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ORIGINAL ARTICLE

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Effect of workplace dietary intervention on salt intake and sodium-to-potassium ratio of Japanese employees: A quasi-experimental study

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Abstract

Objectives: Excess salt intake is a major risk factor for hypertension and cardiovascular disease. Modifying workplace environments has been recognized to be important for reducing salt intake. However, studies examining the effects of improving the workplace environment regarding salt reduction are limited. This study aimed to evaluate the effects of workplace dietary intervention on employees' salt intake and sodium-to-potassium (Na/K) ratio.

Methods: A quasi-experimental study was conducted. Two small business establishments in Saitama Prefecture, Japan, were allocated as the intervention ($n = 69$) and comparison ($n = 68$) workplaces, respectively. The 1-year intervention involving healthy lunch and nutrition education was implemented in the intervention workplace. Spot urine samples, physical assessments, and self-administered questionnaire data were collected at baseline, 6 months, and 1 year after the start of the intervention. Analysis of covariance was conducted to investigate differences in the salt intake or Na/K ratio between the study workplaces at year 1. Educational status and rotating work schedules were included as covariates.

Results: Salt intake in the intervention workplace decreased significantly from 10.7 to 9.3 g (−1.4 g change; 95% confidence interval [CI]: "−2.4, −0.5"). The adjusted difference in changes in salt intake between workplaces was statistically significant (−3.7 g change; 95% CI: "−5.2, −2.3"). Although no significant change was observed in the Na/K ratio in the intervention workplace (3.37–3.08; −0.29 change; 95% CI: "−0.59, 0.01"), the adjusted difference in changes between the workplaces was statistically significant (−0.60 change; 95% CI: "−1.03, −0.17").

Conclusions: Providing healthy lunch and nutrition education may be effective approaches to reduce employees' salt intake and Na/K ratio.

KEYWORDS
food environment, nutrition education, salt intake, sodium-to-potassium ratio, spot urine, workplace intervention

1 | INTRODUCTION

Excess salt intake is a major risk factor for hypertension and cardiovascular disease in the Japanese population.[1,2] Globally, the World Health Organization recommends that daily salt intake should be reduced to <5 g/day in adults.[3] Japan is a country with one of the highest salt intake levels worldwide.[1,4] The National Nutrition Survey conducted in 2019 reported a population means sodium intake of 10.9 g and 9.3 g for men and women, respectively.[5] Clearly, the sodium intake among Japanese is still too high. Therefore, there is an urgent need to develop effective intervention programs to reduce Na intake in the Japanese population. In the national health promotion plan, the Japanese government has set a target to reduce the mean population salt intake to 8 g/day by 2022.[6]

In the NIPPON DATA80 long-term follow-up study of Japanese participants, a higher dietary sodium-to-potassium (Na/K) ratio was associated with a higher risk of cardiovascular mortality.[7] In addition, an international study including Japanese participants (INTERMAP) reported that the blood pressure-lowering effect of potassium was attenuated when dietary salt intake was high.[8] Therefore, it is important to reduce both the salt intake and the Na/K ratio.

The workplace has been recognized as a high-priority setting for health promotion and disease prevention in the working population.[9] It has been shown previously that corporate management leadership is essential for the success of workplace health promotion programs.[10–12] In this regard, modifying workplace dietary environments should be an important element of reducing salt intake.[13] It has been suggested that workplace dietary environment interventions in combination with nutrition education can increase fruit and vegetable consumption.[14] However, studies examining the effect of salt reduction by improving the workplace dietary environment are limited, and the results are inconsistent.[15–17] In addition, to our knowledge, no study has evaluated the effect of the workplace dietary environment on the Na/K ratio.

Thus, this study aimed to evaluate the effects of workplace dietary intervention on employees' salt intake and Na/K ratio. This intervention included the provision of healthy lunches and nutrition education along with corporate management leadership. In addition, to examine the effects of healthy lunch and nutrition education on changes in salt intake separately, we compared changes in salt intake and Na/K ratios between those with and without healthy lunch consumption in the intervention workplace.

2 | PARTICIPANTS AND METHODS

2.1 | Study design and participants

This study was a non-randomized controlled trial (quasi-experimental study). The study design is shown in Figure 1. This study was performed for 1 year, from January 2019 to February 2020.

In this study, Company A was designated as the intervention workplace. Company B, which had similar demographic characteristics (e.g., number of employees, age structure, and sex ratio as Company A), was designated as the comparison workplace. Both companies had been certified as having "Saitama Prefecture Health Management Practices." However, neither company had improved the food environment or provided nutritional education. In addition, neither company operated an employee cafeteria. Company A was a manufacturing company for medical equipment, aircraft, and precision parts processing with 86 employees who all worked on the same premises. The company had a consignment contract with a food delivery service for employees' lunches and provided a dining hall ("hall") for employees to eat. There were no restaurants in the vicinity, and the employees ate lunches provided by the vendors or brought their own lunches into the hall. Company B was a construction company with 74 employees. The company designed and constructed buildings, sale, purchase, and rental of real estate, and brokerage management. In addition to the head office, there were three sales offices and construction sites in the city (two to three locations at any time) and two sales offices outside the neighboring cities. In all the workplaces, employees ate their lunches at their own table or the meeting table or dined out.

In January 2019, full-time workers aged 18–70 years of both companies were recruited to participate in the study. The company manager or the person-in-charge who served as the point of contact for this study was excluded from the study subjects. In total, 69 (80.2%) and 68 (91.9%) employees of Company A and Company B participated in this study, respectively. All applicants met

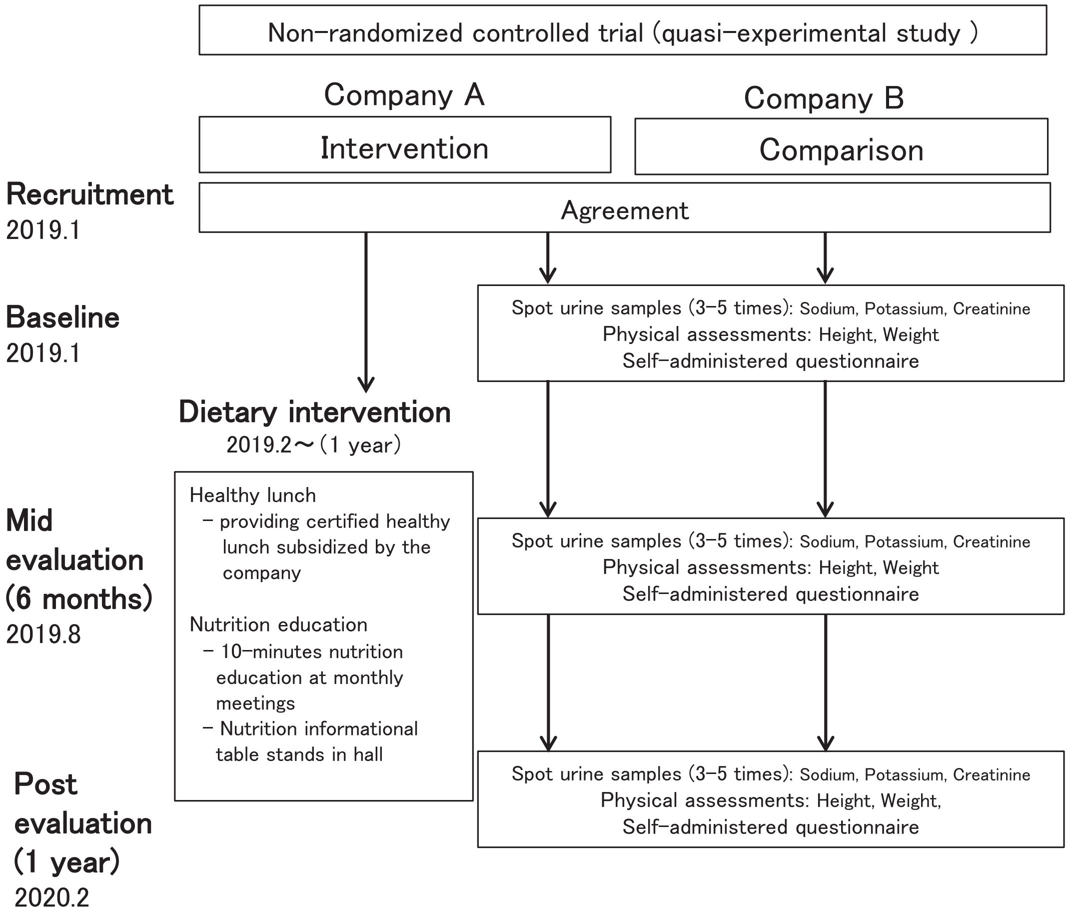

FIGURE 1 Study design

the eligibility criteria. This study was approved by the Ethical Committee of Kagawa Nutrition University (approval number: 209) and conducted in accordance with the Declaration of Helsinki (2013) of the World Medical Association. All participants were informed of the study protocol and provided written informed consent before inclusion in the study. Participants received no financial incentives. The study protocol was registered in the UMIN Clinical Trials Registry (UMIN 000036044).

2.2 | Interventions

The intervention program comprised healthy lunch and nutrition education. These interventions were implemented under the corporate management leadership after the Health and Productivity Management (H&PM) declaration by the management of Company A in February 2019. H&PM is an approach that considers the health management of employees from a corporate management perspective and promotes it strategically.[18] Company B did not receive any intervention. Evaluation data for both companies were collected at baseline, 6 months, and 1 year (Figure 1). Personalized numerical results regarding salt intake and Na/K ratio estimated from urine and body mass index (BMI) calculated from body measurements were returned at each time point. For Company A, a comparison of the participant's distribution and the person's numerical values were returned, while for Company B, only the person's numerical values were returned.

2.2.1 | Healthy lunch

The healthy food environment provided certified healthy lunch subsidized by the company. The certified healthy lunch was "Smart Meal®,"[19,20] which is a meal that has been certified as a "healthy meal" by the "Healthy Meal and Healthy Food Environment consortium," comprising 13 academic societies, including the Japan Society for Occupational Health. The criteria were based on the "Dietary Reference Intakes for Japanese 2015 (DRIs)"[21] and "Guidelines for meals provided for the prevention of non-communicable diseases and health promotion,"[22] which were both released by the Ministry of Health, Labour and Welfare. Specifically, the Smart Meal energy equivalent was either 450–650 kcal per meal or 650–850 kcal per meal. The protein–fat–carbohydrate (PFC) energy ratio (%E) was within the range recommended by DRIs for persons aged 18 years or older (PFC% E: protein, 13%–20% E; fat, 20%–30% E; carbohydrate, 50%–65% E); the weight of vegetables (vegetables, mushrooms, seaweed, and potatoes) was at least 140 g; and salt equivalent was <3.0 g and 3.5 g for the 450–650 kcal per meal and 650–850 kcal per meal, respectively.

In February 2019, Company A contracted with a vendor to provide boxed lunches that met the Smart Meal criteria (650–850 kcal per meal). The Smart Meal lunch was provided daily and was purchased by employees for 350 yen per meal; the company subsidized 100 yen of 450 yen per meal for Smart Meal lunches. No subsidy was provided for anything other than Smart Meal lunches (such as noodles), which cost 450 yen per meal.

2.2.2 | Nutrition education

Nutrition education had two components: 10 min of nutrition education at monthly meetings and nutrition information table stands in the hall.

Company A held a monthly general meeting in which all employees gathered to report on the progress of their work. Beginning in February 2019, 10 min of nutrition education, conducted by the first author, was incorporated into the meeting, which all employees were required to attend as part of their duties. The nutrition education included salt reduction, potassium intake, and weight control, as recommended in the lifestyle modifications of the Japanese Society of Hypertension Guidelines for the Management of Hypertension (JSH 2014).[23] The monthly nutrition education was also placed on nutrition information table stands (A5 size, color-printed on both sides, and inserted into an acrylic holder) on all tables in the hall. Thus, nutrition education was provided to all employees in company A.

2.3 | Data collection and measurements

2.3.1 | Outcome measures

The primary outcome was changed in employees' salt intake during the 1-year intervention. The secondary outcomes were changes in Na/K ratio and BMI during the 1-year intervention.

All data were collected during employees' work hours in individual workplaces. A self-administered questionnaire and five urinalysis kits were distributed to the participants by the person in charge of each company before the start of each survey period. The researchers collected and checked the questionnaires during the survey period, and missing or illogical responses were resurveyed or corrected.

Height and weight were measured at each company at baseline, 6-month, and 1-year survey periods. Both companies used the equipment of the hospital commissioned by Company A to conduct regular health examinations during both survey periods, and the measurement methods were standardized. Height was measured to 0.1 cm using the AD-6227 digital height meter (A&D Corporation), and body weight was measured to 0.1 kg using a precision scale (WB-150; Tanita Corporation). Weight was measured by subtracting 1.0 kg of clothing weight. BMI (kg/m^2) was calculated with measured height and weight. Company A conducted the measurements in the morning (9:30–11:30 a.m.) in the hall during all survey periods. Company B conducted the measurements in a conference room at its headquarters during both survey periods. Participants were instructed to visit the site at their own convenience in the morning (8:30 a.m. to 12:00 noon) and afternoon (1:00 p.m. to 4:00 p.m.) to obtain measurements.

Multiple spot urine samples were used to estimate salt intake and the Na/K ratio. Participants were requested to collect urine five times on different days during the survey period at baseline (January 24–31, 2019), 6 months (August 1–8, 2019), and 1 year (February 3–10, 2020). Saturdays and Sundays were excluded for all periods. Each study participant was provided with five urine collection kits for each survey period. A cold storage box for the placement of samples was installed in all company toilets. Participants were instructed to have their urine collected at different times if possible. Those who could not collect urine five times due to business trips or vacations were requested to submit at least three samples during the survey period. Urine specimens were collected from all toilets daily during the survey period. Collected urine samples were sent to a laboratory company (BML, Inc.) at approximately 5:00 p.m. every day and were promptly analyzed for Na (mEq/L), K (mEq/L), and creatinine (mg/dL).

The estimated 24-h sodium excretion (mmol/day) was calculated using the formula of Uechi et al.[24] This formula has been reported to provide the most accurate estimates of sodium excretion when compared to the regression method and the conventional method.[24,25] The estimated salt excretion (mg/day) was calculated by converting 1 mol of the estimated sodium excretion into 58.5 mg of salt (NaCl) and dividing it by the percentage of sodium excretion (86%)[26] to calculate the estimated salt intake (g/day).

The formula for calculating 24-h sodium excretion (mmol/day) was as follows: 24-hour sodium excretion (mmol/day) = mean spot sodium concentration (mmol/L)/mean spot creatinine concentration (mmol/L) × predicted

24-h creatinine excretion (mmol/day). Calculation of creatinine excretion was as follows: Predicted 24-h creatinine excretion (mmol/day) = 2.84 × sex (men = 1, women = 0) + 0.05 × age (year) − 0.001 × square of age (year × year) + 0.144 × weight (kg) + 0.01 × height (cm) − 1.14.[24]

For the urinary Na/K ratio, a strong correlation (r = .84–.87) between the mean of multiple (discontinuous 3–7 days) spot urine samples and the 7-day mean of 24-h urine collection has been reported.[27] Therefore, the Na/K ratio was calculated as the mean spot sodium concentration (mmol/L)/mean spot potassium concentration (mmol/L).

2.3.2 | Sociodemographic and lifestyle characteristics

Sociodemographic characteristics (including age, sex, education, marital status, job position, and rotating work schedule) and lifestyle characteristics (including medical history, smoking, drinking status, and physical activity) were evaluated using a self-administered questionnaire.

2.4 | Sample size

The sample size was calculated using Easy R (Saitama Medical Center, Jichi Medical University), which is a graphical user interface for R (The R Foundation for Statistical Computing).[28] We estimated that the minimum required sample size of each workplace was 69 participants for the following reasons: (1) the primary endpoint was salt intake (g per day), (2) the estimated standard deviation (SD) was 4.4 g per day, (3) the estimated effect of the intervention was −2.1 g per day, and (4) a power analysis was performed using a power of 80% and an α of .05. Reasons (2) and (3) are based on previous findings.[15]

2.5 | Statistical analyses

The mean urinary Na, Na/K ratio, and BMI at baseline and year 1 were calculated. Na/K ratio values were transformed using a natural logarithm before calculation to account for the skewed distribution to the right.

Intervention effects were compared using the principle of intention-to-treat,[29,30] carrying baseline data forward for missing data at month 6 and month 6 data forward for missing data at year 1 (Figure 2). Reasons for dropping out included retirement or job transfer.

To evaluate the difference in changes in salt intake between those with and without eating healthy lunch at the intervention workplace, respondents who answered that they "eat Smart Meal®" (every day: n = 14, 3–4 times a week: n = 3, or 1–2 times a week: n = 1)" (n = 18) and those who answered that they "do not eat Smart Meal® (less than once a week: n = 8 or never eaten Smart Meal®: n = 32)" (n = 40) in the 1-year post-survey were included in the analyses (Figure 2).

Mean values of variables for the workplaces at baseline were compared using a t-test. Proportions at baseline were analyzed using the χ^2 test. Differences from baseline to year 1 within workplaces are presented as changes and 95% confidence intervals (95% CI).

Analysis of covariance was conducted to investigate differences in outcome measures at year 1 between the study workplaces. For comparisons between intervention and comparison workplaces, baseline values for salt intake and Na/K ratio, baseline educational status (university education or equivalent and high school graduates and below), and rotating work schedule (yes, no) were used as covariates. Since BMI was not significantly different at baseline, we only adjusted for educational status and rotating work schedule. For comparisons between consumed and not consumed healthy lunch at the workplaces, baseline values for salt intake and Na/K ratio and baseline job position (manager, middle manager, or others) were used as covariates.

Changes during the intervention (baseline, month 6, and year 1) were compared with repeated measures analysis of variance. Bonferroni's multiple comparisons were performed for variables with significant differences.

Statistical significance was set at $P < .05$. All statistical analyses were performed using SPSS Statistics 26 for Windows (IBM Japan, Ltd.).

3 | RESULTS

3.1 | Baseline characteristics

Table 1 shows the baseline characteristics. Regarding education, 46.4% in the intervention workplace and 70.6% in the comparison workplace had a university education or equivalent (P = .004). Shift working was only reported in the intervention workplace (10.1%) (P = .013). No significant differences in other variables were observed between the workplaces.

3.2 | Effect of intervention on salt intake

Salt intake decreased significantly from 10.7 to 9.3 g (−1.4 g change; 95% CI: −2.4, −0.5) in the intervention

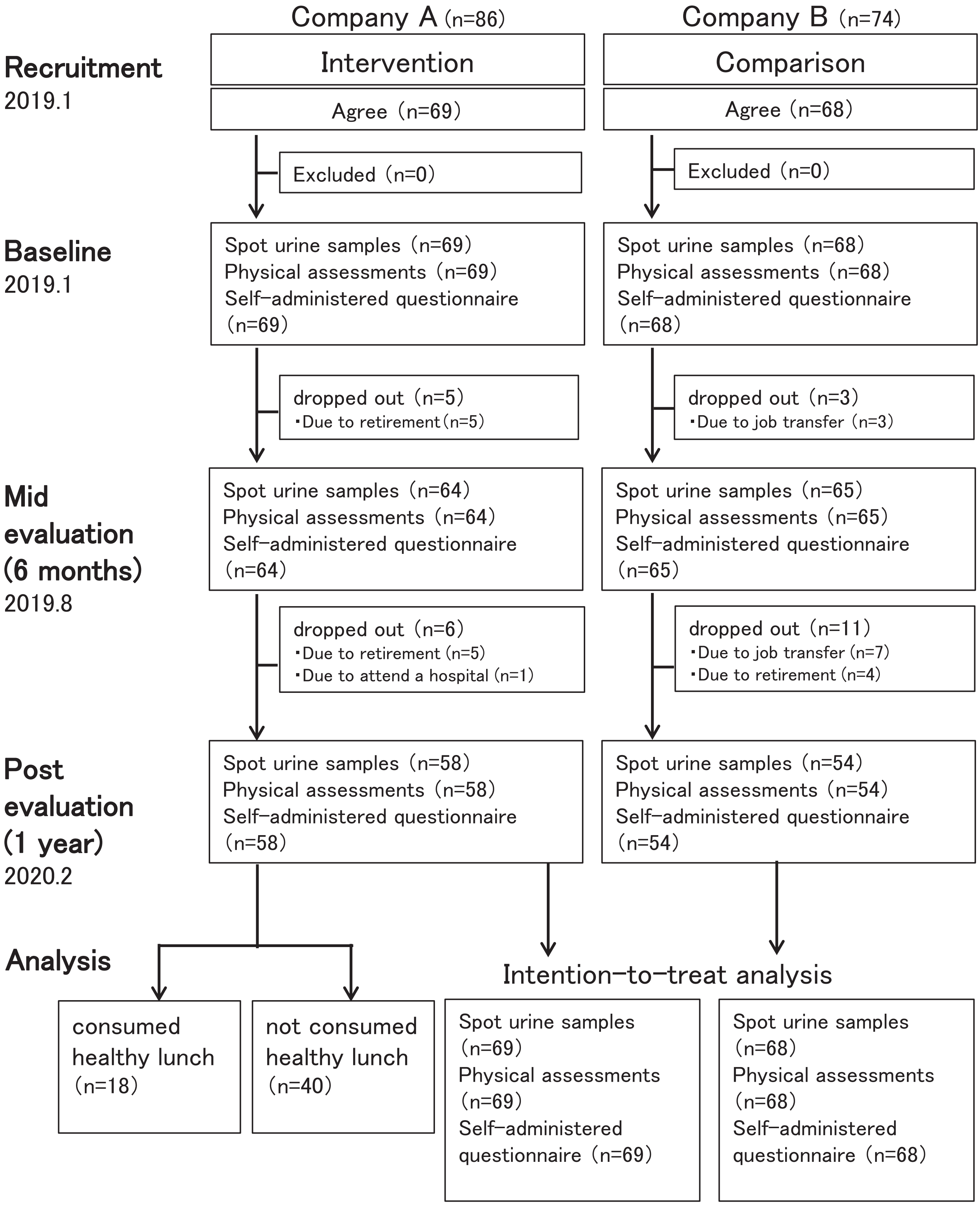

FIGURE 2 Participant flow

workplace after 1-year intervention. However, no significant difference was observed in the comparison workplace (13.0 to 13.1 g; +0.1 g change; 95% CI: −1.3, 1.6). The adjusted difference in changes between workplaces was statistically significant (−3.7 g change; 95% CI: −5.2, −2.3) (Table 2).

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TABLE 1 Subject characteristics at baseline

	Intervention ($n = 69$)	Comparison ($n = 68$)	
	Mean ± SD or *n* (%)	**Mean ± SD or *n* (%)**	***P* value**[a]
Age (years)	40.4 ± 14.5	41.0 ± 15.4	.826
Age group (years)			
18–29	21 (30.4)	26(38.2)	.160
30–39	12 (17.4)	5 (7.4)	
40–49	15 (21.7)	15 (22.1)	
50–59	16 (23.2)	11 (16.2)	
60–	5 (7.2)	11 (16.2)	
Sex			
Male	52 (75.4)	45 (66.2)	.237
Female	17 (24.6)	23 (33.8)	
Educational status			
University education or equivalent	32 (46.4)	48 (70.6)	.004
High school graduates and below	37 (53.6)	20 (29.4)	
Marital status[b]			
Single/never married	37 (53.6)	29 (42.6)	.175
Married/cohabiting	32 (46.4)	37(54.4)	
Divorce/bereavement	0 (0.0)	2 (2.9)	
Job position			
Manager	15 (21.7)	18 (26.5)	.401
Middle manager	8 (11.6)	12 (17.6)	
Others	46 (66.7)	38 (55.9)	
Rotating work schedule[b]			
Yes	7 (10.1)	0 (0.0)	.013
Antihypertensives			
Yes	6 (8.7)	8 (11.8)	.553
Past history or current treatment			
Kidney disease	1 (1.4)	1 (1.5)	1.000
Smoking status			
Current smoker	18 (26.1)	17 (25.0)	.223
Former smoker	10 (14.5)	4 (5.9)	
Never smoker	41 (59.4)	47 (69.1)	
Drinking[c]			
Consume alcohol over the recommended limits	9 (13.0)	12 (17.6)	.455
Physical activity[d]			
Moderate	50 (72.5)	49 (72.1)	.958
High	19 (27.5)	19 (27.9)	

Abbreviation: SD, standard deviation.

[a]Unpaired *t*-test or χ^2 test.

[b]Fisher's exact test.

[c]The recommended limits are 40 g or more for men and 20 g or more for women.

[d](Moderate) Corresponds to sedentary work, however, includes movement and housework such as commuting and shopping, and sports with light intensity. (High) Individuals who are involved in works with high-intensity physical activity or high-intensity leisure-time physical activity such as regular sports habits.

TABLE 2 Changes in salt intake and Na/K ratio and BMI after 1 year of intervention

	Intervention ($n = 69$)						Comparison ($n = 68$)							
	Baseline		Year 1		Change[a]		Baseline		Year 1		Change[a]		Adjusted between-group difference in change[b] (95% CI)	Adjusted *P* value[c]
	Mean	(95% CI)	Mean	(95% CI)	Mean	(95% CI)	Mean	(95% CI)	Mean	(95% CI)	Mean	(95% CI)		
Salt (g/day)	10.7	(9.8, 11.6)	9.3	(8.5, 10.1)	−1.4	(−2.4, −0.5)	13.0	(11.7, 14.2)	13.1	(12.0, 14.3)	0.1	(−1.3, 1.6)	−3.7 (−5.2, −2.3)	<.001
Na/K ratio	3.37	(3.03, 3.71)[d]	3.08	(2.81, 3.35)[d]	−0.29	(−0.59, 0.01)	3.57	(3.19, 3.95)[d]	3.64	(3.28, 4.00)[d]	0.07	(−0.36, 0.50)	−0.60 (−1.03, −0.17)	.007
BMI (kg/m^2)	22.8	(21.9, 23.7)	22.7	(21.8, 23.7)	−0.1	(−0.3, 0.1)	23.7	(22.8, 24.5)	23.9	(23.0, 24.7)	0.2	(0.0, 0.4)	−1.2 (−2.6, 0.1)	.079

Abbreviations: ANCOVA, analysis of covariance; BMI, body mass index; CI, confidence interval.

[a]Difference between baseline and year 1.

[b]Difference between intervention group and comparison group in change after adjustment for baseline value, educational status (university education or equivalent, high school graduates, and below), and rotating work schedule (yes, no). BMI was not significantly different at baseline values, we adjusted only for educational status and rotating work schedule.

[c]*P* values for comparison of mean at year 1 between the intervention group and comparison group by ANCOVA after adjustment for baseline value, educational status (university education or equivalent, high school graduates and below) and rotating work schedule (yes, no). BMI was not significantly different at baseline values, we adjusted only for educational status and rotating work schedule.

[d]Mean values at each point were transformed by the natural logarithm before computation because of the skewed distributions.

3.3 | Effect of intervention on the Na/K ratio and BMI

Although no significant change was observed in the Na/K ratio in the intervention workplace (3.37 to 3.08; −0.29 change; 95% CI: −0.59, 0.01), the adjusted difference in changes between workplaces was statistically significant (−0.60 change; 95% CI: −1.03, −0.17). In addition, no significant change was noted in BMI in the intervention workplace (22.8 to 22.7 kg/m^2; −0.1 kg/m^2 change; 95% CI: −0.3, 0.1), but a significant increase in BMI was observed in the comparison workplace (23.7 to 23.9 kg/m^2; +0.2 kg/m^2 change; 95% CI: 0.0, 0.4). The adjusted difference in changes between workplaces was not statistically significant (−1.2 change; 95% CI: −2.6, 0.1).

Table 3 presents the mean estimated salt intake and Na/K ratio during the intervention (at baseline, month 6, and year 1). Salt intake decreased from 10.7 g at baseline to 9.3 g at year 1 in the intervention workplace ($P = .006$); in the comparison workplace, it decreased from 13.0 g at baseline to 9.6 g at month 6 and then increased to 13.1 g at year 1 ($P < .001$). No significant change was noted in the Na/K ratio in the intervention workplace. However, a significant decrease in the Na/K ratio was observed in the comparison workplace (a decrease from 3.57 at baseline to 3.09 at month 6 and then an increase to 3.64 at year 1; $P < .001$).

3.4 | Changes in salt intake and Na/K ratio between those with and without healthy lunch consumption in the intervention workplace

Regarding job positions, 38.9% of the participants who consumed healthy lunches in the intervention workplace and 75.0% of the participants who did not consume healthy lunches had a manager at baseline ($P = .047$). There were no significant differences in other baseline characteristics, such as sex and age, between the groups.

Salt intake decreased significantly from 14.2 to 9.6 g (−4.6 g change; 95% CI: −7.1, −2.1) in the participants who consumed healthy lunch in the intervention workplace, but no significant change was observed in the participants who did not consume healthy lunch (9.3 to 9.2 g; −0.1 g change; 95% CI: −1.2, 0.9). The adjusted difference in changes between the two groups was not significant (−1.6 g change; 95% CI: −3.9, 0.6) (Table).

The Na/K ratio decreased significantly from 4.17 to 3.13 (−1.04 change; 95% CI: −1.82, −0.27) in the participants who consumed healthy lunch in the intervention workplace, but no significant change was observed in the participants who did not consume healthy lunch (3.09–3.05;

TABLE 3 Changes in salt intake and Na/K ratio during the intervention

	Intervention ($n = 69$)						Repeated-measures ANOVA	Comparison ($n = 68$)						Repeated-measures ANOVA
	Baseline		Month 6		Year 1			Baseline		Month 6		Year 1		
	Mean	(95% CI)	Mean	(95% CI)	Mean	(95% CI)	P value	Mean	(95% CI)	Mean	(95% CI)	Mean	(95% CI)	P value
Salt (g/day)	10.7	(9.8, 11.6)[a]	9.4	(8.5, 10.4)	9.3	(8.5, 10.1)[b]	.006	13.0	(11.7, 14.2)[a]	9.6	(8.8, 10.4)[b]	13.1	(12.0, 14.3)[a]	<.001
Na/K ratio[†]	3.37	(3.03, 3.71)	3.50	(3.08, 3.92)	3.08	(2.81, 3.35)	.130	3.57	(3.19, 3.95)[a]	3.09	(2.78, 3.41)[b]	3.64	(3.28, 4.00)[a]	<.001

Note: Repeated-measures ANOVA: Comparison between the three groups at baseline, month 6, and year 1.

Significant difference between the signs of different superscripts (Bonferroni's multiple comparison test: $P < .05$).

Abbreviations: ANOVA, analysis of variance; CI, confidence interval.

†Mean values at each point were transformed by the natural logarithm before computation because of the skewed distributions.

TABLE 4 Changes in salt intake and Na/K ratio between those with and without healthy lunch consumption after 1 year of intervention

	Consumed healthy lunch ($n = 18$)						Not consumed healthy lunch ($n = 40$)						Adjusted between-group difference in change[b] (95% CI)		Adjusted P value[c]
	Baseline		Year 1		Change[a]		Baseline		Year 1		Change[a]				
	Mean	(95% CI)	Mean	(95% CI)	Mean	(95% CI)	Mean	(95% CI)	Mean	(95% CI)	Mean	(95% CI)			
Salt (g/day)	14.2	(12.0, 16.3)	9.6	(8.2, 11.0)	−4.6	(−7.1, −2.1)	9.3	(8.4, 10.2)	9.2	(8.0, 10.4)	−0.1	(−1.2, 0.9)	−1.6	(−3.9, 0.6)	.152
Na/K ratio	4.17	(3.29, 5.05)[d]	3.13	(2.73, 3.52)[d]	−1.04	(−1.82, −0.27)	3.09	(2.70, 3.48)[d]	3.05	(2.65, 3.44)[d]	−0.04	(−0.39, 0.31)	−0.43	(−1.05, 0.18)	.351

Abbreviations: ANCOVA, analysis of caovariance; CI, confidence interval.

[a]Difference between baseline and year 1.

[b]Difference between group with healthy lunch and group without healthy lunch in change after adjustment for baseline value, job position (manager, middle manager, others), because they were significantly different at baseline.

[c]*P* values for comparison of mean at year 1 between group with healthy lunch and group without healthy lunch by ANCOVA after adjustment for baseline value, job position (manager, middle manager, others) because they were significantly different at baseline.

[d]Mean values at each point were transformed by the natural logarithm before computation because of the skewed distributions.

−0.04 change; 95% CI: −0.39, 0.31). The adjusted difference in changes between the two groups was not significant (−0.43 change; 95% CI: −1.05, 0.18).

4 | DISCUSSION

This 1-year intervention showed a significant effect on the reduction of salt intake and Na/K ratio. The findings suggest that two factors might influence the salt intake and Na/K ratio. First, the interventions were carried out with corporate management leadership from the perspective of H&PM. Our findings are consistent with current, limited evidence on the effects of combined workplace interventions with corporate management leadership.[11–13] The company only subsidized certified healthy lunches, not other meals. The nutrition education was not only for health-conscious employees but for the entire population in company A. Second, we incorporated the provision of certified healthy lunches into the interventions using a Smart Meal with reduced salt <3.5 g, sufficient volume of vegetables at least 140 g, and 650-850 kcal per meal. The mean salt, vegetable, and energy equivalents in the lunches before the intervention were 4.8 ± 0.3 g per meal, 100 ± 5.3 g per meal, and 880.8 ± 55.5 kcal per meal, respectively (the energy equivalent was calculated from the Nutrition Facts label for 2 months, and the vegetable and salt equivalents were calculated from the pictures on the menu list and the actual lunch box weight, as they were not labeled). One of the reasons for the significant decrease in salt intake for the participants who consumed a healthy lunch was that the salt equivalent of the healthy lunch was lower than that before the intervention. The salt intake was significantly higher in the participants who consumed a healthy lunch (14.2 ± 4.1 g) than for those who did not consume a healthy lunch (9.3 ± 4.0 g) at baseline ($P < .001$). In the group that consumed a healthy lunch, 16 out of 18 participants ate the lunch before the change. However, in the group that did not consume healthy lunches, only 2 out of 40 participants ate the lunch before the change.

In line with our present findings, a previous study[31] reported that changing a single meal at lunch could reduce daily salt intake. Notably, no significant change in BMI was observed in the intervention workplace, suggesting that the decrease in salt intake in the intervention workplace was not attributed to a decrease in the amount of energy.

Salt intake and Na/K ratio were significantly reduced in participants who consumed a healthy lunch but not in those who did not consume a healthy lunch in the intervention workplace. A previous study showed that knowledge and awareness of "low-sodium" were not associated with a decrease in sodium excretion.[32] In addition, another study found that the difference in salt intake between those who were careful to reduce their daily salt intake and non-salt-conscious patients was not significant.[33] In other words, even if nutrition education raised awareness of salt reduction in the non-consuming group in this study, it might not have led to an actual reduction in salt intake. The findings suggest that continuous consumption of healthy lunches might have enabled the participants to reduce their salt intake. It may be appropriate to use a lunchbox provider that offers healthy lunches like Smart Meals for small business establishments without a workplace cafeteria.

In the comparison workplace, the salt intake and Na/K ratio were significantly decreased at the 6-month time point but increased at the 1-year time point. A possible reason is that participants in the comparison workplace were from a construction company; urine samples were collected in August, and Na excretion via sweat might have increased. Indeed, studies[34–37] have demonstrated that urinary excretion of Na is decreased during heavy sweating[34–37], and Na excretion in sweat is increased.[34] However, the results are inconclusive as to whether urinary excretion of potassium is reduced during heavy sweating.[34–36] Approximately 30% of the participants in the comparison workplace were outdoor workers, which might have influenced the results at the 6-month time point.

This study has several limitations. First, the intervention was restricted to a single workplace. Furthermore, the intervention was non-randomized. Instead, the control workplace was matched to the intervention groups as closely as possible in terms of characteristics, including the number of employees, age structure, and sex ratio. Second, in our study, the SD of the change before and after the intervention in the control or intervention group[15] was used to calculate the sample size (the change in salt intake in the control group is +0.7 [SD: 4.4] g, and the change in the intervention group is −1.4 [SD: 4.4] g). The mean difference SD of the change between the study groups should have been used. However, the data was not available in the article,[15] which we used for sample size calculation. Third, the control group was started with 68 participants even though the sample size calculation required a minimum of 69 participants. In addition, the sample size calculation did not consider potential dropouts. However, we could not find two other companies besides Company A and Company B with similar demographics (number of employees, age structure, gender ratio, etc.) certified as "Saitama Prefecture Health Management Practices" that would participate in our study. Fourth, it was impossible to examine the individual effects of the healthy lunch and nutrition education. Fifth, we did not examine any changes to the meals other than the healthy lunch. Despite these limitations, this is the first study to show that the workplace dietary intervention and education may reduce employees' salt intake and Na/K ratio in Japanese worksite settings, using validated multiple-spot urine collections. Further studies with a purpose-specific population, including a larger number of participants, are needed to confirm our findings.

5 | CONCLUSIONS

This study showed that a workplace intervention involving subsidized healthy lunch and nutrition education reduced employees' salt intake and Na/K ratio after 1 year. Our findings suggest that this intervention program may be an effective and appropriate approach for small business establishments without a workplace cafeteria.

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CONFLICT OF INTEREST

Authors declare no conflict of interest for this article.

DISCLOSURE

Approval of the research protocol: This study was approved by the Ethical Committee of Kagawa Nutrition University (Approval number: 209). Informed consent: All participants provided informed consent to participate in this study. Registry and registration no. of the study/trial: The registration number of this study is UMIN 000036044 (UMIN-CTR). Animal studies: N/A.

AUTHOR CONTRIBUTIONS

Keiko Sakaguchi and Yukari Takemi designed the study; Keiko Sakaguchi, Fumi Hayashi, Kaori Koiwai, and Yukari Takemi conducted the experiment; Keiko Sakaguchi analyzed the data; Keiko Sakaguchi drafted the manuscript. Masakazu Nakamura supervised manuscript structure from the viewpoint of occupational health. All the authors read, critically revised, and approved the final manuscript.

DATA AVAILABILITY STATEMENT

Research data are not shared due to ethical restrictions.

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