons between different time points for treatment and control groups separately.

Objective Sleep Parameter (z-values)	Group	t0	t1	t2	t0–t1	t0–t2	t1–t2	3 Time Points*
		median (IQR)	median (IQR)	median (IQR)	|r|	|r|	|r|	W
TIB	TG	0.27 (−0.69, 1.03)	−0.15 (−1.00, 0.71)	−0.26 (−0.77, 0.69)	.08	.18	.03	.02
	CG	0.47 (−0.63, 1.05)	0.01 (−0.90, 0.92)	−0.45 (−0.68, 0.64)	.22	.26	.06	.05
Sleep latency	TG	0.20 (−0.26, 0.90)	0.04 (−0.85, 1.00)	−0.64 (−1.01, 0.46)	.18	.45†	.32†	.08
	CG	0.23 (−0.86, 1.04)	−0.01 (−0.77, 0.94)	−0.29 (−0.92, 0.25)	.05	.27	.22	.01
Latency to persistent sleep	TG	0.26 (−0.33, 0.91)	−0.11 (−0.88, 1.00)	−0.29 (−0.99, 0.16)	.20	.41†	.23	.11
	CG	0.94 (−0.52, 1.12)	−0.15 (−0.60, 0.71)	−0.61 (−0.93, 0.17)	.35†	**.50**	.25	.14
Stage R sleep latency	TG	0.42 (−0.30, 1.08)	0.02 (−0.33, 0.94)	−0.82 (−1.01, −0.19)	.14	**.61**	**.54**	.27
	CG	0.69 (−0.56, 1.03)	−0.14 (−1.06, 0.30)	−0.07 (−0.91, 0.73)	.27	.30†	.08	.11
Wake after sleep onset	TG	0.82 (−0.29, 1.10)	−0.37 (−0.94, 0.62)	−0.57 (−0.89, 0.28)	.45†	**.52**	.14	.17
	CG	−0.01 (−0.54, 1.04)	−0.37 (−0.79, 1.09)	−0.56 (−0.81, 0.27)	.11	.31†	.28	.05
TST	TG	−0.33 (−0.78, 0.82)	−0.09 (−0.74, 0.98)	−0.23 (−0.73, 0.87)	.08	.06	.01	.01
	CG	−0.25 (−0.95, 1.07)	−0.32 (−0.83, 0.25)	0.41 (−0.70, 0.91)	.22	.22	.28	.05
Sleep efficiency	TG	−0.71 (−1.05, 0.25)	0.41 (−0.51, 0.86)	0.61 (−0.30, 1.11)	.45†	**.57**	.13	.23
	CG	−0.33 (−0.93, 0.51)	−0.01 (−0.98, 0.76)	0.67 (−0.29, 0.99)	.16	.44†	.27	.08

Median and IQR z-values and effect sizes (Kendall *W*, Bravais Pearson *r*) are shown. * = TG (n = 20), CG (n = 16). † = medium effect size. Bold values indicate large effect sizes. CG = control group, IQR = interquartile range, t0 = baseline, t1 = end of sleep health program of treatment group, t2 = end of sleep health program of control group, TG = treatment group, TIB = time in bed, TST = total sleep time, *W* = Kendall *W*.

84.2% (n = 48) in the last session. The reasons for absence were "unforeseen business matters" (51.9%, n = 14), "vacations" (25.9%, n = 7), or "illness" (18.5%, n = 5). One person simply forgot the date of the first session (3.7%, n = 1).

Objective Sleep Parameters

Results of descriptive statistics of z-values and comparisons across time points of objective sleep parameters are summarized in **Table 3**. As seen from **Table S3** in the supplemental material, median absolute values do not indicate impaired sleep. Nevertheless, improvements occurred in both groups. As expected, the treatment group showed stronger and earlier improvements in most of the objective sleep parameters than the control group: WASO and sleep efficiency already improved from t0 to t1 with medium effects (**Table 3**, **Figure 3A,** and **Figure 3B**). Both parameters further improved throughout the observation period with large effect sizes from t0 to t2. In addition, SL and LPS decreased with medium effects in this group (**Figure 3D** and **Figure 3E**).

In the control group, a reduction in the LPS with a large effect was observed after participation in the sleep health program compared to baseline (t2–t0; **Figure 3E**). Furthermore, sleep efficiency increased and WASO decreased from t0 to t2—both with moderate effects. Stage R sleep latency decreased with a strong effect in the treatment group from t0 to both t1 and to t2 (**Figure 3C**), whereas in the control group a moderate effect occurred from t0 to t2 (**Figure 3C**).

Self-Reported Sleep Parameters

Results of comparisons of self-reported sleep parameters (z-values) across time points are shown in **Table 4**. Descriptive statistics of absolute values summarized in **Table S4** in the supplemental material indicate unimpaired sleep in both groups. Nevertheless, in the treatment group sSL decreased with strong effects across time points (**Table 4**, **Figure 4A**), and sWASO and sTST changed from t1 to t2 with medium effects (**Figure 4B** and **Figure 4C**). In the control group, sSL decreased with a moderate effect from t0 to t2 (**Figure 4A**). Although self-reported restfulness improved with a strong effect in the treatment group from t0 to t1, restfulness declined at t1 in the control group and improved from t1 to t2 (**Figure 4D**).

Results From Questionnaires

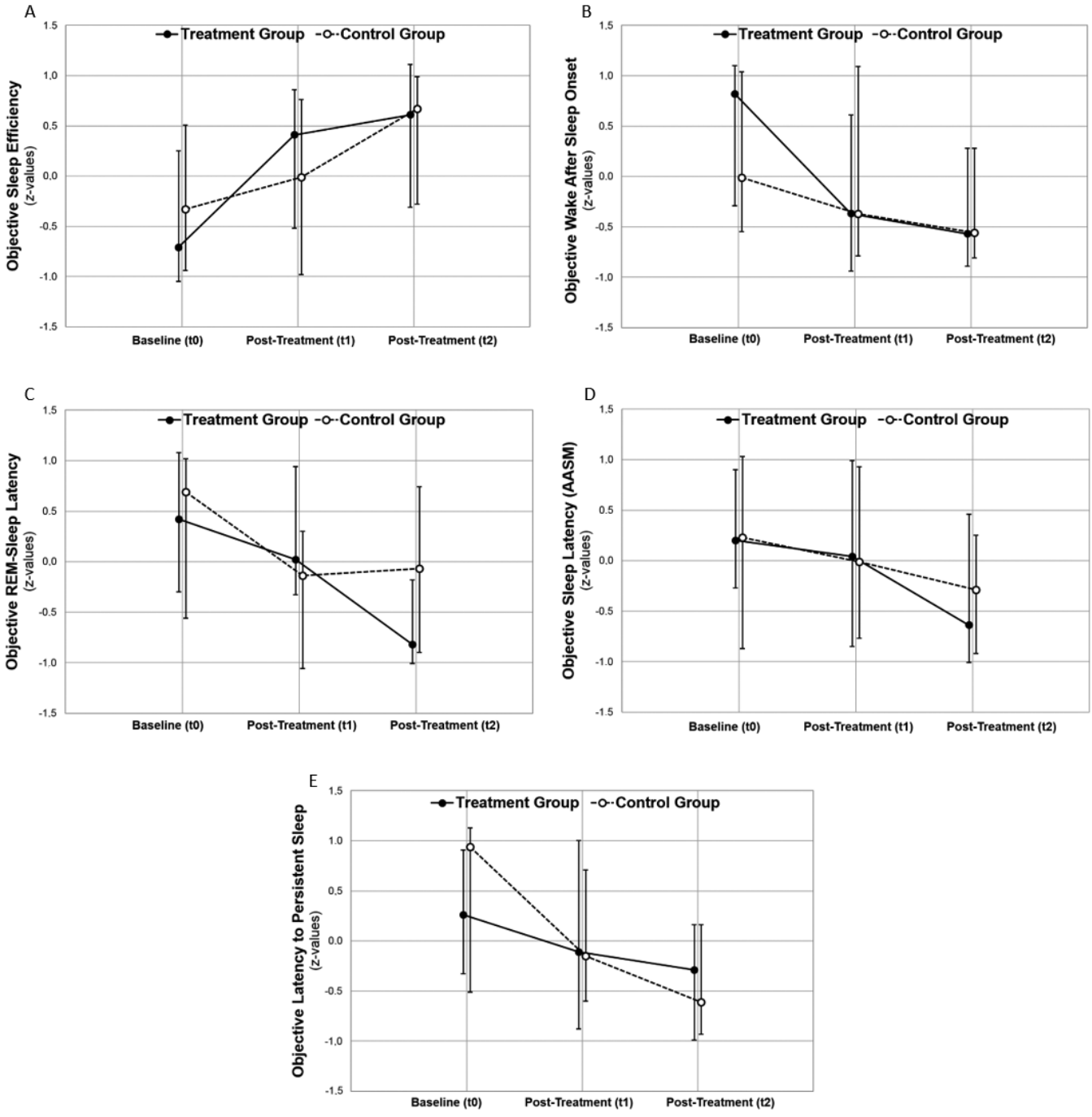
Pittsburgh Sleep Quality Index

Self-reported sleep quality improved across the four time points in both groups (**Table 5**, **Figure 5A**). Whereas effects between t0 and the three measurement times (t1, t2, t3) were all large in the treatment group, in the control group moderate effects were seen from t0 to both, t1 and t3 and large effects were observed after participation in the sleep health program (t2–t0). The median of the PSQI reached a normal level (total score ≤ 5) already at the end of the sleep health program in the treatment group and dropped below the cutoff at the 3-month follow-up in the control group (**Figure 5A**, **Table 5**).

Insomnia Severity Index

The total score of the ISI declined across the four time points (**Table 5** and **Figure 5B**). The improvements from t0 to t1 were moderate in both groups. In the course of the observation period, further decreases in the scores with moderate to large effects were observed in both groups at t2 and t3 compared to t0. The median total scores reached "normal" level (ISI ≤ 7) at t1 in the treatment group and at t3 in the control group (**Table 5**; **Figure 5B**). Comparisons of cutoff scores at all of the four different time points revealed one significant result at t1: the

Figure 3—Objective sleep parameters.



This figure illustrates the objective sleep parameters (median and interquartile range) that improved with medium or large effects in the treatment group (**A, B, C, D, E**) and in the control group (**A, B, C, E**). The treatment group (n = 20) is depicted with a solid line and the control group (n = 16) with a dashed line. Corresponding effect sizes are shown in Table 3.

number of participants with insomnia symptoms was higher in the control group (76.5%) than in the treatment group (40.9%) with a moderate effect ($\chi^2 = 4{,}932$; $P = .026$; Cramer $V = 0.36$).

Epworth Sleepiness Scale

It is important to note that the median values of the total score are within the normal range of ≤ 10 in both groups at all four time points, respectively (**Table 5**, **Figure 5C**). Nevertheless, the ESS scores decline with increasing effects from t0 to t2 and t3 in the treatment group only (**Table 5**, **Figure 5C**).

DISCUSSION

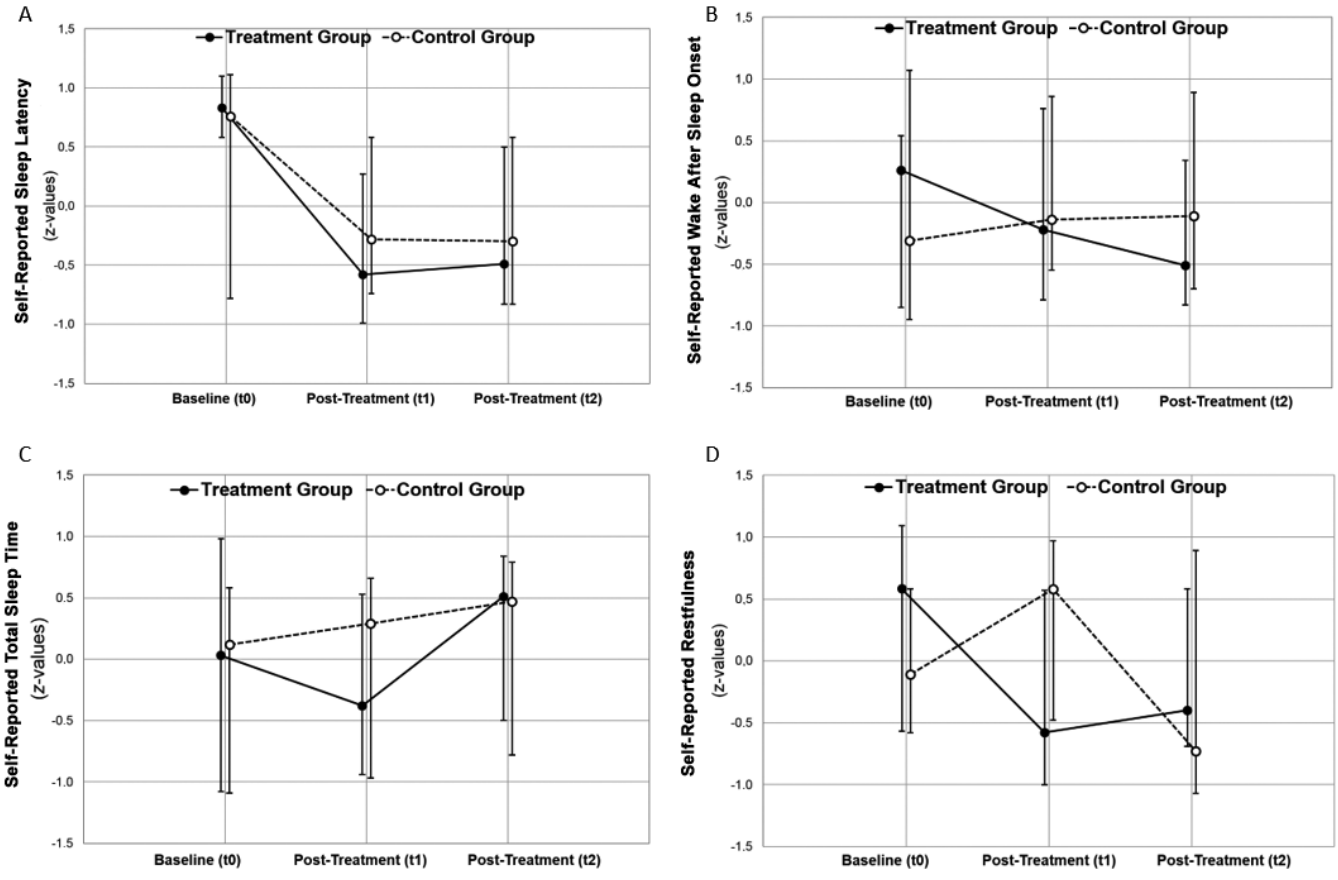
In the current study, a 4-week sleep health program has been shown to be effective in improving objective and self-reported

Table 4—Results of self-reported sleep parameters for three time points and results of comparisons between different time points for treatment and control groups separately.

Self-Reported Sleep Parameter (z-values)	Group	t0	t1	t2	t0–t1	t0–t2	t1–t2	3 Time Points*
		median (IQR)	median (IQR)	median (IQR)	|r|	|r|	|r|	W
TIB	TG	0.34 (−1.07, 1.08)	0.20 (−0.69, 0.61)	−0.15 (−0.62, 0.69)	.04	.13	.05	.00
	CG	−0.35 (−0.99, 0.89)	0.21 (−1.00, 1.05)	0.06 (−0.60, 0.62)	.08	.08	.09	.00
Sleep latency	TG	0.83 (0.58, 1.09)	−0.58 (−0.99, 0.27)	−0.49 (−0.83, 0.50)	**.67**	**.58**	.10	.30†
	CG	0.76 (−0.78, 1.11)	−0.28 (−0.74, 0.58)	−0.30 (−0.83, 0.58)	.19	.43†	.08	.07
Wake after sleep onset	TG	0.26 (−0.73, 1.14)	−0.22 (−0.59, 1.12)	−0.51 (−0.69, −0.24)	.03	.28	.33†	.04
	CG	−0.31 (−0.95, 1.07)	−0.14 (−0.55, 0.86)	−0.11 (−0.70, 0.89)	.10	.10	.01	.01
TST	TG	0.03 (−1.08, 0.98)	−0.38 (−0.94, 0.53)	0.51 (−0.50, 0.84)	.09	.13	.34†	.04
	CG	0.12 (−1.09, 0.58)	0.29 (−0.97, 0.66)	0.47 (−0.78, 0.79)	.02	.27	.08	.03
Sleep efficiency	TG	−0.33 (−1.08, 1.09)	0.12 (−0.80, 0.86)	0.19 (−0.58, 0.72)	.13	.03	.06	.01
	CG	−0.14 (−0.99, 0.75)	0.08 (−1.00, 0.52)	0.47 (−0.79, 0.99)	.04	.21	.26	.06
Restfulness	TG	0.58 (−0.58, 1.09)	−0.58 (−1.00, 0.58)	−0.40 (−0.68, 0.58)	**.52**	.35†	.04	.15
	CG	−0.11 (−0.58, 0.58)	0.58 (−0.49, 0.97)	−0.73 (−1.07, 0.89)	.27	.14	.44†	.12

Median and IQR z-values and effect sizes (Kendall *W*, Bravais Pearson *r*) are shown. * = TG (n = 20), CG (n = 16). † = medium effect size. Bold values indicate large effect sizes. CG = control group, IQR = interquartile range, t0 = baseline, t1 = end of sleep health program of treatment group, t2 = end of sleep health program of control group, TG = treatment group, TIB = time in bed, TST = total sleep time, *W* = Kendall *W*.

Figure 4—Self-reported sleep parameters.



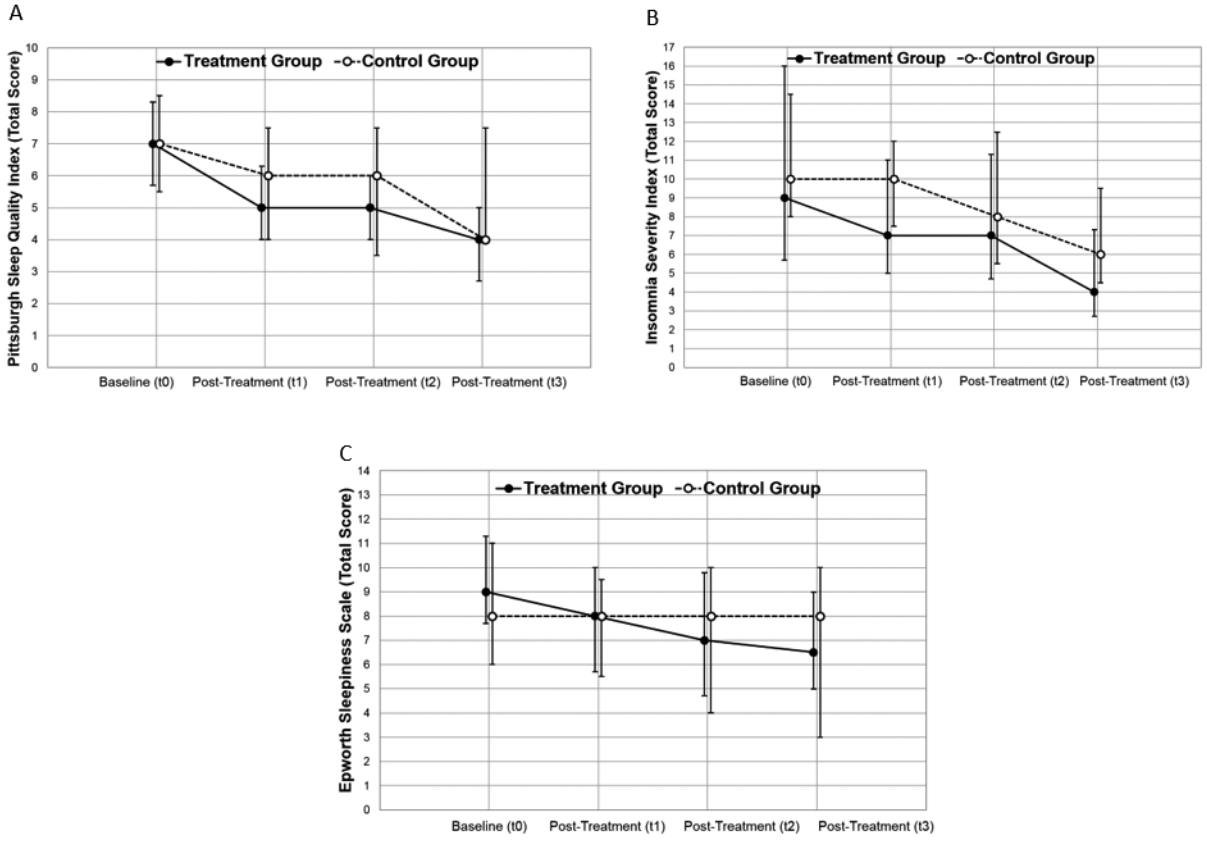
This figure illustrates the self-reported sleep parameters (median and interquartile range) that improved with medium or large effects in the treatment group (**A, B, C, D**) and with medium effects in the control group (**A, D**). The treatment group (n = 20) is depicted with a solid line and the control group (n = 16) with a dashed line. Further corresponding effect sizes are shown in Table 4.

Table 5—Results of total scores of questionnaires for four time points and results of comparisons between different time points for treatment and control groups separately.

Questionnaires	Group	t0	t1	t2	t3	t0–t1	t0–t2	t0–t3	t1–t2	t1–t3	t2–t3	4 Time Points *
		median (IQR)	median (IQR)	median (IQR)	median (IQR)	|r|	|r|	|r|	|r|	|r|	|r|	W
PSQI score	TG	7.0 (5.8, 8.3)	5.0 (4.0, 6.3)	5.0 (4.0, 6.0)	4.0 (2.8, 5.0)	**.53**	**.54**	**.57**	.26	.40†	.16	.40†
	CG	7.0 (5.5, 8.5)	6.0 (4.0, 7.5)	6.0 (3.5, 7.5)	4.0 (4.0, 7.5)	.35†	**.53**	.46†	.09	.03	.04	.26
ISI score	TG	9.0 (5.8, 16.0)	7.0 (5.0, 11.0)	7.0 (4.8, 11.3)	4.0 (2.8, 7.3)	.40†	.32†	**.55**	.02	.46†	.44†	.41†
	CG	10.0 (8.0, 14.5)	10.0 (7.5, 12.0)	8.0 (5.5, 12.5)	6.0 (4.5, 9.5)	.33†	**.50**	.49†	.28	.32†	.16	.27
ESS score	TG	9.0 (7.8, 11.3)	8.0 (5.8, 10.0)	7.0 (4.8, 9.8)	6.5 (5.0, 9.0)	.18	.39†	.46†	.30†	.33†	.05	.19
	CG	8.0 (6.0, 11.0)	8.0 (5.5, 9.5)	8.0 (4.0, 10.0)	8.0 (3.0, 10.0)	.22	.23	.24	.11	.10	.07	.03

Median, IQR, and effect sizes (Kendall *W*, Bravais Pearson *r*) are shown. * = TG (n = 22), CG (n = 17). † = medium effect size. Bold values indicate large effect sizes. CG = control group, ESS = Epworth Sleepiness Scale, IQR = interquartile range, ISI = Insomnia Severity Index, PSQI = Pittsburgh Sleep Quality Index, t0 = baseline, t1 = end of sleep health program of treatment group, t2 = end of sleep health program of control group, t3 = 3-month follow-up, TG = treatment group, *W* = Kendall *W*.

Figure 5—Self-reported sleep quality.



This figure illustrates self-reported sleep quality (Pittsburgh Sleep Quality Index **(A)** and Insomnia Severity Index **(B)**) and self-reported daytime sleepiness (Epworth Sleepiness Scale **(C)**) across four time points (treatment group: n = 22, control group: n = 17). Median and interquartile ranges are depicted for the total scores. The results of the treatment group are shown with a solid line and with a dashed line for the control group. Corresponding effects sizes are depicted in Table 5.

sleep with stable and long-lasting effects in members of the German Armed Forces. Although the study population was rather heterogeneous and comprised individuals with different levels and causes of sleep impairment, a significant positive effect of this new preventive method was observed. To the best of our knowledge, studies on sleep health programs in the military context have not yet been published. Furthermore, several sleep health programs have been implemented as part of sleep education programs in children and adolescents,[30] but only a few programs are available for the adult population. The workplace-based, face-to-face studies published focus on sleep knowledge and sleep hygiene education[31,32] or on cognitive behavioral therapy for insomnia (CBT-I).[33,34] Only one of these studies applied objective measures of sleep by using

wrist actigraphy in a study on workplace-based group CBT-I,[34] but none implemented PSG recordings. A sleep health program with 1,189 firefighters, which comprised a mandatory educational session, a voluntary sleep disorders screening, diagnosis, and treatment if indicated, revealed a reduction in injuries and disability, but did not evaluate objective parameters of sleep.[32]

Objective Sleep Parameters

From the objective sleep parameters measured by polysomnography, SL (treatment group only), LPS, stage R sleep latency, sleep efficiency, and WASO improved with medium to strong effects in both groups. Furthermore, these improvements persisted at later time points. The results thus are similar to effects observed in a meta-analysis on the efficacy of CBT-I on diary measures and/or PSG in chronic insomnia; in this earlier study, similar significant improvements with medium to large effect sizes with a decrease in SL and WASO were reported, as well as an increase in sleep efficiency at the posttreatment time point.[35]

Both the treatment group and the control group, which turned into a treatment group after t1, benefited from the sleep health program. In light of the tight time schedule, it is reasonable that the effects on objective sleep parameters were strongest in the treatment group not directly after the end of their participation in the program, but at the following time point (t2), which was approximately 8 weeks later. Not surprisingly, these results clearly indicate that it takes more time than just 4 weeks to practice and change sleep-related behaviors to achieve noticeable improvements in sleep quality. The results of the current study indicate that four sessions are sufficient to induce long-lasting changes; this is in line with a study on dose-response effects of CBT-I, which indicated that four individual, biweekly sessions were most effective.[36] There are no studies available on dose-response effects of sleep health programs on PSG outcome parameters.

Interestingly, stage R sleep latency decreased with a strong effect across time in the treatment group and with a moderate effect in the control group. Stage R sleep latency has been demonstrated to be susceptible to first-night effects in healthy individuals in the laboratory.[37–39] In-home PSG performed in young healthy individuals, the dynamics of habituation of stage R sleep evolved across 4 nights, expressed by a continuous decrease of stage R sleep latency.[40] Analyses on possible first-night effects and on variability of sleep parameters in the current study (not reported here) did not confirm an effect on stage R sleep latency. Stage R sleep alterations have been repeatedly described in depressed patients,[41] including a shortened stage R sleep latency. Because severe depressive symptoms were part of the exclusion criteria, it is very unlikely that shorter stage R sleep latency was due to depression in the current study. Pharmacological studies on the treatment of chronic insomnia also revealed a decrease of stage R sleep latency.[42,43] Hoever et al. in their study hypothesized that this effect might indicate a kind of REM sleep rebound in individuals who were susceptible to chronic partial REM sleep deprivation.[42] However, approximately one-fourth of participants did not report insomnia symptoms (baseline ISI < 7). Though it was not the aim of the study, we analyzed respiration and periodic leg movements of the second PSG night and found obstructive sleep apnea (OSA) according to the diagnostic criteria of the AASM (2014)[44] in 12.3% of the 57 study participants. OSA was homogenously distributed across the treatment and the control groups (Fisher exact test: $P = .439$). Despite the inclusion of participants with OSA, the sleep health program still showed good effects on outcome parameters. None of the participants met the AASM criteria for periodic limb movement disorder (2014).[44]

Self-Reported Sleep Parameters

A decrease in the sSL, which improved in the treatment group after participating in the program with large effects, was also observed in an 8-week worksite-based healthy sleep program, which provided knowledge about normal sleep and common sleep disorders, and key concepts of traditional CBT-I[33] to 53 adult members of an employee wellness center. The program was very similar to the one presented here, aside from the additional topics of yoga, tai chi, and qi gong. In a pre-post assessment with a 23-item questionnaire, almost all ratings improved significantly, with the largest changes seen in knowledge about sleep, followed by the number of nights with "poor quality," initiating and maintaining sleep and competence towards dealing with individual sleep problems.

In the current study, the self-reported feeling of restfulness in the morning and the sSL improved in both groups after their participation in the sleep health program, reaching moderate to strong effects and corroborating a treatment effect on restfulness at t1. Ohayon et al.[45] found two main predictors of daytime consequences in individuals reporting sleep disturbances: global sleep dissatisfaction and nonrestorative sleep. In a study by Harvey et al.,[46] individuals with and without insomnia rated feeling alert upon waking and during the day as well as feeling rested and restored on waking as the most important factors when judging sleep quality. Therefore, the improvements in restfulness point to a crucial effect of the sleep health program on self-reported sleep quality.

A further treatment effect was observed with regard to insomnia severity in the ISI. The improvements with large effects in the ISI after the participation in the sleep health program in both groups may be accounted for by the contents of one session on cognitive strategies, which are also applied in CBT-I, (eg, stimulus control and relaxation techniques). These results are in line with the repeatedly shown positive effects of CBT-I in different meta-analyses.[35,47]

The control group improved only in one of the seven objective and in none of the self-reported sleep parameters at t1, which was expected because the group was still waiting for the intervention to begin. Nevertheless, moderate improvements were already observed at t1 in the PSQI and ISI. Considering that the control group already started to fill in the sleep diary at baseline in parallel with the treatment group, a possible self-monitoring effect of completing a sleep diary every evening and morning might have led to insights concerning potentially disturbing sleep-related behavior[48] resulting in behavioral modifications in some of the participants. After participation in the sleep health program, large improvements occurred in the control group in the PSQI and ISI, and in the LPS. The further improvements in all questionnaires in both groups in

the 3-month follow-up, except for the ESS in the control group, indicate a stable effect, which became larger across time. Although excessive daytime sleepiness and strategies against it were the main topic of the last session, median ESS scores changed with moderate effects only in the treatment group. Regardless, the median ESS scores lay within the normal range in both groups at any time point.

Limitations and Strengths

One of the limitations of the study was that participants could not be completely randomized by an automatic or predefined algorithm. For reasons related to time and personnel restrictions, sites could only participate in the study consecutively, not concurrently, hampering overall randomization. For the stated reasons, it was also not possible to delay the entry of the control subjects into the program to the end of t2 or even later at the 3-month follow-up, as would be desirable.

Furthermore, the amount of complete PSG data of all planned 6 nights per person was very small; therefore, only a reduced data set could be analyzed. Nevertheless, the data regarding objective and self-reported sleep parameters are encouraging for the further implementation of the sleep health program within workplace health promotion efforts.

One advantage of the sleep health program is that there is no need for comprehensive medical diagnostic procedures in the run-up to the intervention. As seen from the PSG data (**Table S3** and **Table S4**) and the only slightly elevated scores in the PSQI and ISI at baseline, the sleep quality of most of the study population was only minimally impaired. The sleep health program is, therefore, suitable for individuals with subsyndromal sleep disturbances and might have preventive effects. Nevertheless, at the end of the sleep health program further diagnostic or treatment steps might be recommended for some of the participants (eg, OSA). Therefore, trained personnel should offer the sleep health program to identify those who might have sleep disorders requiring further diagnostics and/or treatment. One strength of the study was that all contents were imparted by a clinical and health psychologist and certified expert in sleep medicine (CS), ruling out the effect of having different coaches.

The total amount of time participants spend with the sleep health program comprises approximately 8 hours distributed over a time period of 3 weeks (4 sessions: 90 min/wk; keeping a sleep diary: maximum 5 min/d during participation in the intervention; practicing of techniques if appropriate: several min/d). Most of the members of the German Armed Forces are used to almost-daily exercise, which may help with adherence to the program ("military discipline"). In the current study, participation was voluntary, and as in nonmilitary samples, it became clear that compliance mainly depends on personal motivation and/or psychological strain. The opportunity to engage with the sleep health program during worktime within the workplace health promotion definitely facilitated participation.

CONCLUSIONS

The workplace-based sleep health program on sleep has positive effects on objective and self-reported measures of sleep in members of the German Armed Forces. Meanwhile, the sleep health program is disseminated by psychologists of the German Armed Forces, who received an intensive training by HDH and CS in a 4-day "train-the-coaches" seminar. Although there were only four sessions to be attended during working hours at each site, quite a high percentage of individuals were not able to take part in the sleep health program due to (unforeseen) business matters or duty-related travels. Therefore, and for the purpose of broader and easier accessibility, an electronic-based version of the program is currently being implemented. By analogy with the "stepped care model"[49] in insomnia treatment, these different steps of applying the sleep health program[50] should improve the availability for most of the military service members in need of support to improve their sleep.

ABBREVIATIONS

AASM, American Academy of Sleep Medicine
CBT-I, cognitive behavioral therapy for insomnia
ESS, Epworth Sleepiness Scale
ISI, Insomnia Severity Index
LPS, latency to persistent sleep
OSA, obstructive sleep apnea
PHQ-15, Patient Health Questionnaire for Somatic Symptoms
PHQ-9, Patient Health Questionnaire for Depressive Symptoms
PSG, polysomnography
PSQI, Pittsburgh Sleep Quality Index
PTSD, posttraumatic stress disorder
REM, rapid eye movement
SL, sleep latency
sSL, self-reported sleep latency
sTIB, self-reported time in bed
sTST, self-reported total sleep time
sWASO, self-reported wake after sleep onset
t0, baseline
t1, directly after the intervention was finished in the treatment group
t2, directly after the intervention was finished in the control group
t3, 3-month follow-up
TIB, time in bed
TST, total sleep time
WASO, wake after sleep onset

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DISCLOSURE STATEMENT

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