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Original Article

Self-Reported Recovery from 2-Week 12-Hour Shift Work Schedules: A 14-Day Follow-Up

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ABSTRACT

Background: Recovery from fatigue is important in maintaining night workers' health. This study compared the course of self-reported recovery after 2-week 12-hour schedules consisting of either night shifts or swing shifts (i.e., 7 night shifts followed by 7 day shifts) to such schedules consisting of only day work.

Methods: Sixty-one male offshore employees—20 night workers, 16 swing shift workers, and 25 day workers—rated six questions on fatigue (sleep quality, feeling rested, physical and mental fatigue, and energy levels; scale 1–11) for 14 days after an offshore tour. After the two night-work schedules, differences on the 1st day (main effects) and differences during the follow-up (interaction effects) were compared to day work with generalized estimating equations analysis.

Results: After adjustment for confounders, significant main effects were found for sleep quality for night workers (1.41, 95% confidence interval 1.05–1.89) and swing shift workers (1.42, 95% confidence interval 1.03–1.94) when compared to day workers; their interaction terms were not statistically significant. For the remaining fatigue outcomes, no statistically significant main or interaction effects were found.

Conclusion: After 2-week 12-hour night and swing shifts, only the course for sleep quality differed from that of day work. Sleep quality was poorer for night and swing shift workers on the 1st day off and remained poorer for the 14-day follow-up. This showed that while working at night had no effect on feeling rested, tiredness, and energy levels, it had a relatively long-lasting effect on sleep quality.

1. Introduction

Recovery from work-related fatigue is important in maintaining employee health [1–4]. Studies show that the inability to recover after work, as assessed by self-reports, predicts longer sickness absence [5,6], as well as cardiovascular disease and cardiovascular mortality [7,8]. The effort–recovery model defines recovery as a process of unwinding to and stabilizing at a baseline level of activation in the absence of specific work demands [3,9]. Recovery can be impeded when the body's psychophysiological systems remain activated, even when work demands have been removed. According to the allostatic load model an accumulative process of increased and prolonged activation over time may cause gradual wear and tear on the body's organs causing a predisposition to disease [9,10].

Working long hours can impede the recovery process in two ways. Firstly, prolonged exposure to work demands may leave the employee experiencing a higher level of fatigue than after an 8-hour working day. Secondly, the reduction in time to unwind may not be sufficient to recover completely in between working days [11]. When recovery is impeded in schedules with long working hours and extended working weeks, it leads to an

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accumulation of fatigue over the working period [12,13], and a spill-over of the level of fatigue into the start of the free period [14]. Recovering from long night shifts in extended schedules is seen to be extra challenging, as the opportunity to recover between shifts is further impeded by sleep problems and disruption of the physiological circadian rhythm associated with the changed sleep/wake cycle [15–17].

Long working hours in extended schedules are standard in the Norwegian offshore petroleum industry [18–20]. The remote offshore locations of the oil platforms necessitate compressing the working hours into 12-hour shifts and extending the working periods to 14–21 days. Shift schedules consist of: permanent day work; permanent night work; fixed shifts: alternating day and night shifts every other tour; or swing shifts: either 7 night shifts followed by 7 day shifts every tour, or vice versa. The offshore working periods are followed by 3–4 weeks of respite.

Studies from the offshore petroleum industry have assessed sleep after 2 weeks of night shifts, swing shifts (7 night shifts followed by 7 day shifts), and day shifts, but omitted other dimensions of fatigue [20–22]. For sleep quality, night and swing shift workers scored similarly to day workers during the free period, but for sleepiness, night workers scored poorer [20,21]. However, fatigue does not only consist of a sleep-related dimension, it also has a mental and a physical dimension, as well as dimensions for lack of energy and reduced activities [22–24]. Studying multiple dimensions of fatigue is important in understanding the full scale of implications of working at night in schedules with long shifts and extended weeks [19,22].

Previous research on compressed and extended night working periods have not assessed recovery indicators beyond 7 days of the free period [18,19,25], while in this period sleep indicators still fluctuated [18]. Recovery is a dynamic process that unfolds over time [26] and knowing more about it would be beneficial for recovery theory [9]. Therefore, a longer follow-up than 7 days is needed to study the course of recovery to a period of stability inherent to the definition of recovery.

This study aimed to compare the course of self-reported recovery from work-related fatigue after 2-week 12-hour schedules that consisted of either night shifts or swing shifts (7 night shifts followed by 7 day shifts) to such schedules consisting of only day work, by assessing several dimensions of fatigue during a 14-day follow-up period.

2. Materials and methods

2.1. Participants and procedure

In total, 2,492 invitations were distributed in eight oil companies active on the Norwegian Continental Shelf. Inclusion was restricted to: (1) male employees; (2) at least 2 years offshore experience; and (3) parental responsibility for at least one child living at home younger than 18 years. The latter criterion mirrored the research goal of the larger project under which this study falls, i.e., studying work–family balance amongst offshore personnel. Response was received from 184 employees, of whom 20 did not meet the inclusion criteria and were excluded, 60 declined to participate or withdrew from the study, and 33 were lost to follow-up. Eight swing shift workers rotating from day to night shifts were excluded from analysis, as were two swing shift workers of whom the rotation directions were unknown. The final study sample consisted of 61 participants, all of whom had given written informed consent prior to the start of the study. It was not known how many of the 2,492 employees approached for this study were eligible for participation, because privacy regulations prevented the research team from gaining information on how many employees met the third inclusion criterion.

The study had an observational, repeated measures design. Participants received a booklet by postal mail that consisted of a diary that assessed self-perceived recovery and a general questionnaire that assessed demographic, work-related, and health-related background information. The diary was filled in daily during the first 14 days of a self-chosen free period; the general questionnaire was filled in on the 1st day of that same free period.

2.2. Dependent variables

2.2.1. Daily self-reported recovery

Self-reported recovery was the main outcome of this study and was assessed daily by six single-item questions. The items consisted of questions on sleep quality, feeling rested, physical tiredness, mental tiredness, energy for activities related to the family and home, and energy for activities of personal interest. All questions were assessed with similar questions, for example: "On a scale from very little to a great extent, how *mentally tired* did you feel today?" The items were assessed on an 11-point Likert scale anchored on both extremes with *very badly* and *very well* for sleep quality, and with *very little* and *a great extent* for the remaining items. The outcomes for sleep quality, feeling rested, and both items on energy levels were reverse-coded for data analysis to consistently assign low scores to positive levels of self-reported recovery. Single-item questions on recovery, with comparable 1–10 Likert scale answer categories, have been used in previous diary studies to reduce the burden of participation for the respondent [11,27]. Single-item questions have been found to be valid, reliable, and practical in studies where full questionnaires are not feasible [28,29].

2.3. Independent variables

2.3.1. Shift schedule

For the offshore tour preceding the diary study, the shift schedule was assessed together with the starting and finishing times of the shifts. From this information the shift schedules were categorized into night shifts, swing shifts (7 night shifts followed by 7 day shifts), and day shifts.

2.4. Background information and control variables

2.4.1. Demographic and health-related information

Demographic information was assessed regarding age, level of education, marital status (partner/no partner), and age of the children living at home. Based on the idea that younger children require more care and, therefore, could be considered more fatiguing, the age of the children was dichotomized into: (1) at least one child younger than 7 years; and (2) all children aged 7 years or older. Self-perceived general health status was assessed using a single-item question with answer categories on a 5-point Likert scale ranging from *very good* to *very poor* [30].

2.4.2. Fatigue, need for recovery, and sleep problems during offshore period

For the offshore tour preceding the diary study, information was assessed regarding fatigue, need for recovery, and sleep problems. Self-perceived ratings of fatigue and need for recovery were assessed using the Checklist Individual Strength (CIS) [31,32] and Need for Recovery Scale [33,34], respectively. Sleep problems experienced during the offshore working period were assessed with four questions answered on a 4-point Likert scale (never/sometimes/often/every day). Three questions came from the Karolinska Sleep Questionnaire (problems with falling asleep, problems awakening, disturbed/restless sleep) [35] and one from a questionnaire developed by Gustafsson et al [36] (problems falling asleep because thoughts of my job keep me awake). The recall period for the questions on fatigue, need for recovery, and sleep problems was adjusted to the duration of the offshore working period.

2.4.3. Work-related information

For the offshore tour preceding the diary study, separate items assessed the duration of the tour and the total amount of overtime. Total overtime was dichotomized into the categories ≤ 14 hours and > 14 hours, corresponding to on average of ≤ 1 h/d and > 1 h/d, respectively.

Job demands were assessed using the quantitative demands and decision demands subscales from the General Questionnaire for Psychological and Social Factors at Work (QPS_{Nordic}) [37]. Job control was assessed using the control of decision and control of work pace subscales from the QPS_{Nordic}. Job demands and job control were scored on a scale from 1 to 5, from very seldom/never to very often/always. Other work-related information included offshore experience (in years) and employment in other paid work during the free period (yes/no).

2.5. Statistical analysis

Data analysis was conducted in IBM SPSS 21.0 (IBM, Armonk, NY, USA) with statistical significance set at $p < 0.05$. Differences in demographic, and health- and work-related background variables between the shift groups were studied by performing Chi-square tests for categorical outcomes and analysis of variance (ANOVA) for continuous outcomes.

Separate analyses were performed for each of the six recovery items. The distribution of each recovery outcome was skewed and therefore log-transformed. Generalized estimating equations analysis is well suited for analyzing data with repeated measures and can handle missing data well. Generalized estimating equations analysis was used with robust standard errors and an unstructured working correlation matrix to calculate the association between shift groups (night shifts and swing shifts, respectively, with day shifts as reference). The model for the mean consisted of the main effects for shift group (as a factor), days of the free period (as a covariate, with the value of 0 corresponding to 1st day of the free period), and an interaction term between shift group and days of the free period. The main and interaction effects were transformed back to the original scale, which means that main and interaction effects were expressed as multiplicative differences. The main effects for night and swing shifts indicated differences in the level of recovery on the *1st day of the free period* relative to day shifts. The interaction effects indicated differences in the *rate of recovery over the 14-day follow-up*. This means that under the assumption of a linear effect of time on the log scale, the interaction coefficients indicated whether any differences between shift groups present on the 1st day increased (if significantly larger than 1), decreased (if significantly smaller than 1), or remained the same (if not significantly different from 1) during the follow-up period.

Based on the literature and logical consideration, assessment of confounding was done for age, level of education, age of the children living at home, job demands, job control, and overtime. Assessment of confounding was done for each recovery outcome separately according to four steps: (1) Determination of an association between the outcome and the background variable and/or its interaction with the days of the free period ($p < 0.05$). (2) When only a main effect was found, it was added to the crude model; the main and interaction terms were added to the crude model when either an interaction effect only or a main and interaction effect were found. (3) Confounding was defined by a change of 10% in the main effect estimates for shifts (night and/or swing shifts) when the main effect estimate for the possible confounder was added, and a change of 10% in the interaction terms for shifts when the interaction term(s) of the possible confounder was (were) added to the crude model. (4) In the adjusted model, all the confounders established in Step 3 were simultaneously added to the crude model. All analyses were done on the log-transformed data; after adjustment for confounding, the data were transformed back to the original 11-point scale.

2.6. Ethics

Approval for this study was granted by the Region West-Norway Ethics Committee for Medical and Health Research (University of Bergen, Bergen, Norway; numbers 2009/187-7). Signed informed consent was given by all participants prior to their inclusion in the study.

3. Results

The final study sample consisted of 61 participants: 20 individuals participated after an offshore tour of night shifts, 16 individuals participated after an offshore tour of swing shifts, and 25 individuals participated after an offshore tour of day shifts. Day shift schedules started between 06:00 and 08:00 and on average lasted 14.6 days [standard deviation (SD) = 2.6]. Night shift schedules started between 18:30 and 19:00 and on average lasted 14.3 days (SD = 2.2). The swing shift schedules were on average 14.6 days (SD = 2.3) and were worked from 19:00 to 07:00 the 1st week and from 07:00 to 19:00 the 2nd week.

The distributions of the background variables over the three shift groups are presented in Table 1 for demographic and health-related variables, and in Table 2 for work-related variables. Statistically significant differences between the shift groups were found for level of education ($p = 0.043$) and overtime during the offshore working period ($p = 0.030$).

3.1. Crude recovery models

Figs. 1 and 2 depict the nonadjusted development of the recovery outcomes over time for night shifts and day shifts, and swing shifts and day shifts, respectively. In the crude models (Table 3), the main effects for night workers were 1.24–2.44 times higher than day workers on the recovery outcomes, with all but energy for own activities reaching statistical significance ($p < 0.05$). Interaction effects for night shifts with days of the free period varied between 0.94 and 0.99, and were statistically significant for feeling rested [0.94, 95% confidence interval (95% CI) 0.91–0.97; $p < 0.001$] and physical tiredness (0.94, 95% CI 0.89–0.99; $p = 0.027$).

For swing shift workers the main effects were 0.90–1.73 for which only physical tiredness reached statistical significance (1.40, 95% CI 1.05–1.86; $p = 0.022$). The interaction effects of swing shifts with days of the free period varied between 0.96 and 1.04; none reached statistical significance.

3.2. Adjusted recovery models

Adjusted models are given in Table 4, where variables that were identified as confounders for each association between the individual recovery outcomes and shifts were added to the corresponding model. For the outcome “energy levels for activities of own interest” no confounders were identified, leaving the crude model as best estimate for the main and interaction effects of night shifts and swing shifts.

For night shift workers, the adjusted models showed 1.24–1.67 times higher main effects than for day workers, with only a

Table 1
Distribution of demographic and health-related background variables

	Day shift ($n = 25$)				Night shift ($n = 20$)				Swing shift ($n = 16$)				F (df)	p
	n	%	Mean	(SD)	n	%	Mean	(SD)	n	%	Mean	(SD)		
Age (y)			42.2	(8.6)			39.8	(6.2)			42.6	(6.9)	0.86 (2,58)	0.428
Marital status														
Single/divorced/widowed	3	12.0			0	0.0			1	6.3			2.62 (2)	0.271
Partner	22	88.0			20	100.0			15	93.7				
Children														
1 child age < 7 y	14	56.0			15	75.0			9	56.3			2.05 (2)	0.360
All children age ≥ 7 y	11	44.0			5	25.0			7	43.7				
Education														
Primary/secondary school	12	48.0			16	80.0			7	43.7			6.30 (2)	0.043
College/university degree	13	52.0			4	20.0			9	56.3				
General health														
Very good	6	24.0			8	40.0			3	18.7			0.02 (1)	0.902
Good	17	68.0			7	35.0			13	81.3				
Neither good nor poor	2	8.0			5	25.0			0	0.0				

SD, standard deviation.

statistically significant main effect for sleep quality (1.41, 95% CI 1.05–1.89; $p = 0.021$), indicating a significantly poorer sleep quality for night workers. The interaction terms for night shifts varied by 0.96–0.99; none reached statistical significance.

For swing shift workers, the main effect estimates varied between 0.90 and 1.73, with only sleep quality (1.42, 95% CI 1.03–1.94; $p = 0.031$) reaching statistical significance, indicating a poorer sleep quality for swing shift workers as compared to day workers. The interaction effects for swing shifts with days of the free period varied by 0.95–1.03; none were statistically significant.

4. Discussion

The aim of the study was to compare the course of self-reported recovery from work-related fatigue after working in 2-week 12-hour schedules that consisted of either night shifts or swing shifts (7 night shifts followed by 7 day shifts) to such schedules consisting of day work only. The results showed that compared to day workers, both night shift workers and swing shift workers scored poorer on sleep quality on the 1st day of the free period. The rate of recovery of sleep quality over the 14-day follow-up was similar for night and swing shift workers compared to day workers. This indicated that, compared to day workers, the poorer sleep quality for night and swing shift workers on the 1st day off remained throughout the follow-up period. For the remaining recovery dimensions, night and swing shift workers reported similar levels to day workers on the 1st day off as well as similar rates of recovery over the 14-day follow-up. This showed that compared to day workers, night and swing shift workers had similar courses of recovery for feeling rested, physical and mental tiredness, and for energy for own activities and activities related to the family and home.

Table 2
Distribution of work-related variables, as well as fatigue, need for recovery, and sleep problems during the offshore working period

	Day shift ($n = 25$)				Night shift ($n = 20$)				Swing shift ($n = 16$)				F (df)	p
	n	%	Mean	(SD)	n	%	Mean	(SD)	n	%	Mean	(SD)		
Job demands (1–5)			3.2	(0.5)			3.2	(0.4)			3.0	(0.5)	0.57 (2,58)	0.567
Job control (1–5)			3.0	(0.8)			2.7	(0.6)			2.7	(0.3)	1.52 (2,57)	0.229
Offshore experience (y)			13.0	(8.3)			11.8	(5.1)			13.0	(7.6)	0.19 (2,57)	0.826
Checklist individual strength (20–140)			64.6	(16.0)			73.0	(20.6)			63.1	(22.8)	1.41 (2,56)	0.253
Problems with falling asleep														
Never/sometimes	22	88.0			18	90.0			14	87.5			0.07 (2)	0.967
Often/every day	3	12.0			2	10.0			2	12.5				
Disturbed/restless sleep														
Never/sometimes	17	68.0			11	55.0			8	50.0			1.51 (2)	0.471
Often/every day	8	32.0			9	45.0			8	50.0				
Problems awakening														
Never/sometimes	22	88.0			18	90.0			14	87.5			0.07 (2)	0.967
Often/every day	3	12.0			2	10.0			2	12.5				
Thoughts of my job keep me awake														
Never/sometimes	24	96.0			19	95.0			15	93.7			0.12 (2)	0.948
Often/every day	1	4.0			1	5.0			1	6.3				
Need for recovery (0–100)														
< 55	17	70.8			14	70.0			14	87.5			1.82 (2)	0.402
≥ 55	7	29.2			6	30.0			2	12.5				
Overtime														
≤ 14 h	14	56.0			12	60.0			15	93.7			7.01 (2)	0.030
> 14 h	11	44.0			8	40.0			1	6.3				
Paid work in free period														
No	17	68.0			15	75.0			13	81.3			0.90 (2)	0.635
Yes, sometimes or always	8	32.0			5	25.0			3	18.7				

SD, standard deviation.

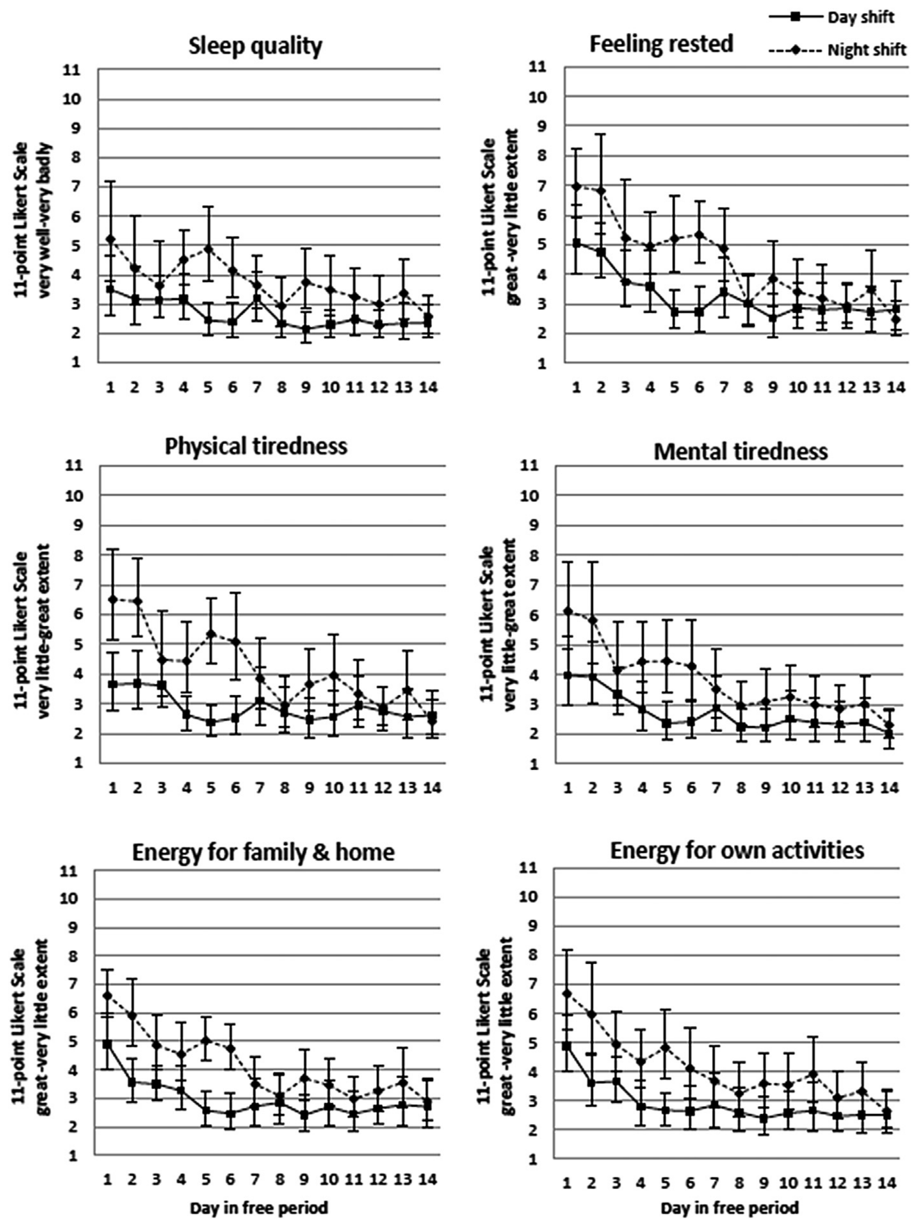

Fig. 1. The nonadjusted course of six recovery outcomes after day shifts and night shifts (geometric mean 95% confidence interval).

The results are consistent with findings of several other studies on offshore workers and other working populations, showing that recovery is needed directly following night work [13,18,38,39]. Additionally, previous studies among offshore workers have indicated that the readjustment of the cortisol rhythm after 2 weeks of night work may take as long as 11 days [19,40]. This finding is consistent with the reported sleep problems in the present study. However, in contrast to the present study's findings, Saksvik et al [21] did not find differences in sleep quality after returning home from an offshore petroleum platform for night or swing shift workers compared to day workers. This difference in findings may partly be explained by the fact that Saksvik et al [21] did not adjust for confounders in their study, while in the present study differences in sleep quality between swing shift and day workers were found only in the adjusted model.

The findings suggest that schedules that included night work (2 weeks of night shifts and swing shifts consisting of 7 night shifts followed by 7 day shifts), when compared to day work, particularly influenced sleep quality and did not affect the remaining recovery dimensions, i.e., feeling rested, tiredness, and energy levels. In the crude analyses, effects were present for night work on feeling rested, tiredness, and energy for family and home. However, after adjusting the analyses for work- and family-related factors these effects decreased and were no longer statistically significant. This indicates that work- and family-related factors partly explain the association between night work and recovery. Therefore, the effects of work- and family-related factors on recovery deserves further investigation in those working in nonstandard schedules, as was also suggested by Jansen et al [41].

Working at night seemed to have a long lasting effect on sleep quality, which was particularly clear in the swing shift group.

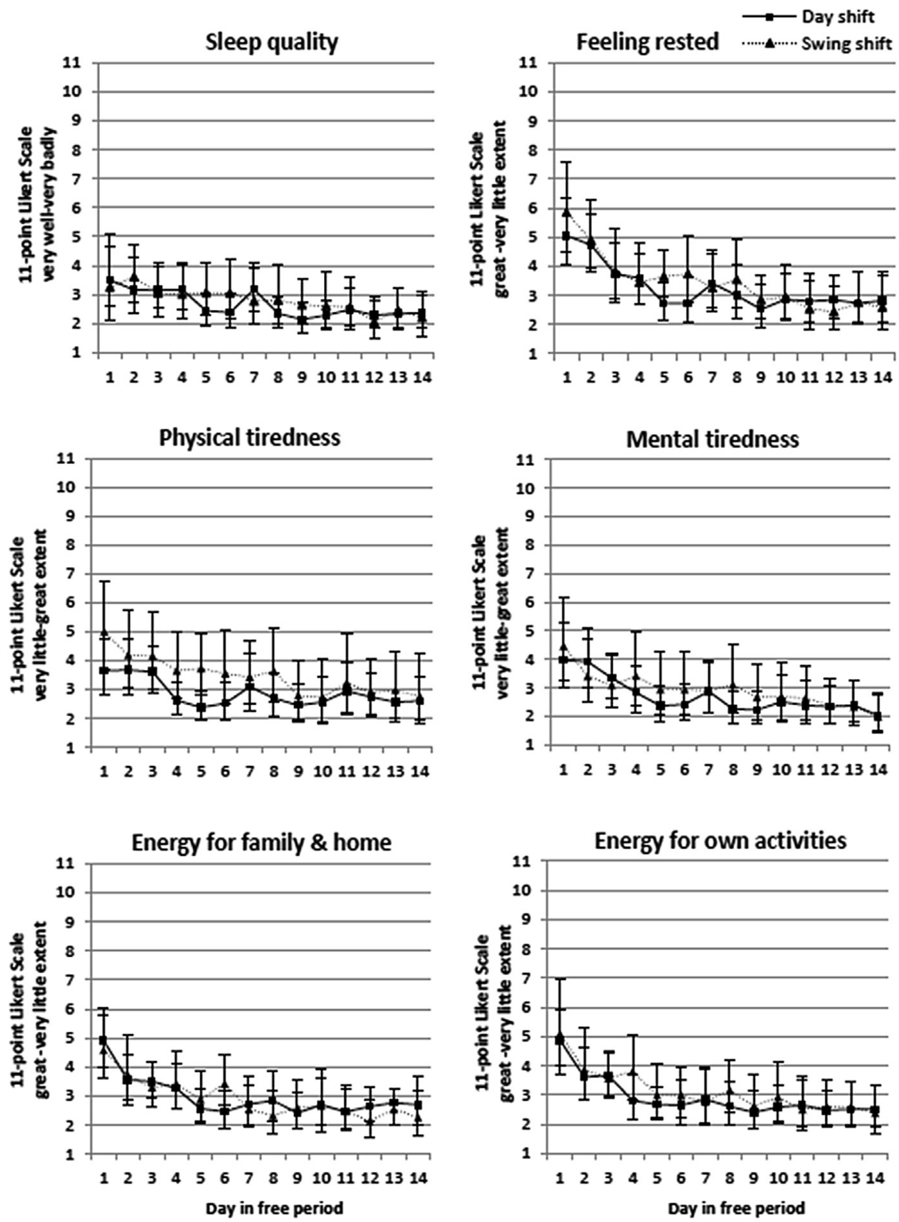

Fig. 2. The nonadjusted course of six recovery outcomes after day shifts and swing shifts (geometric mean 95% confidence interval).

Usually, swing shift workers prefer to rotate from night shifts to day shifts rather than rotating from day shifts to night shifts, because it gives them the opportunity to adjust their day/night rhythm before returning home [42]. However, the present study suggests that 1 week of day work after 1 week of night work is not long enough to improve sleep quality to the level of those who had worked only day shifts. This may be explained by previous research that found that swing shift workers slept shorter than day shift and night shift workers during the 2-week offshore period [21]. Even though the participants in the present study did not report any differences in sleep problems during the offshore working period (Table 2), sleep duration was not assessed and, therefore, this explanation could not be verified. The long lasting effect of night work on sleep quality is further seen in the similar rate of recovery for night and swing shift workers compared to day workers, i.e., night and swing shift workers continued to report poorer sleep quality throughout the 14-day follow-up.

4.1. Strengths and limitations

The main strength of the study was the long follow-up duration into the free period that extended previous study durations [18,19,21,25]. Additionally, the study assessed several dimensions of recovery from work-related fatigue following compressed and extended schedules, as opposed to previous research that focused solely on the dimension of sleep [18,20,21,25]. Factor analyses showed that all items were dimensions of recovery, as they all loaded onto one underlying construct (data not shown). Other strengths of the study are the strict inclusion criteria. The single sex sample (91% of the offshore population is male [43]) controlled for differences found between sexes regarding fatigue ratings [22,41].

This study also had some limitations. One was the study's small sample size, which may have reduced the statistical power to observe differences between the shift groups, which were nevertheless found for sleep quality. In addition, it can be stated that the

Table 3
The crude associations for night shifts ($n = 20$) and swing shifts ($n = 16$), with day shift as reference ($n = 25$), for the course of recovery during the first 14 days of a free period for six recovery items

	Sleep quality			Feeling rested			Physical tiredness			Mental tiredness			Energy for family and home			Energy for own activities		
	exp(β)	95% CI	*p*	exp(β)	95% CI	*p*	exp(β)	95% CI	*p*	exp(β)	95% CI	*p*	exp(β)	95% CI	*p*	exp(β)	95% CI	*p*
Shifts																		
Day shift	1.00	—		1.00	—		1.00	—		1.00	—		1.00	—		1.00	—	
Night shift	1.60	1.27–2.02	< 0.001	2.44	1.73–3.43	< 0.001	1.84	1.39–2.46	< 0.001	1.48	1.09–2.01	0.012	1.78	1.27–2.51	0.001	1.24	0.70–2.20	0.455
Swing shift	1.25	0.94–1.66	0.118	1.09	0.74–1.59	0.673	1.40	1.05–1.86	0.022	0.90	0.63–1.29	0.562	1.04	0.77–1.41	0.801	1.73	0.90–3.34	0.102
Days	0.96	0.93–0.99	0.009	0.97	0.95–0.996	0.023	1.03	0.99–1.07	0.136	0.96	0.93–0.98	<0.001	0.98	0.96–1.01	0.175	0.98	0.95–1.01	0.122
Shifts × days																		
Day shift × days	1.00	—		1.00	—		1.00	—		1.00	—		1.00	—		1.00	—	
Night shift × days	0.99	0.95–1.03	0.491	0.94	0.91– 0.97	<0.001	0.94	0.89–0.99	0.027	0.98	0.95–1.01	0.270	0.97	0.93–1.01	0.098	0.99	0.94–1.04	0.647
Swing shift × days	1.04	0.98–1.09	0.165	0.99	0.95– 1.02	0.467	0.96	0.91–1.02	0.163	0.99	0.96–1.02	0.584	0.99	0.95–1.02	0.419	0.96	0.92–1.01	0.119

CI, confidence interval.

Table 4
The adjusted associations for night shifts ($n = 20$) and swing shifts ($n = 16$), with day shift as reference ($n = 25$), for the course of recovery during the first 14 days of a free period for six recovery items

	Sleep quality*			Feeling rested†			Physical tiredness‡			Mental tiredness§			Energy for family and home‖			Energy for own activities¶		
	exp(β)	95% CI	*p*	exp(β)	95% CI	*p*	exp(β)	95% CI	*p*	exp(β)	95% CI	*p*	exp(β)	95% CI	*p*	exp(β)	95% CI	*p*
Shifts																		
Day	1.00	—		1.00	—		1.00	—		1.00	—		1.00	—		1.00	—	
Night	1.41	1.05–1.89	0.021‖	1.67	0.74–3.80	0.218	1.42	0.91–2.22	0.121	1.44	0.85–2.43	0.179	1.65	0.58–4.74	0.350	1.24	0.70–2.20	0.455
Swing shift	1.42	1.03–1.94	0.031	1.56	0.67–3.62	0.298	1.52	0.94–2.46	0.086	1.01	0.52–1.93	0.986	0.90	0.23–3.53	0.876	1.73	0.90–3.34	0.102
Days	0.91	0.85–0.98	0.008	1.06	0.93–1.20	0.373	1.22	1.01–1.48	0.044	1.18	1.03–1.35	0.021	0.94	0.84–1.04	0.225	0.98	0.95–1.01	0.122
Shifts × days																		
Day shift × days	1.00	—		1.00	—		1.00	—		1.00	—		1.00	—		1.00	—‖	
Night shift × days	0.99	0.96–1.03	0.766	0.98	0.93–1.02	0.278	0.98	0.92–1.04	0.494	0.96	0.92–1.01	0.125	0.97	0.94–1.01	0.149	0.99	0.94–1.04	0.647
Swing shift × days	1.03	0.98–1.09	0.217	0.98	0.94–1.02	0.350	0.95	0.89–1.01	0.089	0.96	0.92–1.01	0.086	0.99	0.95–1.03	0.615	0.96	0.92–1.01	0.119

CI, confidence interval.
* Adjusted for job control and job control × days, overtime and overtime × days, and age of the children living at home.
† Adjusted for level of education and level of education × days, job demands and job demands × days, job control, overtime, and age of the children living at home.
‡ Adjusted for level of education and level of education × days, job demands and job demands × days, and overtime and overtime × days.
§ Adjusted for job demands and job demands × days, and overtime and overtime × days.
‖ Adjusted for age, job demands and job demands × days, overtime and overtime × days, and age of the children living at home.
¶ Not adjusted, no confounders identified.

response rate was low, even though calculating the exact response rate was not possible, because it is unknown how many of those recruited for participation had children living at home. Low response rates are common in diary studies due to high participation burden, with response rates as low as 6% being reported [27]. A low response rate and the inclusion criterion of having at least one child younger than 18 years may have caused a selection effect and may limit the external validity of the study. However, similarities with the general offshore population in exposure during the offshore period to job demands, as well as similarities in job control and subjective health (data not shown) [44], indicated that limited external validity may not have been an issue. Generalization to other worker populations should be done with caution. The offshore population is a healthy working population, because, for safety reasons, they need to meet the requirements of a health certificate. An additional limitation is the lack of objective measures to anchor our self-reported findings. These could have included, for example, actigraphy for sleep and sleep quality [45], or salivary cortisol for physiological recovery [40]. A final limitation is that this study did not include a baseline measurement from which full recovery could be determined. Due to the short follow-up of previous research, it was not possible to identify an appropriate baseline. However, the present study's data suggest that all three schedules reached relative stability for all recovery outcomes during the second week off (Figs. 1, 2), suggesting that future research may consider a day beyond the first 2 weeks as a valid baseline. Preferably, a baseline value should be aggregated from assessment of multiple consecutive days.

4.2. Conclusion

After 2 weeks of 12-hour night shifts and swing shifts, only sleep quality was poorer on the 1st day off and remained poorer during the 14-day follow-up, compared to such schedules of day work. This showed that while working at night may have had no effect on feeling rested, tiredness, and energy levels, it had a relatively long-lasting effect on sleep quality.

This study contributes to the theoretical and practical understanding of the effects of working time arrangements on the recovery process, showing that 12-hour night work in extended weeks may have a long, negative effect on sleep quality. The study showed that night work offshore resulted in poorer sleep quality than day workers, even when followed by a week of day work before returning home. This persisted to be poorer for 2 weeks into the free period. Therefore, even though swing shifts rotating from night shifts to day shifts is the preferred shift rotation direction [42], this schedule still has an impact on sleep quality.

Conflicts of interest

The authors declare that they have no conflict of interest.

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