



## Original Article

# The impact of the shift system on health and quality of life of sleep technicians<sup>☆, ☆ ☆</sup>



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## ABSTRACT

**Background:** Sleep technicians are at high risk of shift work sleep disorders. We therefore aimed to identify the optimal shift system for sleep technicians.

**Methods:** We performed a nationwide survey of the work schedules, health and quality of life of sleep technicians using e-mail questionnaires including the Insomnia Severity Index (ISI), Epworth Sleep Scale (ESS), Functional Outcomes of Sleep Questionnaire-10 (FOSQ-10), Short Form-12 Health Survey (SF-12), and Hospital Anxiety and Depression Scale (HADS) in Korea. A multivariate general linear model was used to assess the effect of shift schedules on health and quality of life.

**Results:** Fifty-four technicians from 30 sleep laboratories participated. Their work schedules were classified as fixed night (F) (n = 18), slow rotation alternating from a night-only to a day-only schedule with a 3-months to one-year interval (S) (n = 20), rapid rotation within a week (R) (n = 5), night once a week (D+) (n = 5) and day (D) (n = 6). The adjusted ISI and HADS-anxiety scores were higher in F, S, and R than D and D+. Among night shift-dominant schedules, a less favorable profile was observed for R followed by F, and S regarding the ISI, FOSQ-10, mental SF-12 and HADS-depression. The physical SF-12 was lower in the order of R, S and F. The HADS-anxiety score was higher in the order of F, R and S.

**Conclusions:** The S system appears to have the least negative effect on health and quality of life among night shift-dominant systems. The development of consensus guidelines for scheduling shifts in sleep laboratories is urged.

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## 1. Introduction

Shift work disrupts the normal circadian rhythm, leading to not only sleep disturbances but also medical and psychosocial problems and safety issues [1]. However, night shift work is inevitable for sleep technicians who perform polysomnography, placing

themselves at risk for shift work sleep disorder (SWSD) to test others' sleep disorder. This ironic situation of sleep technicians needs special attention from sleep specialist who operate sleep laboratories.

There have been several suggestions regarding shift systems to protect shift workers from negative health consequences, such as

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forward rotation in the case of 8-h shifts, avoidance of permanent night shifts, a minimum 11 h of recovery time between shifts, work times not exceeding 12 h and no more than 3 consecutive nights of work [1–3]. However, individualized guidelines are needed according to the characteristics and intensity of the work. Until now, the shift work-related issues of sleep technicians have been rarely discussed, and no guidelines for their shift system exist. Although some reports have discussed many types of shift workers [4] including nurses [5] and emergency care paramedics [6], those results cannot be applied to sleep technicians in unique situation in which most of the work must be performed at night.

Thus, we aimed to survey the current shift schedules and assess their effects on the health and quality of life of sleep technicians to identify the optimal shift system for sleep laboratories.

## 2. Methods

### 2.1. Study design and participants

We performed a nationwide survey of the work schedules, health and quality of life of technicians working in sleep laboratories registered in the Korean Sleep Research Society (KSRS). The KSRS is a professional society for clinicians and researchers involved in sleep medicine in Korea. First, we contacted the sleep specialists who were the supervisors of the sleep laboratories and requested the outline of the shift systems and the contact information of the sleep technicians. The shift systems depending on institution were described in a previous report [7]. We sent emails with links to web-based questionnaires to the sleep technicians between 22 January 2017 and 30 March 2017 and received replies until January 2018. We obtained information about the details of the shift systems of 30 (66.7%) of the 45 laboratories; all 30 responding laboratories were run by university-affiliated hospitals. Fifty-four (91.5%) of the 59 technicians working at the participating sleep laboratories participated in the survey.

### 2.2. Questionnaire

The questionnaire included information about the demographics, family dependents, spousal support, salary, permanent or temporary job status, capacity of the sleep laboratory and hospital, health habits, medical history, shift system, actual shift schedule for the most recent month, work demands, job satisfaction, preference for specific shift schedules, sleepiness during work hours, sedative intake, health perception and quality of life.

The questionnaire collected information on the number of family dependents, who were defined as people taken care of by the participants, such as children and elderly individuals. The attitude of the spouses of the participants toward the shift schedule was classified as extremely unsupportive, fairly unsupportive, indifferent, fairly supportive, or extremely supportive. The health habits surveyed were exercise, smoking, alcohol consumption and caffeine intake. Monthly salary was categorized in five grades with intervals of 500 dollars. Medical histories of hypertension, diabetes, irritable bowel syndrome, gastric ulcers and others were assessed, including the time of the diagnosis.

Questions related to the shift system and associated variables were partly adopted from the Standard Shiftwork Index [8] and the Survey of Shiftworkers [9]. They were translated into Korean by two sleep specialists who are fluent in both Korean and English. The extent of control over the shift schedule of the technicians was categorized as complete, quite a lot, a fair amount, not very much, or none. The frequency of having to change their schedule with

short notice was classified as almost always, frequently, sometimes, rarely, or almost never. The preference for a daytime job was assessed with the following question: “All other things being equal, would you prefer to give up working shifts and have a daytime job without shifts?” The answers were yes, probably yes, maybe, probably not, or definitely not.

To assess health perception and quality of life, we used the Insomnia Severity Index (ISI), the Epworth Sleep Scale (ESS), the Functional Outcomes of Sleep Questionnaire-10 (FOSQ-10), the Short Form-12 Health Survey (SF-12), and the Hospital Anxiety and Depression Scale (HADS). The characteristics, meaning and cut-off values of the questionnaires are summarized in Table 1.

The ISI is a 7-item self-reporting questionnaire that measures the patient's perception of insomnia severity. The ISI queried participants about sleep problems in the past 2 weeks. The participants graded each question on a scale ranging from minimal (0 points) to very severe (4 points) [10]. A validated Korean version of the ISI was used to screen insomnia symptoms [11].

The ESS measures the impact of subjective daytime sleepiness and consists of eight items that assess the participant's likelihood of falling asleep in a particular situation that is commonly encountered in daily life. Each item is scored on a scale ranging from 0 (no napping) to 3 (high probability of napping) [12]. The validated Korean version of the ESS was used for this study [13].

The FOSQ-10 is a 10-item shortened version of the 30-item FOSQ designed to assess the impact of daytime sleepiness on activities of daily living [14]. We generated a Korean version of the FOSQ-10 with the questions extracted from the validated Korean version of the 30-item FOSQ [15].

In addition, we asked the participants to rate their sleepiness during work time as 0 (never doze), 1 (slight chance of dozing), 2 (moderate chance of dozing), or 3 (high chance of dozing) for each shift for the past month. The mean values for day shifts and night shifts were calculated for each subject.

The SF-12 is a short version of the 36-item SF health survey questionnaire (SF-36) that uses a subset of 12 items from the SF-36 to measure health-related quality of life. Each question is rated on a 5-point Likert scale, and the sum of the scores is calculated with a standardized scoring algorithm. Scores can be transformed into mental composite summary (MCS) and physical composite summary (PCS) scores. The PCS score had a median of 53.6 with an interquartile range (IQR) from 46.5 to 56.5, and the median MCS score was 52.9, with an IQR from 45.1 to 57.3 in the US general population aged 18 and older [16]. The PCS and MCS scores in the general Korean population were comparable with those in the general US population [17].

The HADS is a 14-item scale that generates ordinal data and is divided into 7 items related to anxiety (HADS-anxiety) and 7 items related to depression (HADS-depression). Each item on the questionnaire is scored from 0 to 3 [18,19]. The validated Korean version of the HADS was used for this study [20].

### 2.3. Categorization of the shift system

Sleep technicians were classified by shift systems into fixed night (F), slow rotation (S), rapid rotation (R), night once a week (D+) and day (D) groups. Those who had only night shifts were classified as the F group. Those rotating between the night-only schedule and day-only schedule with a cycle longer than one week were classified as the S group. If their weekly shift schedules included two or more night shifts and one or more day shifts, they were classified as the R group. Those who worked during the day but had night shift work once a week were classified as the D+

**Table 1**  
Questionnaires used to assess health perception and quality of life.

Questionnaire	Abbreviation	Number of items	Range of score	Meaning of higher score	Reference value
Insomnia Severity Index	ISI	7	0 to 28	More insomnia	15 or higher is considered as significant insomnia [10]
Epworth Sleepiness Scale	ESS	8	0 to 24	More sleepiness	11 or higher is considered as excessive daytime sleepiness [12]
Functional Outcomes of Sleep Questionnaire-10	FOSQ-10	10	5 to 20	Better functional status	17.8 ± 3.1 in normal controls [14]
Short Form-12 Health Survey	SF-12	12	0 to 100	Higher quality of life	50 is considered as average [16]
Mental composite summary	MCS		0 to 100	Better mental health status	50 is considered as average [16]
Physical composite summary	PCS		0 to 100	Better physical health status	50 is considered as average [16]
Hospital Anxiety and Depression Scale	HADS	14			
Anxiety score	HADS-anxiety	7	0 to 21	Higher level of anxiety	8 or higher is considered as probable case of anxiety disorder [19]
Depression score	HADS-depression	7	0 to 21	Higher level of depression	8 or higher is considered as probable case of depression [19]

group. Those who worked mostly during the day and worked at night on occasion (less than once a week) and absolute day workers were classified as the D group. Those with F, S and R systems were regarded as night shift workers, while the D+ and D groups were considered day workers based on the similar outcome profile in this survey. Their weekly schedules were described as series of day (D), night (N) and off (X).

#### 2.4. Statistics

Categorical data are given as numbers and percentages, and continuous variables are given as the mean ± standard deviation or median [IQR]. The clinical characteristics and outcomes were compared between five groups according to shift system. A comparison between the F and S groups was additionally performed because the majority of technicians had either the F or S schedule. For univariate analysis, the  $\chi^2$ -test or Fisher's test was used for the comparison of categorical variables. Student's *t* test was used for the comparison of continuous data between two groups, while one-way analysis of variance (ANOVA) or the Kruskal–Wallis test was performed when more than two groups were compared. For multivariate analysis, a general linear model ANOVA was used to investigate the differences in health perception and quality of life adjusted for confounders between shift systems. The variables that were different between groups and associated with health perception at the level of  $p < 0.1$  were selected as confounders. A value of  $p < 0.05$  was considered statistically significant. Statistical analyses were performed using SAS (version 9.4, SAS Institute Inc., Cary, NC, USA).

This study was approved by the Institutional Review Board of Kangwon National University Hospital (KNUH-2017-05-008-001).

### 3. Results

#### 3.1. Sociodemographic characteristics and health behaviors

There were 48 men and 6 women with a median age of 34.4 (range 23–51) years. They had worked in sleep laboratories for a median of 79.5 (range 6–265) months. Sociodemographic characteristics and health habits across the shift system are described in Table 2.

A total of 55% of the technicians worked exclusively for sleep laboratories, but the others also had duties in other

neurophysiology laboratories. The proportions of the technicians working exclusively for sleep laboratories differed among the groups ( $p = 0.002$ ). Overall, 72.2% had permanent positions, and the proportion was different across the groups ( $p = 0.033$ ). The S and D+ groups had a higher income than others ( $p = 0.008$ ). More of participants in the R and S groups had family dependents than the other groups ( $p = 0.011$ ). Only four sleep technicians in this study wore sunglasses when they went home after a night shift. The D+ group had more intake of coffee ( $p = 0.040$ ) and alcohol ( $p = 0.032$ ) than the others. The comparison between S and F revealed no additional factors with a significant difference.

#### 3.2. Details of the shift systems

Eighteen technicians were in the F group. Among them, 17 had an every other night except Sunday (NXNXNXX or XNXNXNX) schedule, and 1 had an every other night (NXNX) schedule regardless of weekday or weekend.

Twenty technicians were in the S group. These technicians had a shift schedule alternating from a night-only schedule to a day-only schedule that rotated every 3 months to 1 year. Ten had an every other night except Sunday (NXNXNXX or XNXNXNX) schedule, and the other 10 had an every other night (NXNX) schedule regardless of weekday or weekend during the period of the night-only schedule. They worked for other neurophysiologic laboratories during day-only schedule. Regarding the shift schedule at the time of the survey, only one technician was on day-only schedule which was rotated from two weeks before the survey and another technician was in the opposite situation. The other technicians were all on night-only schedule for at least one month before the time of the survey.

Five technicians in the R group had two or more night shifts mixed with day work in a week. Their weekly schedules were NNXDX (n = 1), DXNNXXX (n = 1), DDDNNXX (n = 1) and DNXNXXX (n = 2). Five technicians were in the D+ group. They had duties in other neurophysiologic laboratories during the daytime while working regularly for the sleep laboratory during the nighttime once a week on average. Six technicians were in the D group: two were in charge of polysomnography scoring during the daytime with or without extended work at evening once a week, and the others were basically day workers for other neurophysiology laboratories who partly worked for the sleep laboratories during

**Table 2**  
Sociodemographic characteristics and health behaviors according to shift system.

Variable	Mean $\pm$ SD, median [IQR] or number (%)				
	Day (D, n = 6)	Once a week (D+, n = 5)	Rapid rotating (R, n = 5)	Slow rotating (S, n = 20)	Fixed night (F, n = 18)
Age (year)	32.0 [25.0–37.0]	33.0 [33.0–39.0]	36.0 [30.0–37.0]	34.5 [32.5–36.5]	33.0 [30.0–34.0]
Sex: male	5 (83.3)	5 (100)	5 (100)	17 (85.0)	16 (88.9)
Body mass index (kg/m <sup>2</sup> )	22.5 $\pm$ 2.7	25.3 $\pm$ 2.2	22.9 $\pm$ 3.0	25.5 $\pm$ 2.8	25.0 $\pm$ 3.1
Marital status: married	3 (50.0)	3 (60.0)	4 (80.0)	17 (85.0)	13 (72.2)
Support of spouse: supportive	2 (66.7)	3 (100)	3 (75.0)	16 (94.1)	11 (84.6)
<b>Presence of family dependents</b>	3 (50.0)	2 (40.0)	<b>4 (80.0)</b>	<b>17 (85.0)</b>	9 (50.0)
Number of beds in hospital	1,500 [750–2,704]	1,000 [1,000–1,000]	700 [500–800]	1,100 [900–1,950]	1,000 [800–1,000]
Number of sleep technicians	2.0 [2.0–2.0]	2.0 [1.0–2.0]	2.0 [2.0–2.0]	2.0 [1.0–3.5]	2.0 [1.0–2.0]
<b>High income: upper one third</b>	2 (33.3)	3 (60.0)	1 (20)	10 (50)	2 (11.1)
<b>Permanent position*</b>	4 (66.7)	4 (80.0)	2 (40.0)	19 (95.0)	10 (55.6)
Working hours per week	45.7 $\pm$ 1.6	44.5 $\pm$ 6.6	43.1 $\pm$ 7.7	47.3 $\pm$ 5.2	45.5 $\pm$ 5.1
<b>Working days per week*</b>	5.0 $\pm$ 0.0	4.0 $\pm$ 0.7	3.4 $\pm$ 0.9	3.2 $\pm$ 0.3	3.0 $\pm$ 0.1
<b>Having control over shift schedule: fair to complete</b>	4 (66.7)	5 (100.0)	3 (60.0)	7 (35.0)	10 (62.5)
<b>Short notice for changing schedule: sometimes to always*</b>	2 (33.3)	1 (20.0)	4 (80.0)	1 (5.0)	5 (31.3)
<b>Working exclusively for sleep laboratory*</b>	2 (33.3)	0	3 (60.0)	9 (45.0)	16 (88.9)
Duration of working for sleep laboratory (months)	78.0 [18.0–136.0]	36.0 [36.0–180.0]	52.0 [49.0–113.0]	103.0 [52.0–129.0]	73.0 [43.0–104.0]
Use of sunglasses when returning home after night shift	0	0	0	1 (5.0)	3 (16.7)
Exercising more than once a week	4 (66.7)	3 (60.0)	4 (80.0)	12 (60.0)	11 (61.1)
Smoking	1 (16.7)	2 (40.0)	1 (20.0)	9 (52.9)	4 (23.5)
<b>Alcohol consumption per week (number of drinks)</b>	4.3 [0.0–20.0]	<b>21.0 [8.0–40.0]</b>	2.0 [0.0–8.6]	3.0 [1.1–5.0]	5.5 [3.8–10.0]
<b>Coffee intake per week (number of cups)</b>	7.5 [2.0–14.0]	<b>15.0 [14.0–42.0]</b>	3.0 [0.0–3.0]	13.0 [4.5–14.0]	6.5 [2.5–14.0]

Abbreviations: SD = standard deviation.

The variables that were significantly different depending on the shift system are indicated with an asterisk \* ( $p < 0.05$ ).

The variables that were significantly different after regrouping are presented in bold font ( $p < 0.05$ ).

The D group included those who were in charge of polysomnography scoring during the daytime and those who partly worked for the sleep laboratories during day time with occasional evening or night shift as needed (once or twice a month).

The D+ group had duties in other neurophysiologic laboratories during the daytime while working regularly for the sleep laboratory during the nighttime once a week on average.

The R group consisted of those whose weekly shift schedules included two or more night shifts and one or more day shifts.

The S group consisted of those rotating between the night-only schedule and the day-only schedule with a cycle longer than one week.

The F group consisted of those who had only night shifts.

day time with occasional extended work in the evening or night shift as needed (twice or less a month) (Table 2).

Only 3 technicians with the R schedule had consecutive night shifts (NNXX), and the others had one or more days off between the night shifts (NXNX). No technician had three or more consecutive night shift schedules.

### 3.3. Demand and control

The number of night shifts was four or fewer per week, with mean shift durations of 14.5 (range 9–19) hours. A total of 43 (89.6%) of the technicians had night shift work durations longer than 12 h. The recovery time between consecutive night shifts was shorter than 11 h (7.5 h) for 2 (3.7%) technicians with R schedule. The start time of the night shift ranged from 14:00 to 20:00, and the end of the shift ranged from 7:00 to 9:00. The number of working days per week was fewer in night shift (F, S and R) workers than in day (D and D+) workers ( $p < 0.001$ ). The weekly working hours was 45.8 (range 39–60) hours and similar across the groups.

Regarding the extent of control over the shift schedule, the answer was complete for 2 (3.7%), quite a lot for 9 (16.7%), a fair amount for 18 (33.3%), not very much for 14 (25.9%), and none for 9 (16.7%) technicians. The D+ group had more control, and the S

group had less control over their shift schedules than the others ( $p = 0.018$ ). Being asked to change their schedule at short notice was reported as almost always occurring by one (1.9%), frequently occurring by 3 (7.5%), sometimes occurring by 9 (16.7%), rarely occurring by 20 (30.7%) and almost never occurring by 19 (35.2%) technicians. Short notice for changing schedule was more frequent in the R group ( $p = 0.011$ ).

The comparison between S and F showed no additional significant differences except for the tendency of a higher frequency of short notices in the F group ( $p = 0.069$ ) (Table 2).

### 3.4. Preference and satisfaction

The sleep technicians thought that specialized work, high income and free time during the day were the advantages of working night shift, whereas fatigue, sense of isolation, and insomnia were disadvantages. Thirteen (24.1%) preferred (definitely or probably) night shift work, while 34 (63.0%) preferred (definitely or probably) switching to daytime jobs when other job conditions were equal.

A total of sixteen (29.6%) technicians wanted to change their shift schedule. Fourteen wanted to change the start/end time of the night shift, and most wanted to delay the start time of the night shift, which would result in shortening the night shift duration. Five

technicians in the F group preferred the R schedule. One technician who had the NXNX schedule preferred the NNXX schedule, and another technician who had the NNXX schedule preferred to have the NXNX schedule. The proportions of those who wanted to change their shift schedule were not different across the groups (Table 3).

Those with the R schedule mentioned that the advantage of the system was flexibility in time management, and the disadvantage was difficulty in circadian adjustment. In cases of the S or F schedule, the advantage was easy adaptation of the biologic rhythm, and the disadvantage was the perception of worsening health and feeling left out.

The comparison between S and F showed no significant difference with regard to preference for a daytime job or another shift schedule.

### 3.5. Health, quality of life and associated factors

In total, 14 (25.9%) the technicians had comorbid disease, including hypertension, diabetes, irritable bowel syndrome, esophagitis, metabolic syndrome, hepatitis B, thyroid cancer, and restless leg syndrome. No significant difference was found in the presence of comorbidity between groups. Among them, nine technicians were newly diagnosed with hypertension, diabetes, irritable bowel syndrome, and esophagitis while working in sleep laboratory. They were in the S and F groups.

Three technicians were taking sleeping pills. One with the S schedule took zolpidem three times per week. The other two, one each from the S and F groups, took melatonin once or twice per week.

The night shift workers (F, S and R) showed relatively unfavorable scores in all health and quality of life parameters except the ESS. Among night shift technicians, there was a trend of a less favorable outcome in the order of R, F and S in regard to the ISI, FOSQ-10, MCS of SF-12 and HADS-depression scores. The PCS of the SF-12 was lower in the order of R, S and F. The HADS-anxiety score was higher in the order of F, R and S.

**Table 3**  
Preference, health status and quality of life depending on shift system.

Variable	Mean ± SD or number (%)				
	Day (D, n = 6)	Once a week (D+, n = 5)	Rapid rotating (R, n = 5)	Slow rotating (S, n = 20)	Fixed night (F, n = 18)
Preferring daytime job	4 (66.7)	3 (60.0)	5 (100.0)	10 (50.0)	12 (66.7)
Preferring another shift schedule	3 (50.0)	0	1 (20.0)	6 (30.0)	6 (33.3)
Presence of comorbid disease	0	1 (20.0)	2 (40.0)	4 (20.0)	7 (38.9)
<b>Development of disease while working for a sleep laboratory</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>4 (20)</b>	<b>5 (29.4)</b>
ISI	10.3 ± 4.3	10.4 ± 6.7	15.0 ± 7.2	12.4 ± 5.4	13.7 ± 5.7
≥ 15	1 (16.7)	2 (40.0)	3 (60.0)	8 (40.0)	9 (50.0)
Sedative intake	0	0	0	2 (10.0)	1 (5.6)
ESS	6.3 ± 2.4	6.4 ± 2.9	7.6 ± 2.1	6.4 ± 4.1	5.1 ± 3.8
≥ 11	0	0	1 (20)	2 (10)	2 (11.1)
FOSQ-10	18.3 ± 1.6	18.7 ± 1.7	15.6 ± 3.1	17.2 ± 2.4	16.5 ± 2.8
<b>Sleepiness during night shift*</b>	<b>2.5 ± 0.7</b>	<b>0.6 ± 0.5</b>	<b>1.4 ± 0.7</b>	<b>1.0 ± 0.6</b>	<b>0.9 ± 0.5</b>
Sleepiness during day shift	0.7 ± 0.5	0.7 ± 0.6	1.0 ± 1.0	0.7 ± 0.6	NA
<b>PCS of SF-12</b>	<b>54.1 ± 2.9</b>	<b>53.8 ± 2.6</b>	<b>47.2 ± 5.2</b>	<b>49.8 ± 7.7</b>	<b>52.4 ± 5.7</b>
<b>MCS of SF-12</b>	<b>49.7 ± 9.1</b>	<b>50.6 ± 8.0</b>	<b>42.7 ± 8.6</b>	<b>52.4 ± 7.1</b>	<b>46.5 ± 9.6</b>
HADS-Anxiety	2.3 ± 1.5	3.8 ± 2.4	5.6 ± 4.4	4.0 ± 3.5	6.1 ± 5.4
≥ 8	0 (0)	0	1 (20)	3 (15)	5 (27.8)
<b>HADS-Depression</b>	<b>5.5 ± 2.9</b>	<b>6.2 ± 2.9</b>	<b>9.4 ± 3.8</b>	<b>4.9 ± 3.9</b>	<b>7.6 ± 4.9</b>
≥ 8	2 (33.3)	1 (20.0)	4 (80.0)	6 (30.0)	8 (44.4)

Abbreviations: SF-12 = Short Form-12 Health Survey; HADS = Hospital Anxiety and Depression Scale; SD = standard deviation; NA = not applicable.

The variables that were significantly different depending on the shift system are indicated with an asterisk \* (p < 0.05).

The variables that were significantly different when compared after re-grouping are presented in bold font (p < 0.05).

The D group included those who were in charge of polysomnography scoring during the daytime and those who partly worked for the sleep laboratories during daytime with occasional evening or night shift as needed (once or twice a month).

The D+ group had duties in other neurophysiologic laboratories during the daytime while working regularly for the sleep laboratory during the nighttime once a week on average.

The R group consisted of those whose weekly shift schedules included two or more night shifts and one or more day shifts.

The S group consisted of those rotating between the night-only schedule and the day-only schedule with a cycle longer than one week.

The F group consisted of those who had only night shifts.

The PCS of the SF-12 was lower in the R and S groups than in the others (p = 0.037). The MCS of the SF-12 was lower in the R and F groups than in the others (p = 0.013).

A high level of anxiety (HADS-anxiety score ≥ 8) was reported by 9 patients (16.7%), and they were all night shift workers (F, S and R). A high depression score (HADS-depression score ≥ 8) was reported by 21 patients (38.9%). The HADS-depression score was higher in the R and F groups than in the others (9.4 ± 3.8 versus 4.9 ± 3.9, p = 0.017).

The comparison between the S and F groups showed no additional significant differences with regard to health and quality of life (Table 3).

Other than the shift system, the following factors were associated with the participants' health perception and quality of life. The ISI was associated with sex (p = 0.075), presence of comorbid disease (p = 0.046), frequent short notice for changing schedule (p = 0.027), and amount of alcohol consumed (p = 0.037). No factor was found to be associated with ESS. The FOSQ-10 tended to be associated with the extent of control over the shift schedule (p = 0.060). No factor was found to be associated with PCS of the SF-12. The MCS of the SF-12 was associated with frequent short notice of schedule changes (p = 0.002) and number of working hours per week (p = 0.009). The HADS-anxiety was associated with short notice for changing schedule (p = 0.029), the presence of comorbid disease (p = 0.011), and amount of alcohol consumed (p = 0.055). The HADS-depression was associated with short notice for changing schedule (p = 0.005), the presence of comorbid disease (p = 0.008) and number of working hours per week (p = 0.042).

### 3.6. Multivariate analysis for health perception and quality of life

Overall, adjusting for confounders did not change the trend identified in the univariate analysis. The adjusted ISI of the night shift (F, S, and R) workers (mean 13.9, standard error 0.8) was higher than that of the day (D and D+) workers (mean 9.3, standard

error 1.7,  $p = 0.020$ ). The adjusted FOSQ-10 score was lower in the R and F groups (mean 15.9, standard error 0.5) than in the others (mean 17.7, standard error 0.4,  $p = 0.010$ ). The adjusted HADS-anxiety score of the night (F, S and R) shift workers (mean 5.3, standard error 0.61) was higher than that of the day (D and D+) workers (mean 2.4, standard error 1.2,  $p = 0.042$ ) (Table 4).

Between the S and F groups, only short notice was a significant confounder for ISI, MCS of SF-12, HADS-anxiety and HADS-depression. The comparison between two groups showed no significant difference in those parameters adjusted for short notice.

#### 4. Discussion

The current shift system varied depending on individual sleep laboratories. The night shift workers (F, S and R) had higher insomnia and anxiety scores than the day workers (D and D+). There was a trend of more negative outcome in sleep, functioning in activities of daily living, health-related quality of life and mood in the order of R, F, and S.

##### 4.1. Demand and control

Sleep technicians had longer work times per shift and fewer working days per week, maintaining weekly working hours that were comparable to those of general daytime workers in hospitals. Extended shifts up to 12 h with more days off were reported to result in no additional risk of sleepiness during work or insomnia [4] and improve work-life balance with a low risk of adverse health or organizational effects in shift workers [21]. However, the effect of extended work longer than 12 h has not yet been evaluated, and sufficient recovery time should be ensured in the case of consecutive extended work days.

Sleep technicians had relatively high degree of autonomy with regard to their work time. Less autonomy regarding their work schedule was associated with poor functional outcome. Offering individual control over work time is helpful because individual differences exist in chronotype and resilience to shiftwork [1]. Irrespective of the high degree of autonomy regarding their original

work time, those with the R schedule tended to be frequently asked to change their schedule on short notice, which was associated with low health-related quality of life, anxiety, depression and insomnia.

##### 4.2. Fixed night versus rotating shift work

Health perception and quality of life were not significantly worse in the fixed night versus rotation groups, particularly the rapid rotating group. However, the anxiety score and the frequency of newly diagnosed comorbidity tended to be higher in the fixed night group.

A debate exists about whether fixed or rotating shift schedules are better for shift workers [22]. Controlled intervention studies for this situation are scarce, and most controlled intervention studies have been conducted in workers with regular 3-shift systems [23].

Alertness during work and efficiency of work were better in those with fixed night shifts than in those with rotating shifts in previous studies [2]. The effect of the shift schedule on the length and quality of sleep varied depending on the study [23–25]. With regard to chronobiology, a fixed schedule would be better if light is well controlled [22,26]. However, circadian disruption is inevitable due to family and social commitments on days off, and only a small percent of permanent night workers had an endogenous melatonin rhythm that was completely adjusted to night work [27].

The psychosocial effects have rarely been measured in comparisons between fixed night and rotating shift workers.

The results of this study support the general recommendation to avoid a permanent night shift because of its potential negative psychosocial and health effects [2,3].

##### 4.3. Rapid rotation versus slow rotation

The slow rotating group had comparatively favorable health and quality of life profiles in this study.

Whether rapid or slow rotation is better for rotating shift schedules is controversial. A rapid rotation shift system is generally considered preferable to a slow rotation system because of more regular social contact and less disruption of the circadian rhythm

**Table 4**  
Adjusted health perception and quality of life depending on shift system.

Outcome	Adjusted mean ± SE				
	Day (D, n = 6)	Once a week (D+, n = 5)	Rapid rotation (R, n = 5)	Slow rotation (S, n = 20)	Fixed night (F, n = 18)
<b>ISI</b>	10.4 ± 2.2	7.7 ± 2.6	<b>15.1 ± 2.6</b>	<b>13.5 ± 1.3</b>	<b>14.1 ± 1.3</b>
ESS	6.3 ± 1.5	6.4 ± 1.6	7.6 ± 1.6	6.4 ± 0.8	5.1 ± 0.9
<b>FOSQ-10</b>	18.1 ± 1.0	18.0 ± 1.1	<b>15.5 ± 1.1</b>	17.5 ± 0.6	<b>16.1 ± 0.6</b>
<b>PCS of SF-12</b>	54.1 ± 2.9	53.8 ± 2.6	<b>47.2 ± 5.2</b>	<b>49.8 ± 7.7</b>	52.4 ± 5.7
MCS of SF-12	50.0 ± 3.5	50.5 ± 3.8	44.5 ± 4.2	51.7 ± 2.0	47.0 ± 2.1
<b>HADS-Anxiety</b>	2.5 ± 1.6	2.3 ± 1.9	<b>5.0 ± 1.9</b>	<b>4.8 ± 0.9</b>	<b>5.9 ± 1.0</b>
HADS-Depression	5.9 ± 1.6	6.4 ± 1.7	8.0 ± 1.9	5.4 ± 0.9	7.3 ± 1.0

Abbreviations: SD = standard error.

The variables that were significantly different when compared after regrouping are presented in bold font ( $p < 0.05$ ).

The Insomnia Severity Index was adjusted for the presence of comorbid disease, the amount of alcohol consumed, and short notice for changing schedule.

The Epworth Sleepiness Scale was not adjusted.

The Functional Outcomes of Sleep Questionnaire-10 was adjusted for the extent of control over the shift schedule.

The physical composite summary of the SF-12 was not adjusted.

The mental composite summary of the SF-12 was adjusted for short notice for changing schedule.

The HADS-anxiety was adjusted for the presence of comorbid disease, the amount of alcohol consumed and short notice for changing schedule.

The HADS-depression was adjusted for the presence of comorbid disease and short notice for changing schedule.

The D group included those who were in charge of polysomnography scoring during the daytime and those who partly worked for the sleep laboratories during day time with occasional evening or night shift as needed (once or twice a month).

The D+ group had duties in other neurophysiologic laboratories during the daytime while working regularly for the sleep laboratory during the nighttime once a week on average.

The R group consisted of those whose weekly shift schedules included two or more night shifts and one or more day shifts.

The S group consisted of those rotating between the night-only schedule and day-only schedule with a cycle longer than one week.

The F group consisted of those who had only night shifts.

[2]. However, slow rotation that allows adaptation of the internal body clock is also preferred [22].

The results of this study support that slow rotation allowing adaptation is more preferable to rapid rotation trying to maintain the circadian rhythm.

#### 4.4. Implications for practice

Sleep laboratories need highly specialized personnel, and a fixed night shift schedule is generally preferred. However, rotating shift schedules to reduce the number of nights for each sleep technician is recommended to protect from the negative health and social consequences of night shifts. Based on the results of this study, slow rotating system is the most recommendable in terms of the health and quality of life of sleep technicians. A slow rotation system is generally not feasible within sleep laboratories because most of the work needs to be performed during the night. A slow rotating system is possible by sharing duties with daytime work of other electrophysiology laboratories or taking turns for daytime work of sleep laboratory in the case of large-sized sleep laboratories.

A small number of sleep technicians who used sunglasses when they went home after a night shift in this study gives rise the need for education to reduce SWSD.

#### 4.5. Strengths and limitations

This is the first study to evaluate the effects of various shift systems in sleep laboratories, emphasizing the importance of scheduling shifts for sleep technicians. Health and quality of life were assessed using a structured questionnaire and individual and job-related factors were controlled.

This study has several limitations. This was a cross-sectional study, and we could not measure the changes in health and quality of life after exposure to a specific shift system for a certain length of time. We could not compare the differences between the NNXX and the NXNX schedules because only three technicians had the NNXX schedule, which is the common shift schedule in US sleep laboratories [28]. The number of participants in the R group was too small to generalize, and the worse profile in health and quality of life may have resulted from the short recovery time between consecutive night shifts rather than from the rapid rotation itself. Another limitation is the significant differences in job status between groups. Those with the S schedule tended to have worked longer for sleep laboratories and to currently receive higher salaries in permanent position. This suggests that the S group could be adapted to working the night shift for longer time and be treated relatively better by their employer, although the duration of working in the sleep laboratory, level of income and position were not found to be significantly associated with the health and quality of life measures. In other aspects, majority of the technicians in the S group were on a night-only schedule for at least one month before this survey, which could have attenuated the difference from the F group in the health perception and quality of life parameters.

The age of most sleep technicians was approximately 30 years in this study because the history of most sleep laboratories is shorter than 20 years in Korea. The effect of shift schedule can be different in other age group because age influences tolerance to shift work [29], with decrease of resilience to shift work as they age [30].

## 5. Conclusion

Health and quality of life concerns were prevalent among night shift sleep technicians. The results of this study suggest that slow rotation with day work schedule is relatively preferable to rapid

rotation or fixed night working. Allowing autonomy with regard to work schedules, avoiding changes in work schedules on short notice and ensuring sufficient recovery time are also important.

Overall, we urge the development of consensus guidelines for shift schedules for sleep technicians to minimize negative effects on health and quality of life. To develop reliable and detailed guidelines for optimal shift systems, more studies including controlled interventions incorporating various shift systems are required.

## Abbreviations

ANOVA	one-way analysis of variance
D	day
D+	night once a week
ESS	Epworth Sleepiness Scale
F	fixed night shift
FOSQ-10	Functional Outcomes of Sleep Questionnaire-10
GLM	general linear model
HADS	Hospital Anxiety and Depression Scale
IQR	interquartile range
ISI	Insomnia Severity Index
MCS	mental composite summary
PCS	physical composite summary
R	rapid rotation night shift
S	slow rotation night shift
SF-12	Short Form-12 Health Survey
SWSD	shift work sleep disorder

## CRediT authorship contribution statement

**Seo-Young Lee:** Conceptualization, Investigation, Writing - original draft. **Pamela Song:** Investigation, Writing - review & editing. **Su Jung Choi:** Methodology, Writing - review & editing. **Sooyeon Suh:** Methodology, Writing - review & editing. **Sung Ok Kwon:** Formal analysis. **Eun Yeon Joo:** Supervision, Investigation, Writing - review & editing.

## Conflict of interest

The authors have no conflicts of interest.

The ICMJE Uniform Disclosure Form for Potential Conflicts of Interest associated with this article can be viewed by clicking on the following link: <https://doi.org/10.1016/j.sleep.2020.09.026>.

## References

- [1] Kecklund G, Axelsson J. Health consequences of shift work and insufficient sleep. *BMJ* Nov. 2016;i5210. <https://doi.org/10.1136/bmj.i5210>.
- [2] Knauth P. Designing better shift systems. *Appl Ergon* Feb. 1996;27(1):39–44. [https://doi.org/10.1016/0003-6870\(95\)00044-5](https://doi.org/10.1016/0003-6870(95)00044-5).
- [3] Managing shift work: Health and safety guidance - HSG256." <https://www.hse.gov.uk/pubns/books/hsg256.htm> (accessed Dec. 27, 2019).
- [4] Driscoll TR, Grunstein RR, Rogers NL. A systematic review of the neuro-behavioural and physiological effects of shiftwork systems. *Sleep Med Rev Jun.* 2007;11(3):179–94. <https://doi.org/10.1016/j.smrv.2006.11.001>.
- [5] Choi SJ, Joo EY. Light exposure and sleep-wake pattern in rapidly rotating shift nurses. *J. Sleep Med.* Jun. 2016;13(1):8–14. <https://doi.org/10.13078/jsm.16002>.
- [6] Sofianopoulos S, Williams B, Archer F. Paramedics and the effects of shift work on sleep: a literature review. *Emerg Med J Feb.* 2012;29(2):152–5. <https://doi.org/10.1136/emj.2010.094342>.
- [7] Lee S-Y, Choi SJ, Suh S, et al. And shift work disorder study group. "A nationwide survey of shift schedules for sleep technicians in Korea. *J Sleep Med.* Jun. 2018;15(1):15–9. <https://doi.org/10.13078/jsm.18007>.
- [8] Barton J, Spelten E, Totterdell P, et al. The Standard Shiftwork Index: a battery of questionnaires for assessing shiftwork-related problems. *Work Stress Jan.* 1995;9(1):4–30. <https://doi.org/10.1080/02678379508251582>.
- [9] Tucker P, Smith L, Macdonald I, et al. The impact of early and late shift changeovers on sleep, health, and well-being in 8- and 12-hour shift systems.

- J Occup Health Psychol Jul. 1998;3(3):265–75. <https://doi.org/10.1037//1076-8998.3.3.265>.
- [10] Bastien CH, Vallières A, Morin CM. Validation of the Insomnia Severity Index as an outcome measure for insomnia research. *Sleep Med Jul.* 2001;2(4):297–307. [https://doi.org/10.1016/S1389-9457\(00\)00065-4](https://doi.org/10.1016/S1389-9457(00)00065-4).
- [11] Cho YW, Song ML, Morinc CM. Validation of a Korean version of the insomnia severity Index. *J Clin Neurol* 2014;10(3):210. <https://doi.org/10.3988/jcn.2014.10.3.210>.
- [12] Johns MW. A new method for measuring daytime sleepiness: the Epworth sleepiness scale. *Sleep Nov.* 1991;14(6):540–5. <https://doi.org/10.1093/sleep/14.6.540>.
- [13] Cho YW, Lee JH, Son HK, et al. The reliability and validity of the Korean version of the Epworth sleepiness scale. *Sleep Breath Sep.* 2011;15(3):377–84. <https://doi.org/10.1007/s11325-010-0343-6>.
- [14] Chasens ER, Ratcliffe SJ, Weaver TE. Development of the FOSQ-10: a short version of the functional outcomes of sleep questionnaire 2009;32(7):5.
- [15] Han NE, Kim DY, Lee S-A. Validity of Korean version of functional outcomes of sleep questionnaire in patients with simple snoring and obstructive sleep apnea. *Sleep Med. Res. Jun.* 2014;5(1):5–14. <https://doi.org/10.17241/smr.2014.5.1.5>.
- [16] Ware JE, SF-12. *How to score the SF-12 physical and mental health summary scales.* Health Institute, New England Medical Center; 1998.
- [17] Kim S-H, Jo M-W, Ahn J, et al. Assessment of psychometric properties of the Korean SF-12 v2 in the general population. *BMC Publ Health Dec.* 2014;14(1):1086. <https://doi.org/10.1186/1471-2458-14-1086>.
- [18] Zigmund AS, Snaith RP. The hospital anxiety and depression scale. *Acta Psychiatr Scand* 1983;67(6):361–70. <https://doi.org/10.1111/j.1600-0447.1983.tb09716.x>.
- [19] Bjelland I, Dahl AA, Haug TT, et al. The validity of the Hospital Anxiety and Depression Scale: an updated literature review. *J Psychosom Res Feb.* 2002;52(2):69–77. [https://doi.org/10.1016/S0022-3999\(01\)00296-3](https://doi.org/10.1016/S0022-3999(01)00296-3).
- [20] Oh SM, Min KJ, Park DB. A study on the standardization of the hospital anxiety and depression scale for Koreans: a comparison of normal, depressed and anxious groups. *J Korean Neuropsychiatr. Assoc. Mar.* 1999;38(2):289–96.
- [21] Bamba C, Whitehead M, Sowden A, et al. “A hard day’s night?” the effects of Compressed Working Week interventions on the health and work-life balance of shift workers: a systematic review. *J Epidemiol Community Health Sep.* 2008;62(9):764–77. <https://doi.org/10.1136/jech.2007.067249>.
- [22] Eastman C. How to reduce circadian misalignment in rotating shift workers. *ChronoPhysiol Ther Jul.* 2016;6:41–6. <https://doi.org/10.2147/CPT.S111424>.
- [23] Sallinen M, Kecklund G. Shift work, sleep, and sleepiness - differences between shift schedules and systems. *Scand J Work Environ Health Mar.* 2010;36(2):121–33. <https://doi.org/10.5271/sjweh.2900>.
- [24] Pilcher JJ, Lambert BJ, Huffcutt AI. Differential effects of permanent and rotating shifts on self-report sleep length: a meta-analytic review. *Sleep Mar.* 2000;23(2):155–63.
- [25] Karhula K, Hakola T, Koskinen A, et al. Permanent night workers' sleep and psychosocial factors in hospital work. A comparison to day and shift work. *Chronobiol Int* 2018;35(6):785–94. <https://doi.org/10.1080/07420528.2018.1466792>.
- [26] Wilkinson RT. How fast should the night shift rotate? *Ergonomics Dec.* 1992;35(12):1425–46. <https://doi.org/10.1080/00140139208967412>.
- [27] Folkard S. Do permanent night workers show circadian adjustment? A review based on the endogenous melatonin rhythm. *Chronobiol Int Apr.* 2008;25(2):215–24. <https://doi.org/10.1080/07420520802106835>.
- [28] Bixby J. Awake, alert, and ready to work: strategies for sleep technicians to manage shift work. *RT Decis. Mak. Respir. Care Jun.* 2008;21(6):24–7.
- [29] Costa G. Factors influencing health of workers and tolerance to shift work. *Theor Issues Ergon Sci Jul.* 2003;4(3–4):263–88. <https://doi.org/10.1080/14639220210158880>.
- [30] Oginska H, Pokorski J, Oginiski A. Gender, ageing, and shiftwork intolerance. *Ergonomics Jan.* 1993;36(1–3):161–8. <https://doi.org/10.1080/00140139308967868>.