Effects of a Modified Ambulance Night Shift System on Fatigue and Physiological Function among Ambulance Paramedics

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Abstract: Effects of a Modified Ambulance Night Shift System on Fatigue and Physiological Function among Ambulance Paramedics: Hidemaro Takeyama, et al. Faculty of Human Wellness, Department of Registered Dietitians, Tokaigakuen University—Objectives: In the present study, we modified a night shift system for an ambulance service so that ambulance paramedics were assured of taking a nap, and examined the effects of this new system on the fatigue and physiological function of ambulance paramedics. Methods: Ten ambulance paramedics at a fire station in the center of a large city in Japan voluntarily enrolled as subjects in this field study. They worked a 24-h shift system. There were two teams of 5 ambulance paramedics in the fire station. Three ambulance paramedics per shift usually provided the emergency services. In the traditional system, the ambulance paramedics had to deal with all emergency calls throughout a 24-h shift (T-shift). In the modified system, 2 ambulance paramedics were allotted time for naps in the 21:00–3:00 (C-shift) or 3:00–8:30 (B-shift) shift by the addition of another a firefighter (D-shift). Results: There were fewer emergency dispatches and nap time was longer in the B- and C-shifts than in the T-shift. Parasympathetic nerve activities during naps in B- and C-shifts were higher than in the T-shift. The results of critical flicker fusion frequency and 3-choice reaction time in the B-shift at 7:30 tended to be higher and shorter than that in T-shift. Conclusions: The results of this study suggest that the modified night shift which ensured time for ambulance paramedics to take long, restful power naps alleviated subjective fatigue, and improved physiological function which are often adversely affected by night workload.

Key words: Ambulance paramedics, Fatigue and physiological function, Nap, Night shifts

The nature of ambulance paramedic work is characterized by its heavy physical burden and inherent social responsibility, making it a highly stressful occupation due to the various emergency rescue services required in unexpected situations. Previous studies have indicated physical and psychological disturbances among ambulance paramedics1–8). Specifically, it has been reported that exposure to stressful situations such as a victim’s injury and/or death, and to unpredictable and dangerous situations causes mental disturbances among ambulance paramedics6–8). Another occupational characteristic of ambulance paramedic work is the 24-h shift. Ambulance services generally respond to more emergency calls than fire services. Due to the progress of our “24-h society” in recent years, the number of night emergency calls for ambulance service has been gradually increasing in Japan9). Under such a shift system, we presumed that ambulance paramedics have insufficient time to take naps, sufficiently, a situation which would adversely affect on their psycho-physiological function. Our previous study suggested that fatigue and stress among ambulance paramedics are higher than among firefighters because of their more frequent emergency calls during night work10). Therefore, we thought that an improvement of the night work system so as to reduce
the number of responses to emergency service calls among ambulance paramedics would be very important. To reduce fatigue during the night shift, we modified a dispatch system for ambulance services during the night so that ambulance paramedics could be assured of adequate nap time at four fire stations, and examined the effects of the new system on the fatigue of the ambulance paramedics. Especially, we carried out an intensive intervention study at one fire station. In the present study, we examined the effects of the new system on fatigue and physiological function among ambulance paramedics using the data obtained at one fire station.

**Subjects and Methods**

Ten ambulance paramedics at a fire station in the center of a large city in Japan voluntarily enrolled as the subjects in this field study conducted over 42 days in February and March 2001. They worked under a 24-h shift system. There were two teams consisting of 5 ambulance paramedics in the fire station. Three ambulance paramedics per shift usually provided emergency services. All team members worked 24 h every second day, and took turns taking 15 days off every 8 wk. Their ages ranged from 29–51 yr (average 36.1 yr). All subjects were healthy and none were taking continuous medication. This study was approved by the Ethical Committee of Tokaigakuen University. The subjects were given a detailed description of the study, and their informed consent was obtained.

Figure 1 shows the 24-h work schedule with the traditional and modified systems for dealing with ambulance calls. Day work (8:45 to 21:30) for the firefighters and ambulance paramedics included deskwork, maintenance of vehicles and equipment, training for emergency service, and actual emergency service calls. During night work (21:30 to 7:30), all fire station members including firefighters were divided into 5 groups for night work. The 5 groups took turns working consecutive 2-h shifts: 22:00–0:00, 23:45–1:45, 1:30–3:30, 3:15–5:15, and 5:00–7:00 for dealing with emergency calls from the operation center. Ambulance paramedics were assigned to the 22:00–0:00 block every shift. They took a nap in a private room during the night work period except during their 2-h shifts and when called out on an emergency. Under the traditional system, ambulance paramedics had to deal with all emergency calls throughout a 24-h shift (T-shift). Under the modified system, 2 ambulance paramedics were assured time to take a nap during each shift at either 21:30–3:00 (C-shift) or 3:00–8:45 (B-shift) by the addition of another firefighter (D-shift). The firefighters who were assigned to the D-shift worked the usual firefighting services during day work. The firefighter in D-shift had to deal with fire calls as well as ambulance calls during night work. The leader of the ambulance paramedics was assigned to the A-shift as in the traditional shift. Other subjects were randomly assigned to the B- or C-shift. One or the other of the 2 teams was engaged in the
modified system during the initial and latter halves of the investigation. The three meals when on duty were at 11:30 am, 16:30 pm, and 7:30 am.

Subjects were requested to fill out a questionnaire concerning their subjective complaints of fatigue, work content, and time of naps. They were also asked to undergo a critical flicker fusion frequency (CFF) test, 3-choice reaction time (3CRT) test, and the measurement of oral temperature before and after work of the night work period. These measurements were also conducted after the emergency service calls. Heart rate (HR) and its variability (HRV) were measured using portable ECG recorders for the 8 subjects during 24-h shifts under both systems. In this study, only data from the T-, B- and C-shifts were used because there was no change in the A-shift from the traditional system, and the subjects in the D-shift were only firefighters.

Measurement
To examine subjective complaints of fatigue, a questionnaire based on one developed by the Industrial Fatigue Research Committee of the Japan Society for Occupational Health11) was used. The original questionnaire consists of 30 questions regarding subjective feelings of fatigue. The Committee is planning to revise the questionnaire, and has prepared a trial revision. In this study, we used the trial version in which each subject is asked to answer each question with a 5-grade rating from "absolutely no" to "absolutely yes". The trial version consists of 36 questions from the old questionnaire and 6 new questions regarding mental stress, visual and musculoskeletal complaints. The revised questionnaire classifies 5 factors, feelings of drowsiness, instability, uneasiness, local pain or dullness, and eyestrain by factor analysis. A critical flicker fusion frequency was successively measured five times in descending order using a Roken Digital Flicker (Model IRDF-1, Shibata Co., Ltd., Tokyo, Japan) and the average value was calculated. Oral temperature was measured with a clinical thermometer (Terumo Co., Ltd., Tokyo, Japan). To measure 3CRT, we developed a computer program that detects the time between the expression of one to three numbers presented randomly on a PC display and the pressing of the corresponding number key with a finger of the dominant hand. Three-choice reaction time was evaluated using the average of 10 trials. Heart rate and HRV were recorded continuously with a Holter-type ECG recorder (Active Tracer AC301, GMS Inc., Tokyo, Japan) except when subjects were bathing. The data were then transferred to a computer and a frequency analysis of R-R intervals was performed using the Memcalc System12) (Suwa Trust Co., Ltd., Tokyo, Japan). High frequency power (HF: 0.15–0.4 Hz) was calculated. High frequency was used as an indicator of parasympathetic levels.

Data analysis
The 5-grade rating score of the questions on the fatigue were converted into 1 to 5 points for each question. The average rates of the complaints regarding the 5 factors (feelings of drowsiness, instability, uneasiness, local pain or dullness, and eyestrain) were calculated. Comparisons of the number of emergency calls and dispatches, and the length of nap among the 3 shifts were performed by one-way ANOVA. The means of HF and the ratio of LF and HF (LF/HF) were analyzed every 5 min. The levels of HF and LF/HF during the total nap period showed relative changes in relation to the overall mean. The results of the subjective complaints of fatigue, CFF, 3CRT, and oral temperature over the night shift were subtracted from the values at 21:30. Statistical comparison was performed among the 3 shifts at 7:30 (after the night shift period) and at 8:30 (before ending the 24-h shift) by one-way ANOVA. Post-hoc analysis was done according to Scheffe’s method. Statistical analyses were performed using SPSS version 10.0.

Results
The mean number of emergency calls and dispatches during daytime and nighttime showed no significant differences among the 3 shifts. However, the number of emergency dispatches in the B- and C-shifts tended to be fewer than in the T-shift (Table 1). Total lengths of naps showed significant differences among the three shifts (F(2,38)=5.301, p=0.009). Total lengths of nap taken by the C-shift during the night work were significantly longer
than those taken by the T-shift (Fig. 2). The mean HF during naps in the B- and C-shifts were higher than that in the T-shift (F (2,19)=4.981, p=0.018) (Fig. 3). A significant difference in the mean HF values was observed between the T and B-shifts. The data of oral temperatures, 3-CRT and subjective complaints of fatigue were expressed as relative changes in relation to the values at 21:30. The oral temperatures in the T-shifts after the night shift were significantly lower than in the B- and C-shift (F (2,21)=5.119, p=0.015) (Fig. 4). An elevated oral temperature in the T-shift was observed before the end of the 24-h shift (8:30), but the level tended to be low compared with the B- and C-shifts. The CFF value among the 3 shifts declined slightly after the night shift (7:30). The CFF value in the B-shift before the end of the 24-h shift (8:30) tended to be higher compared with the T- and

![Fig. 2. Total length of naps taken by the three shift systems. Bar indicates mean nap length; vertical line indicates SD. *p<0.05.](image)

![Fig. 3. Heart rates and their variability during night-naps among the three shift systems. HF; high frequency power (0.15–0.4 Hz), LF; low frequency power (0.04–0.15 Hz). HF and LF/HF data show relative changes in relation to overall mean; bar indicates mean value; vertical line indicates SD.](image)

![Fig. 4. Changes in oral temperature, CFF and 3CRT during the night among the three shift systems. Values were shown as relative changes in relation to values at 21:30. *p<0.05 difference between B- and C-shifts. Means ± SD.](image)
Discussion

Our previous study indicated that the workload among the ambulance paramedics was higher than that among firefighters due to the large number of emergency service calls at night\(^{(11)}\). In this study, there were fewer emergency action calls and the naps were longer in the two shifts under the modified system than under the traditional system. Therefore, the modified system apparently provided ambulance paramedics with more opportunity to take naps at night compared with the traditional system. We could not estimate the quality of naps utilizing electroencephalographic data because of methodological limitations in the field. However, parasympathetic nerve activities during naps in the B- and C-shifts were higher than in the T-shift. This result suggests the possibility that the naps in the two shifts under the modified system were superior to the naps under the traditional system because the modified system ensured time for workers to take longer and less interrupted naps. Shoji \textit{et al.}\(^{(13)}\) suggested that psychological stress due to uncertainty about waking times might reduce sleep quality. Ambulance paramedics must be ready at all times for emergency calls. Therefore, the establishment of the B- and C-shifts in which they could rely on adequate nap time had a positive effect on the quality of the naps.

The fire station where we carried out the study is completely equipped with private rooms for sleeping. However, in many fire stations in the same city, ambulance paramedics have to take their naps in dormitories along with other team members. Our previous questionnaire study (data not published) with regard to stress and fatigue among firefighters and ambulance paramedics revealed a great demand for individual rooms. If private rooms are not provided, sleep is easily disturbed when other members wake up for emergency service calls. Therefore, it is important to consider not only the night work shift system, but also facilities for taking restful naps.

The oral temperatures of the B- and C-shifts workers at 7:30 were significantly higher than those of workers on the T-shift. The results of CFF and 3CRT in the B-shift at 7:30 tended to be higher and shorter than in the T-shift. Subjective complaints of fatigue at 7:30 in tended to be fewer in the B- and C-shifts. Drowsiness and feelings of local pain and dullness at 7:30 in the T-shift tended to be higher than in the B- and C-shifts. In this study there was no significant difference between the B- and C-shifts. These results suggest that the modified system would reduce complaints of subjective fatigue, as well as the adverse effects on physiological function from being dispatched during the night shift. In the traditional night shift system, ambulance paramedics were always assigned to the shift from 22:00 to 0:00. If there were no emergency calls at night, personnel usually started taking a nap around 2:00 am. In addition, previous studies have suggested that taking a nap in the latter half of the night is better for performance and/or subjective fatigue than a nap in the initial half of the night\(^{(14, 15)}\). Therefore, we hypothesized that the B-shift was better for the subjects than the C-shift. However, no significant difference in our data between the B- and C-shifts was observed, although the small sample size might be one of the reasons.

The results of this study suggest that the new modified night shift system ensures ambulance paramedics have...
the time to take long and restful naps, while reducing the number of complaints of subjective fatigue and the physiological functions adversely affected by night workload.

References