Lower energy intake at breakfast may be correlated to phase delay in heart rate variability indices observed in rotating shift workers.

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【Background】

- Workers on rotating shifts, such as those with day and night shifts, have altered biological rhythms and are thus at higher risk of developing type 2 diabetes and cardiovascular disease compared to those with regular day shifts.
- The autonomic nervous system has a circadian rhythm, which is assessed by spectral analysis of heart rate variability (HRV).
- Skipping breakfast results in lower levels of sympathetic nervous activity during the morning. To our knowledge, there has been few studies which explored the relationship between breakfast and biological rhythms in workers with rotating shifts.

【Objective】

The aim of this study was to explore the relationship between breakfast and autonomic nervous system activity in rotating shift workers.

【Methods】

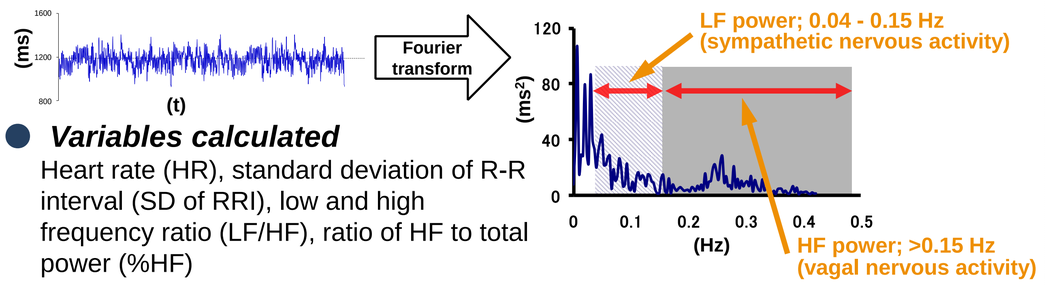
- ***Participants***

Participants were female nurses and caregivers (n=7) working in rotating shifts at a healthcare facility for the elderly in Japan.

- ***Definition of rotating shift workers***

Rotating shift workers were defined as those engaging in both day (08:30 - 17:30 hr) and night shifts (17:30 - 08:30 hr).

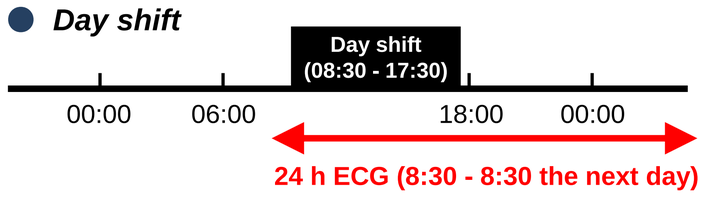
- ***Spectral analysis of variation of R-R intervals in QRS complex (HRV)***



- ***Variables calculated***

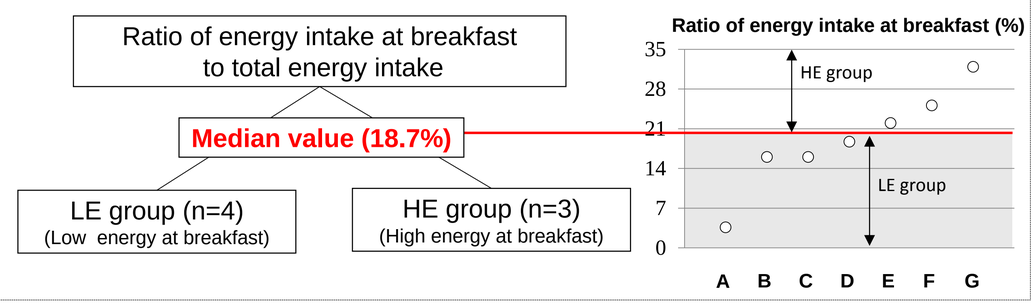
Heart rate (HR), standard deviation of R-R interval (SD of RRI), low and high frequency ratio (LF/HF), ratio of HF to total power (%HF)

- ***Day shift***



- ***Measurements***
  - General characteristics
  - Dietary records
  - 24 hour electrocardiogram (ECG)
  - Electronic physical activity monitor

- ***Grouping***



*All study procedures were reviewed and approved by the Institutional Review Board of the National Institute of Occupational Safety and Health, Japan.

【Results】

- General characteristics were not significantly different between groups **(Table 1).**
- Dietary behavior and sleep-wake cycles were not significantly different between groups except at breakfast E% **(Table 2)**.
- Step count and HRV variables averaged for 24 h were not significantly different between groups **(Table 2)**.
- Although both groups had diurnal rhythms of the autonomic system, the phase of HR, LF/HF, and %HF in a 24-h period were significantly different between groups **(Figure 1; Table 3)**.

Table 1. General characteristics

		LE (n=4)	HE (n=3)	P value
Age*	(yr)	42.3±5.4	42.0±10.6	1.000
Working experience†	(yr)	5.6±1.9	6.3±2.7	0.858
Height*	(cm)	160.2±3.2	155.3±1.3	0.271
Weight†	(kg)	58.3±7.4	55.7±0.3	1.000
Body Mass Index†	(kg/m²)	22.5±2.0	23.1±0.3	0.289

Values are expressed as mean ± standard error.
*Non-paired t test; †Mann-Whitney-U test.

Table 2. Dietary behavior, sleep-wake cycle, step counts, and HRV variables

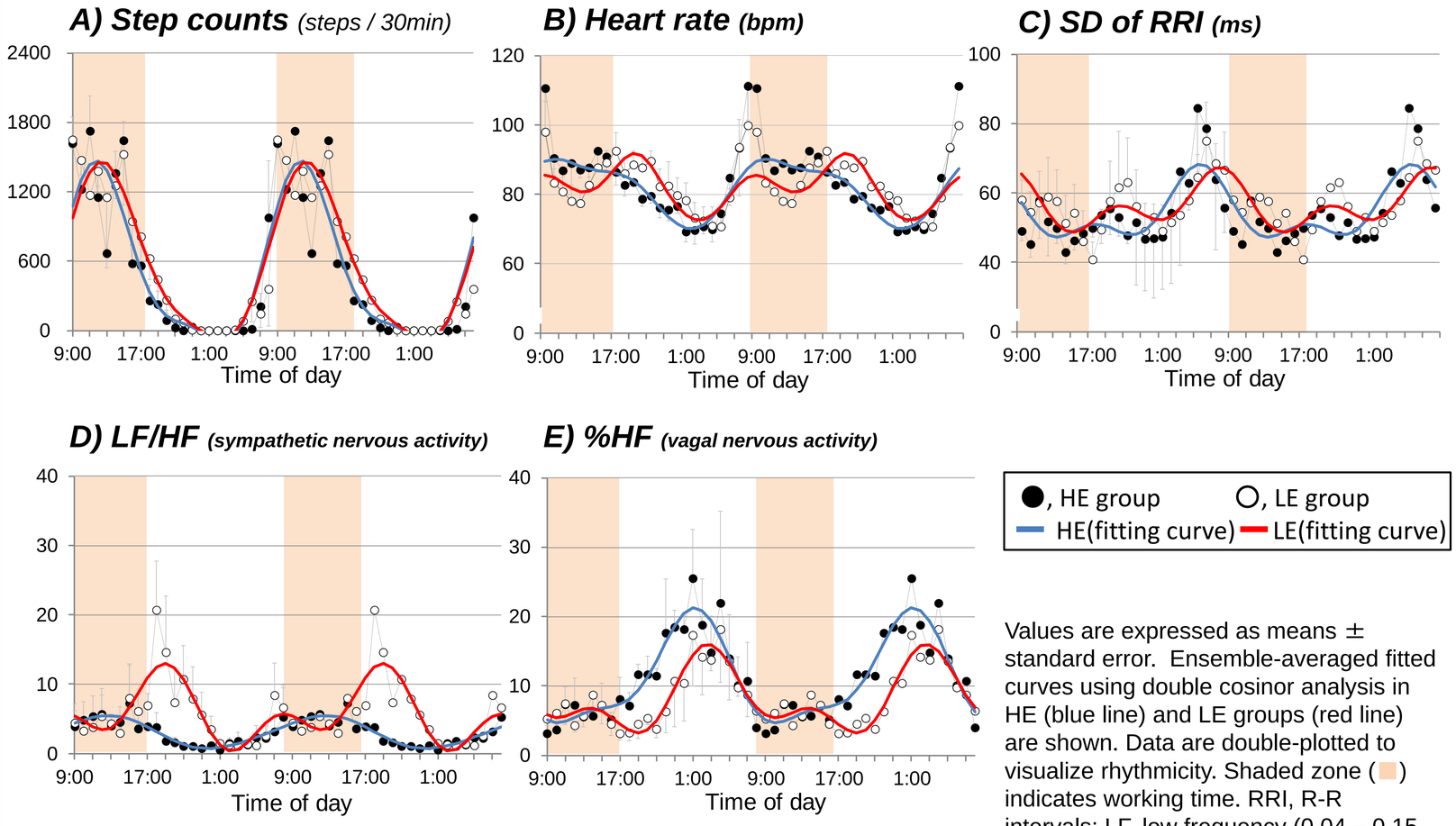
		LE (n=4)	HE (n=3)	P value
Total energy intake*	(kcal)	2007 ± 77	1748±138	0.157
Breakfast*#	(kcal)	273 ± 72	452±18	0.092
Lunch†#	(kcal)	548 ± 38	552±26	0.928
Dinner*#	(kcal)	1073 ± 159	601±113	0.075
Snacking*	(kcal)	113 ± 109	142±107	0.861
Mealtimes				
Breakfast time*	(hr)	7.1 ± 0.2	7.1±0.2	0.858
Lunch time*	(hr)	12.9 ± 0.2	12.9±0.3	0.856
Dinner time*	(hr)	19.9 ± 0.5	19.8±0.6	0.858
Sleep-wake cycle				
Bed time*	(hr)	24.5 ± 0.8	23.6±0.8	0.355
Wake-up time*	(hr)	7.0 ± 1.0	7.3±0.4	0.643
Sleeping hours†	(hr)	6.5 ± 1.3	7.7±0.4	0.643
Step counts	(steps/day)	13828 ± 1669	12405±839	0.724
05:00~10:00*	(steps)	2012 ± 101	3144±537	0.165
11:00~15:00*	(steps)	4963 ± 409	4913±470	0.939
17:00~22:00*	(steps)	2249 ± 641	1173±313	0.238
24 h average				
HR†	(bpm)	81.7 ± 3.3	80.9±1.3	0.480
SD of RRI*	(ms)	55.9 ± 7.6	54.8±6.5	1.000
LF power†	(ms²)	133 ± 43	148±38	0.724
HF power*	(ms²)	118 ± 58	177±82	0.289
LF/HF†		5.58 ± 2.78	2.68±1.65	0.480
%HF*	(%)	8.10 ± 2.53	12.10±2.55	0.289

Values are expressed as mean ± standard error. *Non-paired t test; †Mann-Whitney-U test. # Breakfast, lunch, and dinner time were defined as 05:00 - 10:00, 11:00 - 15:00, and 17:00 - 22:00, respectively. HR, Heart rate; SD of RRI, standard deviation of R-R interval; LF, low frequency (0.04 - 0.15 Hz); HF, high frequency (>0.15 Hz); LF/HF, ratio of LF to HF; %HF, ratio of HF to total power.

Table 3. Phase and amplitude in a 24-h period

			LE (n=4)	HE (n=3)	P value
Step counts	Acrophase§	(hr)	13.0±0.3	12.5±0.5	0.157
	Amplitude*	(steps/30 min)	377±40	375±41	1.000
HR	Acrophase§*	(hr)	17.3±1.9	13.1±0.7	**0.034**
	Amplitude*		6.3±1.1	12.0±3.8	0.289
SD of RRI	Acrophase§*	(hr)	7.8±1.5	7.6±3.0	0.948
	Amplitude*	(%)	7.1±1.0	16.0±3.8	**0.047**
LF/HF	Acrophase§*	(hr)	18.7±1.1	14.4±0.5	**0.034**
	Amplitude†		4.30±2.61	2.37±1.50	0.724
%HF	Acrophase§*	(hr)	6.0±1.4	1.6±1.0	**0.034**
	Amplitude†	(%)	5.44±2.15	8.28±2.38	0.157

Values are expressed as mean ± standard error. *Non-paired t test; †Mann-Whitney-U test. § Acrophase (rad) was converted to phase shift (h) from midnight. LF, Low frequency (0.04 - 0.15 Hz); HF, high frequency (>0.15 Hz); LF/HF, ratio of LF to HF; %HF, ratio of HF to total power.



Values are expressed as means ± standard error. Ensemble-averaged fitted curves using double cosinor analysis in HE (blue line) and LE groups (red line) are shown. Data are double-plotted to visualize rhythmicity. Shaded zone ( ) indicates working time. RRI, R-R intervals; LF, low frequency (0.04 – 0.15 Hz); HF, high frequency (> 0.15 Hz); LF/HF, ratio of LF to HF; %HF, ratio of HF to total power.

Figure 1 (A-E). Ensemble-averaged 10 min step counts and heart rate variability variables in HE (filled circles, n=3) and LE groups (open circles, n=4)

【Discussion】

- In our study, diurnal variation of HRV was observed (Fig 1), which indicated an increased LF/HF at day time and decreased LF/HF at night time. Although sleep-wake cycle and physical activity were the exogenous factors influencing the diurnal variation of HRV, no significant difference was found between the groups (Table 2), suggesting that there might be other factors related to the phase of HRV variation.
- Animal studies supported the possibility that dietary behavior may be a time cue for entrainment of circadian rhythms. Accordingly, in our human study, the ratio of energy intake at breakfast might have been the factor contributing to the phase delay.

【Conclusion】

Lower energy intake at breakfast might result in phase delay for the cardiac autonomic system in rotating shift workers.

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