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Dietary intake and dinner timing among shift workers in Japan

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Abstract: Objectives: Shift workers are at an increased risk of diet-related chronic conditions. We aimed to investigate dietary intake and dinner timing among shift workers. **Methods:** A questionnaire survey was administered to the employees of 43 companies in Japan between December 2013 and February 2014. The dietary intake of workers was assessed through a validated food frequency questionnaire (FFQ). Nutrient intake was evaluated by adjusting the total energy intake using a nutrient residual model. Analysis of covariance was used to obtain the means of total energy and nutrient intake by the work schedule (shift or daytime), and the means of total energy and nutrient intake by dinner timing (regular or irregular). **Results:** Valid responses were obtained from 2,062 daytime and 302 shift workers. A valid response rate to the FFQ was slightly but significantly lower among shift workers than among daytime workers (87.1% and 91.8 %). When compared to daytime workers, shift workers were more likely to eat dinner at irregular times (46.7% vs. 3.6%). Shift work was associated with a higher mean body mass index (23.4 kg/m^2 vs. 22.3 kg/m^2), a higher proportion of being overweight (27.7% and 18.8%), higher total energy intake, and lower intakes of dietary fiber, vitamin B_2, folic acid, vitamin C, potassium, calcium, magnesium and iron. Moreover, irregular dinner timing was associated with lower intakes of protein, folic acid, and zinc in daytime workers, and lower intakes of carbohydrate and copper in shift workers. **Conclusions:** These findings indicate a need to improve the diet of shift workers.

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Key words: Body mass index, Dietary habit, Nutrient intake, Shift work, Total energy intake

Introduction

Shift work is associated with an increased risk of chronic conditions such as obesity, metabolic syndrome, type 2 diabetes, and cardiovascular disease[1,2)]. Shift and daytime workers have been shown to differ in meal frequency, meal timing, and food choices[1,3-7)]. Skipping meals and irregular meal timing can disturb the circadian rhythm and lower diet quality[1)]. A previous study of Japanese male workers indicated that energy intake from dinner was the highest among three meals[8)]. Therefore, it seems to be important to investigate meal skipping and meal timing, especially with regards to dinner.

Several studies have investigated the diet quality of shift workers[3,4,9-11)]. A longitudinal study showed that shift work was an independent risk factor for weight gain in Japanese male workers[12)]; however, a meta-analysis of cross-sectional studies failed to show conclusive results regarding total energy intake in shift workers[3)]. Furthermore, few studies have provided results on nutrient intakes in shift workers[9,10)].

Investigating dietary intake and dietary habits can help establish educational interventions to improve diets and prevent diet-related chronic conditions among shift work-

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Supplementary materials (Appendices) are available in the online version of this article.

ers. Therefore, we conducted a cross-sectional study to investigate dietary intake and dinner timing among shift workers in Japan.

Subjects and Methods

Study design and participants

This cross-sectional survey was conducted between December 2013 and February 2014 in Shizuoka, Japan. An invitation to join the survey was mailed to all manufacturing companies (n = 400) with 21-300 employees located in western Shizuoka, using a commercially available database[13]. The first 43 companies to respond to the invitation were chosen to reach the planned number of study participants (n = 3,000).

An invitation and questionnaires [one general questionnaire and one food frequency questionnaire (FFQ)] for each employee were mailed to the company and distributed to the employees by the management department of each company. Employees who were willing to join the survey completed the anonymous questionnaires and submitted them in sealed envelopes to the managers of their companies. The sealed envelopes were mailed to the research team at the Hamamatsu University School of Medicine. As rewards for joining the survey, gift certificates were given to each participant ("*Quocard*", equivalent to 500 yen), and each company received an automatic sphygmomanometer for health management use.

We included only subjects aged 18-79 years, and excluded those with a total energy intake <500 kcal/day or > 4,000 kcal/day, as estimated by the FFQ, and based on the energy intake in Japanese adults[14]; those with alcohol intake >10 *go*/day (unit of Japanese *Sake*; approximately 277 g of alcohol); or those with missing data regarding their work schedule.

Informed consent was obtained via submission of the completed questionnaires. The study protocol was approved by the Ethics Committee of the Hamamatsu University School of Medicine (no. 25-203).

Measures

The general questionnaire included a question on the employee's work schedule, with the response options, "fixed daytime work", "shift work with night shifts", and "shift work without night shifts". The responses were categorized into two groups, "daytime work" and "shift work", as too few workers reported working night shifts. Dinner timing on workdays was investigated with the question, "What is the approximate time you eat dinner (the largest meal if you eat dinner twice) on a workday?" Response options included, "before 8:00 p.m.", "between 8 and 9 p.m.", "between 9 and 10 p.m.", "after 10:00 p.m.", and "irregular timing". As a previous study defined having meals at the same time every day as a "regular" dietary habit,[15] we grouped all response options indicating a fixed dinner time into "regular dinner timing". The subjects' body mass indices (BMI, kg/m^2) were calculated from their self-reported body weight (kg) divided by the height squared (m^2). A BMI of 25 kg/m^2 or higher was defined as overweight, and BMI of lower than 18.5 kg/m^2 was defined as underweight. Those with missing data regarding dinner timing or BMI were excluded from each analysis.

Dietary assessment

We used a FFQ that was developed and validated for estimating the habitual dietary intake of Japanese adults[16]. Briefly, food items and the portion size of each food item are determined based on dietary records obtained from the National Nutrition Survey (now the National Health and Nutrition Survey)[14] for randomly selected population-based subjects in Shizuoka. The FFQ includes 86 food items and asks about the usual consumption rates and portion sizes during the previous month. The consumption frequencies include five categories for beverages including alcoholic beverages (1-3 times/month, 1-2 times/week, 3-4 times/week, 5-6 times/week, and once/day), and six categories for foods (the frequencies listed above, as well as a twice/day or more option). The portion sizes include three categories (regular size, half or less than half the regular size, and one and a half times the regular size or more) for foods, and cup of drinks for beverages. Energy and nutrient intake was calculated based on the Standard Tables of Food Composition in Japan[17]. The relative validity of the FFQ was examined using 3-day dietary records (3-DR); the median correlation coefficients for nutrient intake between the FFQ and 3-DR were 0.51 and 0.26 for crude and energy-adjusted values, respectively. Reproducibility was examined by administering the FFQ twice in a 1-week interval; the median correlation coefficients for nutrient intake between the first and second FFQ were 0.63 and 0.76 for crude and energy-adjusted values, respectively[16]. Nutrient intake was evaluated by adjusting the total energy intake using the nutrient residual model[18]. In this model, regression analyses are used to compute residuals of nutrient intake by removing the variation caused by total energy intake[18]. Furthermore, the proportion of the energy intake derived from carbohydrates, protein, fat and alcohol among the total energy intake was evaluated.

Statistical analysis

Differences in sociodemographic characteristics by work schedule were tested with the Chi-square test for categorical variables and the t-test for continuous variables. The age- and sex-adjusted means of the total energy and nutrient intakes stratified by the work schedule (shift or daytime) were obtained by analysis of covariance. Then, the age- and sex-adjusted means of the total energy and nutrient intakes stratified by dinner timing

Table 1. Sociodemographic characteristics of the study subjects by work schedule

	Total				Daytime work				Shift work				p-value[a]
	N	%	Mean	SD	N	%	Mean	SD	N	%	Mean	SD	
Total	2,364				2,062				302				
FFQ incomplete (excluded)	210	8.9			171	8.3			39	12.9			0.008
FFQ complete (included)	2,154	91.1			1,891	91.7			263	87.1			
Age, years			43.3	12.1			44.1	12.0			37.9	11.4	<0.001
Gender													
Male	1,495	69.4			1,242	65.7			253	96.2			<0.001
Female	659	30.6			649	34.3			10	3.8			
Body mass index[b], kg/m^2			22.5	3.4			22.3	3.3			23.4	3.6	<0.001
Overweight[b,c]	424	19.9			352	18.8			72	27.7			<0.001
Underweight[b,d]	199	9.3			186	9.9			13	5.0			
Dinner timing on work days[e]													
Irregular timing	190	8.9			68	3.6			122	46.7			<0.001
Regular timing	1,954	91.1			1,815	96.4			139	53.3			
Before 8: 00 p.m.	1,201				1,116				85				
Between 8 and 9 p.m.	466				433				33				
Between 9 and 10 p.m.	193				181				12				
After 10: 00 p.m.	94				85				9				

[a] Tested using chi-square tests for categorical variables and t-tests for continuous variables.
[b] N=2,130
[c] Body mass index ≥ 25 kg/m^2
[d] Body mass index < 18.5 kg/m^2
[e] N=2,144

(regular or irregular) were obtained by analysis of covariance among both daytime and shift workers. Based on a preliminary analysis, we used a sex-adjusted rather than a sex-stratified model, because gender did not have any significant interactive effects.

The statistical analyses were performed with IBM SPSS Statistics 22 (IBM, New York, United States). All tests of significance were 2-tailed, with p-values $<.05$ considered significant.

Results

Sociodemographic characteristics of the subjects

Valid responses regarding age, sex, and work schedule were obtained from 2,062 daytime workers and 302 shift workers. The valid response rate of the FFQ was slightly but significantly lower among shift than daytime workers (87.1% and 91.7%, respectively; p-value = .008; Table 1)

Shift workers were younger and had a higher mean BMI than daytime workers. The proportion of overweight workers was higher in shift workers than daytime workers (27.7% and 18.8%, respectively), and the proportion of underweight workers was lower in shift workers than daytime workers (5.0% and 9.9%, respectively; p-value < .001). Shift workers were also more likely to be men and to experience irregular dinner timing. Among daytime and shift workers, 3.6% and 46.7% reported eating dinner at irregular times, 59.3% and 32.6% reported eating dinner before 8 p.m., and 37.1% and 20.7% reported eating dinner after 8 p.m., respectively.

Dietary intake stratified by work schedule

The age- and sex-adjusted total energy and nutrient intakes according to work schedule are shown in Table 2. The mean total energy intake of shift workers was higher than that of daytime workers (p-value = .047); in contrast, the mean intake of dietary fiber (p-value = .009), vitamin B_2 (p-value = .032), folic acid (p-value = .004), vitamin C (p-value = .035), potassium (p-value = .026), calcium (p-value < .001), magnesium (p-value = .003) and iron (p-value = .017) were lower in shift workers than in daytime workers. When only men were included in the analysis (N=1,495), the results were not appreciably changed, but the intake of vitamin B_2 and potassium did not reach statistical significance (p-value = .070 and .059, respectively; Supplementary Table 1). Furthermore, while total energy intake tended to be high, some nutrient intakes (e. g. vitamin A and calcium) tended to be low among men.

Dietary intake stratified by dinner timing among daytime workers and shift workers

The age- and sex-adjusted total energy and nutrient intakes according to dinner timing among daytime workers are shown in Table 3. When compared to subjects with

Table 2. Mean dietary intake by work schedule

	Daytime work (N=1,891)		Shift work (N=263)		*p*-value
	Mean	95% CI	Mean	95% CI	
Total energy, kcal	1939	(1913 - 1965)	2018	(1946 - 2090)	0.047
Carbohydrate, % energy	58.2	(57.8 - 58.6)	58.4	(57.3 - 59.5)	0.733
Protein, % energy	13.0	(12.9 - 13.1)	12.9	(12.6 - 13.2)	0.430
Fat, % energy	23.4	(23.2 - 23.7)	23.4	(22.7 - 24.1)	0.979
Alcohol, % energy	5.4	(5.1 - 5.8)	5.3	(4.3 - 6.4)	0.864
Carbohydrate, g	278.9	(277.1 - 280.7)	278.5	(273.5 - 283.5)	0.896
Protein, g	63.2	(62.8 - 63.7)	62.7	(61.3 - 64.0)	0.402
Fat, g	50.8	(50.3 - 51.4)	50.8	(49.3 - 52.2)	0.922
Dietary fiber, g	11.8	(11.6 - 11.9)	11.3	(10.9 - 11.6)	0.009
Vitamins					
Vitamin A, μgRE	410	(404 - 417)	396	(378 - 414)	0.146
Vitamin D, μg	5.2	(5.1 - 5.4)	5.3	(4.9 - 5.7)	0.822
Vitamin E, mg	5.5	(5.4 - 5.6)	5.5	(5.3 - 5.7)	0.981
Vitamin K, μg	172	(168 - 175)	164	(155 - 173)	0.129
Vitamin B_1, mg	0.92	(0.91 - 0.93)	0.93	(0.90 - 0.95)	0.541
Vitamin B_2, mg	1.13	(1.12 - 1.14)	1.09	(1.06 - 1.13)	0.032
Vitamin B_6, mg	1.13	(1.12 - 1.14)	1.11	(1.08 - 1.14)	0.272
Vitamin B_{12}, μg	4.3	(4.2 - 4.4)	4.3	(4.1 - 4.5)	0.683
Folic acid, μg	309	(305 - 313)	292	(282 - 303)	0.004
Vitamin C, mg	96	(94 - 97)	90	(86 - 95)	0.035
Minerals					
Sodium, mg	3582	(3543 - 3621)	3546	(3439 - 3653)	0.537
Potassium, mg	2204	(2181 - 2227)	2126	(2063 - 2190)	0.026
Calcium, mg	441	(434 - 448)	403	(384 - 422)	<0.001
Magnesium, mg	233	(231 - 235)	224	(218 - 230)	0.003
Iron, mg	7.6	(7.5 - 7.7)	7.3	(7.0 - 7.5)	0.017
Zinc, mg	7.8	(7.8 - 7.9)	7.7	(7.6 - 7.9)	0.192
Copper, mg	1.15	(1.15 - 1.16)	1.13	(1.11 - 1.15)	0.073
Manganese, mg	3.84	(3.79 - 3.89)	3.73	(3.59 - 3.87)	0.141

CI, Confidence interval
Age and sex adjusted means were obtained by analysis of covariance.

regular dinner timing, the mean intake of protein (% energy), folic acid, and zinc were lower in those with irregular dinner timing (*p*-values = .006, .044 and .023, respectively). When only men were included in the analysis (N=1,238; 4 participants with missing data regarding dinner timing were excluded), the results were not appreciably changed, but intake of folic acid and zinc did not reach statistical significance (*p*-value = .167 and .059, respectively; Supplementary Table 2).

The age- and sex-adjusted total energy and nutrient intakes according to dinner timing among shift workers are shown in Table 4. The mean intake of carbohydrates and copper were lower in subjects with irregular dinner timing than in subjects who ate dinner at regular times, (*p*-value = .040 and .005, respectively). When only men were included in the analysis (N=253), the results were not appreciably changed (Supplementary Table 3).

Discussion

This study demonstrates that approximately half of the surveyed shift workers reported irregular dinner timing, and that the proportion of workers that reported irregular dinner timing was significantly higher among shift than among daytime workers. When compared to daytime work, shift work was associated with a higher mean BMI, a higher proportion of being overweight, higher total energy intake, lower dietary fiber intake, and a lower intake of some vitamins and minerals. Moreover, irregular dinner timing was associated with low intake of protein, folic acid, and zinc in daytime workers, and low intake of carbohydrates and copper in shift workers.

Table 3. Mean dietary intake by dinner timing among daytime workers

	Regular timing (N=1,815)		Irregular timing (N=68)		*p*-value
	Mean	95% CI	Mean	95% CI	
Total energy, kcal	1937	(1911 - 1963)	1843	(1708 - 1977)	0.177
Carbohydrate, % energy	58.1	(57.7 - 58.5)	58.0	(55.9 - 60.1)	0.910
Protein, % energy	13.1	(13.0 - 13.2)	12.4	(11.9 - 12.9)	0.006
Fat, % energy	23.5	(23.3 - 23.8)	22.7	(21.4 - 24.0)	0.208
Alcohol, % energy	5.3	(4.9 - 5.7)	7.0	(5.0 - 8.9)	0.097
Carbohydrate, g	278.7	(276.9 - 280.5)	277.2	(267.8 - 286.5)	0.753
Protein, g	63.6	(63.2 - 64.1)	60.8	(58.4 - 63.2)	0.025
Fat, g	51.1	(50.5 - 51.6)	49.9	(47.2 - 52.7)	0.433
Dietary fiber, g	11.9	(11.8 - 12.0)	11.3	(10.6 - 12.0)	0.095
Vitamins					
Vitamin A, μgRE	416	(410 - 423)	384	(351 - 418)	0.067
Vitamin D, μg	5.3	(5.2 - 5.5)	4.6	(3.8 - 5.4)	0.064
Vitamin E, mg	5.5	(5.5 - 5.6)	5.3	(5.0 - 5.7)	0.254
Vitamin K, μg	173	(170 - 177)	163	(145 - 181)	0.247
Vitamin B_1, mg	0.92	(0.91 - 0.93)	0.89	(0.85 - 0.94)	0.195
Vitamin B_2, mg	1.14	(1.13 - 1.16)	1.09	(1.02 - 1.15)	0.082
Vitamin B_6, mg	1.14	(1.13 - 1.15)	1.09	(1.03 - 1.15)	0.114
Vitamin B_{12}, μg	4.4	(4.3 - 4.5)	4.1	(3.7 - 4.5)	0.166
Folic acid, μg	313	(309 - 317)	292	(272 - 312)	0.044
Vitamin C, mg	98	(96 - 99)	89	(80 - 98)	0.058
Minerals					
Sodium, mg	3605	(3566 - 3644)	3478	(3276 - 3679)	0.224
Potassium, mg	2227	(2204 - 2250)	2123	(2002 - 2244)	0.100
Calcium, mg	447	(440 - 454)	419	(383 - 455)	0.135
Magnesium, mg	235	(233 - 237)	228	(217 - 239)	0.210
Iron, mg	7.7	(7.6 - 7.8)	7.3	(6.8 - 7.7)	0.096
Zinc, mg	7.9	(7.8 - 7.9)	7.6	(7.4 - 7.8)	0.023
Copper, mg	1.16	(1.15 - 1.17)	1.14	(1.10 - 1.18)	0.227
Manganese, mg	3.88	(3.82 - 3.93)	3.70	(3.43 - 3.97)	0.216

CI, Confidence interval
Age and sex adjusted means were obtained by analysis of covariance.

Shift work and dietary intake

In this study, the total energy intake of shift workers was higher than that of daytime workers. This is not in line with the results of a recent meta-analysis of 12 cross-sectional studies (including 10,367 daytime and 4,726 shift workers), which showed that total energy intake between shift and daytime workers was not statistically different[3]. Among the studies included in the meta-analysis, eight had a small sample size for shift workers (n <100), and one used a single 24-hour recall for dietary assessment, which is unlikely to reflect the usual intake[19]. On the other hand, a study by Morikawa et al. (also included in the meta-analysis) that included 2,254 male workers and used a FFQ for dietary assessment observed a significantly higher total energy intake and BMI in workers with a midnight shift compared to daytime workers 30-39 years old[9]. Furthermore, a recent large-scale (n = 7,856), population-based cross-sectional study using an FFQ for dietary assessment (not included in the meta-analysis) observed that shift workers, and particularly those working ≥5 night shifts per month, had a higher energy intake than daytime workers[11].

In our study, the mean BMI, proportion of overweight subjects, and total energy intake were higher in shift workers than in daytime workers. A cohort study of Japanese male workers spanning 14 years reported that shift work was associated with a 14% higher risk of a 5% BMI increase[12]. Taken together, our findings and these previous reports suggest that a higher energy intake might be an important modifiable risk factor for an increased BMI among shift workers.

Another important finding of this study is that the intake of dietary fiber and some vitamins and minerals were significantly lower in shift workers than in daytime work-

Table 4. Mean dietary intake by dinner timing among shift workers

	Regular timing (N=139)		Irregular timing (N=122)		*p*-value
	Mean	95% CI	Mean	95% CI	
Total energy, kcal	2088	(1978 - 2198)	2033	(1916 - 2151)	0.507
Carbohydrate, % energy	59.6	(58.0 - 61.2)	57.8	(56.1 - 59.5)	0.132
Protein, % energy	12.5	(12.1 - 12.8)	12.4	(12.0 - 12.8)	0.685
Fat, % energy	22.7	(21.7 - 23.7)	22.9	(21.9 - 24.0)	0.699
Alcohol, % energy	5.3	(3.6 - 6.9)	6.9	(5.1 - 8.7)	0.188
Carbohydrate, g	286.7	(279.0 - 294.4)	274.9	(266.7 - 283.1)	0.040
Protein, g	60.3	(58.4 - 62.2)	60.2	(58.1 - 62.3)	0.933
Fat, g	48.9	(46.5 - 51.2)	49.7	(47.2 - 52.2)	0.614
Dietary fiber, g	10.6	(10.2 - 11.1)	10.3	(9.8 - 10.8)	0.380
Vitamins					
Vitamin A, μgRE	348	(323 - 374)	372	(345 - 399)	0.207
Vitamin D, μg	4.7	(4.1 - 5.3)	4.4	(3.8 - 5.0)	0.505
Vitamin E, mg	5.2	(4.9 - 5.4)	5.2	(4.9 - 5.5)	0.869
Vitamin K, μg	158	(146 - 170)	145	(133 - 158)	0.154
Vitamin B_1, mg	0.89	(0.85 - 0.93)	0.90	(0.86 - 0.94)	0.877
Vitamin B_2, mg	1.00	(0.95 - 1.05)	1.03	(0.98 - 1.08)	0.399
Vitamin B_6, mg	1.03	(0.99 - 1.08)	1.05	(1.00 - 1.10)	0.631
Vitamin B_{12}, μg	4.0	(3.7 - 4.3)	4.0	(3.7 - 4.3)	0.886
Folic acid, μg	265	(252 - 278)	262	(248 - 276)	0.788
Vitamin C, mg	76	(70 - 82)	78	(72 - 84)	0.612
Minerals					
Sodium, mg	3405	(3248 - 3563)	3369	(3201 - 3537)	0.758
Potassium, mg	1957	(1873 - 2042)	1998	(1908 - 2088)	0.521
Calcium, mg	359	(335 - 383)	375	(350 - 401)	0.369
Magnesium, mg	211	(203 - 218)	209	(201 - 216)	0.718
Iron, mg	6.8	(6.5 - 7.1)	6.5	(6.2 - 6.8)	0.216
Zinc, mg	7.7	(7.5 - 7.9)	7.5	(7.3 - 7.7)	0.129
Copper, mg	1.12	(1.10 - 1.15)	1.06	(1.03 - 1.09)	0.005
Manganese, mg	3.58	(3.40 - 3.75)	3.41	(3.22 - 3.59)	0.191

CI, Confidence interval
Age and sex adjusted means were obtained by analysis of covariance.

ers; this is partly consistent with results reported by Morikawa et al[9]. Tada et al. reported a significantly lower vegetable intake among shift workers when compared to daytime workers among Japanese female nurses[20]. They also observed that the intakes of pulses as well as milk and dairy products were lower among shift than among daytime workers, but the differences were not statistically significant[20]. Another study reported a low intake of vegetables among male but not female shift workers[10]. In this study, we did not evaluate the food source of dietary fiber, vitamins, and minerals, but it is likely that low intakes of vegetables, pulses, as well as milk and dairy products were responsible for the low nutrient intake among shift workers.

Dinner timing and dietary intake

It seems plausible that shift work might affect meal timing. In our study, the proportion of shift workers who reported eating dinner before 8 p.m. was approximately half that of daytime workers, and the proportion of those who reported irregular dinner timing was >12 times higher among shift workers than among daytime workers. A previous Japanese study reported that shift work was associated with skipping meals, but not with peak dinner time (6 to 7 p.m.)[6]. Another study reported that shift workers showed a wide range of dinner times (from 4 p.m. to 10 p.m.), and some workers ate dinner at their usual time and later again around 11 p.m.[5]. On the other hand, meal timing was not associated with other occupational factors, including type of occupation, overtime working hours, and commuting hours[15]. Overall, shift work is likely an important occupational factor that affects meal timing.

In this study, irregular dinner timing was associated with low intake of some nutrients among both daytime and shift workers. Irregular dinner timing may be an important modifiable factor to improve dietary intake among workers. However, we could not analyze how irregular meal timing was associated with low intake of certain vitamins and minerals. We hypothesize that meals eaten at irregular times may not be well-prepared, have a lower food variety, and may often include fast foods or energy-dense and nutrient-poor foods. A thematic analysis of interviews with shift workers revealed that the factors influencing food choice and dietary intake included time and accessibility; knowledge of the relationship between food and health; attitudes and decisions of co-workers; and the shift schedule[7]. Whereas the shift schedule is not modifiable, the former three factors could be targeted to improve the diet and health of shift workers.

Strengths and limitations of the study

The subjects in this study were employees of 43 small- and medium-sized companies. Thus, the results have good generalizability because approximately 85% of workers in Japan are employed by small- and medium-sized companies[21]. However, we could not separately analyze shift work with or without night shifts because of the small number of shift workers working night shifts. This might have limited our study as shift workers working the night shift may be most vulnerable to an inadequate dietary intake[9]. Dietary intake was assessed by using a FFQ, which can be an effective tool for estimating usual dietary intake, but can have limitations for quantitative assessment.

Conclusions

Shift workers had a higher mean BMI and were significantly more likely to report irregular dinner timing than daytime workers. Shift work was associated with high total energy intake, and both shift work and irregular dinner timing were associated with low intake of some vitamins and minerals. Our findings indicate a need to improve the diet of shift workers through educational programs regarding dietary intake and meal timing.

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Conflicts of interest: None declared.

Supplementary material: This article contains supplymentary material (Apendix), which is arailable in the online version (doi: 10.1539/joh.2018-0070-OA).

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