Short Communication

Autonomic Nervous Activity Changes Due to Shift-Work: An Evaluation by Spectral Components of Heart Rate Variability

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Shift work may be opposed to the worker's endogenous biologic rhythms and disruptive to the circadian system, resulting in internal desynchronization¹. Numerous field and laboratory studies have demonstrated the problems with health implications² such as digestive problems, chest pains, wheezing, nervousness, colds and fatigue, all related to autonomic nerve function. These health problems related to the work schedule are common reasons for workers to give up shift work³.

In this study, to clarify the autonomic nervous activity changes due to shift-work, we planned to monitor the 24-h blood pressure (BP) and RR intervals (RRI). BP and pulse rate (PR) are useful as an indicators of autonomic nerve activity. Moreover spectral analysis of RRI is also reported to reflect the cardiac parasympathetic nervous activity especially under static conditions^{4, 5}.

Methods

Subjects: We studied 7 male subjects (mean age 31.5 ± 8.3) with no history of any medical disorder (including obesity) who work weekly shifts on a rotating basis at a steel pipe cutting factory. The weekly (Mon to Fri) shift work schedule was as follows: daywork, (8:30 to 16:55) and nightwork, (22:35 to 8:40). In this investigation period, 3 subjects were scheduled to work on the pattern of a daywork-week following a nightwork-week and 4 subjects were scheduled to the reverse pattern. All subjects gave informed consent to this study.

Procedure: Before the beginning of daywork (at 8:00 am) or after nightwork (9:00 am) on the 4th day (Thu) of both shifts, an ambulatory BP-multisensor monitoring recorder TM-2425 (A&D Co. Tokyo) was attached by medical doctors. Following this, subjects were instructed to make brief diary entries. After 24 h they removed the recorder by themselves.

Processing of data: BP was measured and recorded every 30 min by an oscilometric method. RRI data for 512 beats were measured as one segment, and each segment was recorded every 30 min. The RRI power spectrum was computed with an analyz-

ing processor TM-2025 (A&D Co. Tokyo). Briefly, power spectral analysis was applied to the RR sequences with an autoregressive model. The area under each peak was measured as a spectral component power by the Fourier transform method⁶. The magnitude of each spectral component was shown as the square root of the calculated power (expressed in milliseconds: ms)^{5, 7}. The low frequency power spectrum (LF; 0.05-0.15 Hz) band reflects changes in RRI caused by sympathetic and parasympathetic activity, especially baroreflex activity, and high frequency (HF; 0.15-0.40 Hz) power is shown to reflect parasympathetic modulation related to respiration⁸. Moreover the HF component is reported to relate to sudden death⁹, type A personality¹⁰ and relaxation¹¹. These findings suggest that HF component may reflect systemic parasympathetic nervous activity. In this study we adopted HF power as an index of parasympathetic nervous function.

Data are the mean $\pm$ s. e. m. The significance of differences was tested with repeated ANOVA (analysis of variance), with $p < 0.05$ taken as significant.

Results

The average sleep duration of night workers was 5.75 ± 0.6 h, and that of day workers was 6.75 ± 0.6 h. There were significant differences ($p < 0.01$) between the two groups. But subjective sleep disturbance was not investigated in this study.

Table 1-a shows the average BP and PR in working and sleeping periods in two types of work shift. Average sBP, dBP and PR during the working period was significantly higher than those during the sleeping period in both shifts. There was no difference between day-shift (day S) and night-shift (night S) during both working and sleeping periods. Table 1-b shows the average HF and LF/HF power indicating the significant differences in HF power between the night S and day S during the sleeping period. Fig. 1 shows the typical continuous representation of the HF and LF/HF power components

Table 1-a. Mean systolic blood pressure, diastolic blood pressure and pulse rate during each period (working or sleeping) in each work shift

		sBP (mmHg)	dBP (mmHg)	PR (b/min)
WORK (n=7)	night S	131.53 $\pm$ 6.88	80.48 $\pm$ 3.36	82.46 $\pm$ 2.54
	day S	121.06 $\pm$ 3.87	77.80 $\pm$ 3.06	89.81 $\pm$ 4.38
SLEEP (n=7)	night S	105.76 $\pm$ 4.00	61.08 $\pm$ 3.75	62.65 $\pm$ 4.67
	day S	111.31 $\pm$ 4.38	64.83 $\pm$ 3.97	59.09 $\pm$ 4.21

S: shift, sBP: systolic blood pressure, dBP: diastolic blood pressure, PR: pulse rate.

Table 1-b. Mean HF and LF/HF components of spectral analysis of 'RR interval variability during each period (working or sleeping) in each work shift

		HF (ms)	LF/HF (ms/ms)
WORK (n=7)	night S	19.69 $\pm$ 7.44	2.89 $\pm$ 1.09
	day S	16.73 $\pm$ 6.32	3.34 $\pm$ 1.26
SLEEP (n=7)	night S	36.73 $\pm$ 13.88*	1.80 $\pm$ 0.68
	day S	44.63 $\pm$ 16.87	1.67 $\pm$ 0.63

S: shift, (*; $p < 0.1$), HF: High Frequency Component, LF: Low Frequency Component, ms: milliseconds.

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Fig. 1. A typical pattern (subject-A) of 24 h continuous representation of the power of the HF components and LF/HF ratio for RRI. Top and Bottom panels show the time course for 'Night work shift' and 'Day work shift' respectively. The left Y axis: HF power. The right Y axis: LF/HF ratio. ms: milliseconds.

of RRI for 24 h. As also shown in Table 1-b, HF power during the sleeping period in the night S, that is parasympathetic function during "daytime-sleep after night work", is significantly lower.

Discussions

HF power during "day sleep" after night work was significantly lower comparing with "night sleep." This indicates that cardiac parasympathetic function during "day sleep" is not efficient enough. Furthermore, it is possible to speculate that there may simultaneously exist a state of systemic parasympathetic nervous dysfunction.

While there was no significant difference between the day and night shifts in the LF/HF ratio. Several reports adopt the LF/HF ratio as an indicator of sympathetic nervous function. But the validity of the LF/HF ratio as an indicator has not yet been established. Average sBP during the sleep period in the night S was lower than that in the day S (not significant). And the average PR during the sleep period in the night S was higher than that in the day S (not significant). These results for BP and PR were not compatible with those for HF power. Because of the small number of observations in this study, no firm conclusion can be drawn concerning the findings.

Several methodological issues should also be discussed. Grossman *et al.*¹²⁾ have made a compelling

case for experimental or statistical correction of measures of respiratory sinus arrhythmia based on respiratory parameters. In our field study we were unable to make the type of correction of estimates of HF power recommended by Grossman, but it should be pointed out that uncorrected HF power behaves as would be expected of vagal modification of RRIs. Our HF data may therefore reflect parasympathetic modulation of RRIs.

Many studies on sleep disturbances in shift workers have been reported. Akerstedt¹³⁾ pointed out that overall the sleep duration of night workers averages only 4 to 6 h, compared to that of day and afternoon workers which averages 7 to 9 h. And shift work has been reported to affect not only sleep length but sleep quality¹⁴⁾.

As mentioned before, in this study we did not ask about subjective sleep disturbance nor sleep quality. But taken together with the reports on sleep quality in shift work, it is possible to speculate that parasympathetic nervous dysfunction, causing HF power reduction, during "day sleep" is related to sleep quality as well as sleep length. Furthermore, "sleep disturbance" and "autonomic nerve dysfunction" may interact to produce deleterious effects on the general psychological and physical well-being of shift workers.

Conclusion

The RRI-spectral analysis method showed parasympathetic nervous dysfunction during day sleep after night work. And the length of the day sleep after night work was shortened compared with night sleep after day work. Those two findings may interact and produce several complaints related to autonomic nervous dysfunction.

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