RESEARCH PAPER

The lack of opportunity to eat together is associated with an increased risk of weight loss among independent older adults: a prospective cohort study based on the JAGES

Taro Kusama[1,2], Sakura Kiuchi[2], Yukako Tani[3], Jun Aida[4], Katsunori Kondo[5,6], Ken Osaka[2]

[1]Division for Regional Community Development, Liaison Center for Innovative Dentistry, Tohoku University Graduate School of Dentistry, Sendai, Miyagi, 980-8575, Japan
[2]Department of International and Community Oral Health, Tohoku University Graduate School of Dentistry, Sendai, Miyagi, 980-8575, Japan
[3]Department of Global Health Promotion, Graduate School of Medical and Dental Sciences, Tokyo Medical and Dental University, Bunkyo-ku, 113-8510, Tokyo, Japan
[4]Department of Oral Health Promotion, Graduate School of Medical and Dental Sciences, Tokyo Medical and Dental University, Bunkyo-ku, 113-8510, Tokyo, Japan
[5]Department of Social Preventive Medical Sciences, Center for Preventive Medical Sciences, Chiba University, Chuo-ku, Chiba, 263-8522, Japan
[6]Department of Gerontological Evaluation, Center for Gerontology and Social Science, National Center for Geriatrics and Gerontology, Obu, Aichi, 474-8511, Japan

Address correspondence to: T. Kusama, Division for Regional Community Development, Liaison Center for Innovative Dentistry, Tohoku University Graduate School of Dentistry 4-1, Seiryo-machi, Aoba-ku, Sendai, Miyagi 980-8575, Japan.
Tel: (+81) 22 717 7639. Email: taro.kusama.a2@tohoku.ac.jp

Abstract

Objective: the present study aimed to investigate the relationship between the frequency of eating together and the risk of weight loss in older adults.
Methods: this was a three-year follow-up prospective cohort study based on a self-reported questionnaire. We used data from the Japan Gerontological Evaluation Study (JAGES) conducted in 2016 and 2019. The participants were independent older adults aged ≥65 years in Japan. We used >5% weight loss during follow-up as the outcome variable and frequency of eating together as the explanatory variable. The relative risks (RRs) and 95% confidence intervals (95% CIs) were estimated based on the Poisson regression model with a Huber–White sandwich estimator for standard errors, including possible confounders.
Results: among 56,919 participants, the mean age was 73.0 years (1SD = 5.5) at baseline, and 47.9% were male. About 15.1% (n = 8,596) of the participants experienced >5% weight loss during follow-up. The proportion of each category of the eating together frequency was 36.6% for 'every day', 10.3% for 'several times a week', 26.8% for 'several times a month', 20.5% for 'several times a year' and 5.8% for 'seldom'. Compared to 'every day', only 'several times a year (RR = 1.07, 95% CI = 1.01–1.13)' and 'seldom (RR = 1.17, 95% CI = 1.08–1.27)' were significantly associated with the increased risk of >5% weight loss.
Conclusion: there is a temporal association between less frequent opportunities to eat together and the increased risk of weight loss among independent older adults.

Keywords: malnutrition, weight loss, eating behaviour, older adults, cohort study

Key Points

- Weight loss is a critical health problem among older adults.
- Eating together is one of the factors affecting older adults' health conditions.
- The lack of opportunity to eat together was associated with an increased risk of weight loss among older adults.
- A clear dose-response relationship by frequency of eating together was not observed.
- The opportunity to eat together may contribute to maintaining older adults' nutritional status.

Introduction

Deterioration of nutritional status is a significant health issue among older adults. Weight loss is one of the clinical signs of malnutrition among older adults, and 15–20% of older adults experienced >5% weight loss in the last six months [1]. Weight loss in later life leads to subsequent health problems, including cognitive decline [2] or disability [3], and it ultimately leads to an increased risk of mortality [4]. Most risk factors for weight loss, such as limitation of physical activity, poor oral health and comorbidity, are commonly found in older adults [5, 6]; therefore, the elucidation of modifiable factors that prevent weight loss among older adults is required.

Previous studies have emphasized the importance of social relationships in maintaining health conditions [7–9]. Social isolation and loneliness, which are subordinate concepts of social relationships [7], are prevalent among older adults due to the progression of an ageing society [9]. The opportunity to have a meal with someone is a kind of eating behaviour related to social isolation or loneliness [10]. Previous studies have revealed that eating with someone contributes to favourable health conditions, including mental health [11] and a decreased risk of mortality [12, 13].

Previous studies also suggested an association between eating alone and poor nutritional status among community-dwelling older adults [14], and eating alone may increase the risk of malnutrition. However, these previous studies were cross-sectional designs and did not mention their causality [14]. Additionally, most studies treated the status of 'eating alone' as just the presence or absence of 'eating alone'. They did not evaluate the dose–response relationship between the frequency of eating together and nutritional status. Elucidating the sufficient frequency of eating together to maintain the nutritional status of older adults will contribute to planning an effective intervention for weight loss prevention. Thus, we investigated the relationship between the frequency of eating together and the incidence of weight loss among older adults using cohort data.

Methods

Study design and participants

The present study was a three-year follow-up prospective cohort design based on a self-reported questionnaire. We used data from the Japan Gerontological Evaluation Study (JAGES), which aims to investigate social determinants of health under the collaboration of multiple universities and municipalities, and it targeted independent older adults above 65 years of age who were not certified to be eligible for long-term public care [15]. Baseline and follow-up surveys were conducted in 2016 and 2019, respectively, and 32 municipalities in Japan were included in these surveys. The questionnaires were sent to the participants by mail and retrieved by mail if they consented. We excluded participants whose information about gender, age, weight and height was missing or invalid. Those whose activities of daily living were not independent were also excluded from the analysed population.

Outcome variables

We used the clinically significant level of weight loss during follow-up as the outcome variable. We determined those who experienced >5% weight loss as a clinically significant level of weight loss. Previous studies have reported an association between >5% weight loss and an increased risk of mortality [16, 17]. We obtained the participants' weight at baseline and follow-up using a self-reported questionnaire, divided the weight in 2019 by that in 2016 and calculated the proportional change of weight per participant. A decrease in weight >5% was categorized as an incidence of weight loss. The previous study confirmed the accuracy of self-reported height and weight of the participants in the JAGES [18]. The interclass correlation coefficient between self-reported and measured weight was 0.97. We excluded participants who reported invalid weights and heights (more than 4 SD of the distribution of these variables in the Japanese population, as obtained from the Japanese National Health and Nutrition Survey) from the analysed population [19]. For the sensitivity analysis, we also used >10% weight loss as the outcome variable.

Explanatory variable

We used the frequency of eating together as an explanatory variable. We asked the participants, 'How often do you eat meals with someone else?' The response options were 'every day', 'several times a week', 'several times a month', 'several times a year' and 'seldom'. Their responses were directly used as categorical variables. We also used the dichotomous variable 'several times a month or more' and 'less than several times a month' for sensitivity analysis because the bias due to misclassification can be interpreted more accessible by employing the dichotomous variables.

Covariates

We selected possible confounders as covariates based on clinical knowledge and previous studies [5, 20–23]. The covariates included in the analysis were gender (male/female) and age (65-69/70-74/75-79/80-84/≥85) as sociodemographic factors; living status (living with someone/living alone) and marital status (with/without spouse) as family structures; equivalent income (<2.00 million JPY/2.00–3.99 million JPY/≥4.00 million JPY: 100 JPY ≈ 1USD) and the number of years of education (≤9 years/10-12 years/≥13 years) as socioeconomic status; comorbidities (stroke, diabetes, cancer and dementia), cognitive decline, depressive symptoms and number of remaining teeth (≤19/≥20) as current general, mental and oral health conditions; instrumental activities of daily living (IADL) and body mass index (BMI) at baseline. We evaluated IADL using the Tokyo Metropolitan Institute of Gerontology Index of Competence [24]. Cognitive decline was assessed by Kihon Checklist-Cognitive Function, and we treated those who corresponded to at least one of the three options as having a cognitive decline [25]. Depressive symptoms were assessed by the geriatric depressive scale-15 with a cut-off of 5 points [26]. We also included the frequency of meeting friends (≥1 times/week, ≥1 time/month, or several times a year/never) as the degree of social isolation, which is widely used to measure social isolation [27], and the frequency of vegetable/fruit intake (≥1 time/day or <1 time/day) and frequency of meat/fish intake (≥1 time/day or <1 time/day) as a current daily diet. Additionally, we considered gender and living status as effect modifiers in the relationship between the frequency of eating together and weight loss because previous studies on eating together or solitary eating reported differences within gender and living status in the results [20, 21].

Statistical analysis

We employed Poisson regression models to evaluate the effect of eating together on weight loss and calculated the relative risks (RRs) and 95% confidence intervals (95% CIs). The proportion of >5% weight loss incidence was >10%, and logistic regression analysis would overestimate the relative risk; therefore, we employed the Poisson regression model with a Huber–White sandwich estimator for standard errors [28, 29]. For >10% weight loss incidence, we estimated odds ratios (ORs) and 95% CIs based on the logistic regression model. We built three models: model 1 was a crude model, model 2 included gender and age, and model 3 included all covariates. We also created the models including the interaction terms between gender or living status and the frequency of eating together to confirm the effect modification of gender and living status in the relationships between eating together and excessive weight loss. We also conducted the analysis with the stratification by gender and living status [30]. In the analysis with the 'Living alone' stratum, we changed the reference category to 'Several times a month', considering the distribution of the participants. We conducted multiple imputations to reduce selection bias. We created 20 imputed datasets using multivariate imputations by chained equations (MICE) and combined the estimates obtained from each dataset using Rubin's rule [31]. For the sensitivity analysis, we also conducted a complete case analysis, excluding those with any missing values. We used Stata/MP version 16.1 (Stata Corp., College Station, TX, USA) to perform the statistical analysis.

Ethical issues

The JAGES in 2016 and 2019 followed the procedures approved by the Ethics Committee on Research of Human Subjects at the National Center for Geriatrics and Gerontology (No. 992 and No. 1274-2), Chiba University (No. 2493 and 3442), and the Japan Agency for Gerontological Evaluation Study (2019–01). Additionally, we followed the STROBE statement to report our observational study.

Results

Figure 1 presents a flowchart of the participants' inclusion. The response rate of participants was 70.3%, and the follow-up rate was 56.2%. Finally, 56,919 participants were included in our analysis. Supplementary Table S1 presents the characteristics of the participants before the multiple imputations.

Initially, MICE imputed 15,328 participants with missing values, and Table 1 and Supplementary Table S2 show the characteristics of participants after multiple imputations. The average age of participants at baseline was 73.0 years (1 SD = 5.5), with 47.9% male. About 15.1% (n = 8,596) of the participants experienced >5% weight loss, and 4.8% (n = 2,736) experienced >10% weight loss during the follow-up. The proportion of participants in each category of the frequency of eating together at baseline, i.e. 'every day', 'several time a week', 'several times a month', 'several times a year' and 'seldom' was 36.6% (n = 20,818), 10.3% (n = 5,895), 26.8% (n = 15,271), 20.5% (n = 11,656) and 5.8% (n = 3,279), respectively. The proportion of those who experienced >5% weight loss in each category of the eating together frequency was 14.3% for 'every day', 14.8% for 'several times a week', 14.6% for 'several times a month', 16.2% for 'several times a year' and 19.0% for 'seldom' (Table 2). The incidence proportions of >5% weight loss were high among the categories of 'several times a year' and 'seldom'. For >10% weight loss, a similar trend in the proportional difference was observed.

Table 3 shows the association between the frequency of eating together and weight loss. In model 3, the frequency of eating together 'several times a year (RR = 1.07, 95% CI = 1.01–1.13)' and 'seldom (RR = 1.17, 95% CI = 1.08–1.27)' was significantly associated with an increased risk of >5% weight loss, respectively. For >10% weight loss, the frequency of eating together 'seldom (OR = 1.29, 95% CI = 1.10–1.52)' was also associated. In the complete case analysis, the point estimates were consistent with those obtained from the imputed datasets (Supplementary Table S3). The sensitivity analysis using
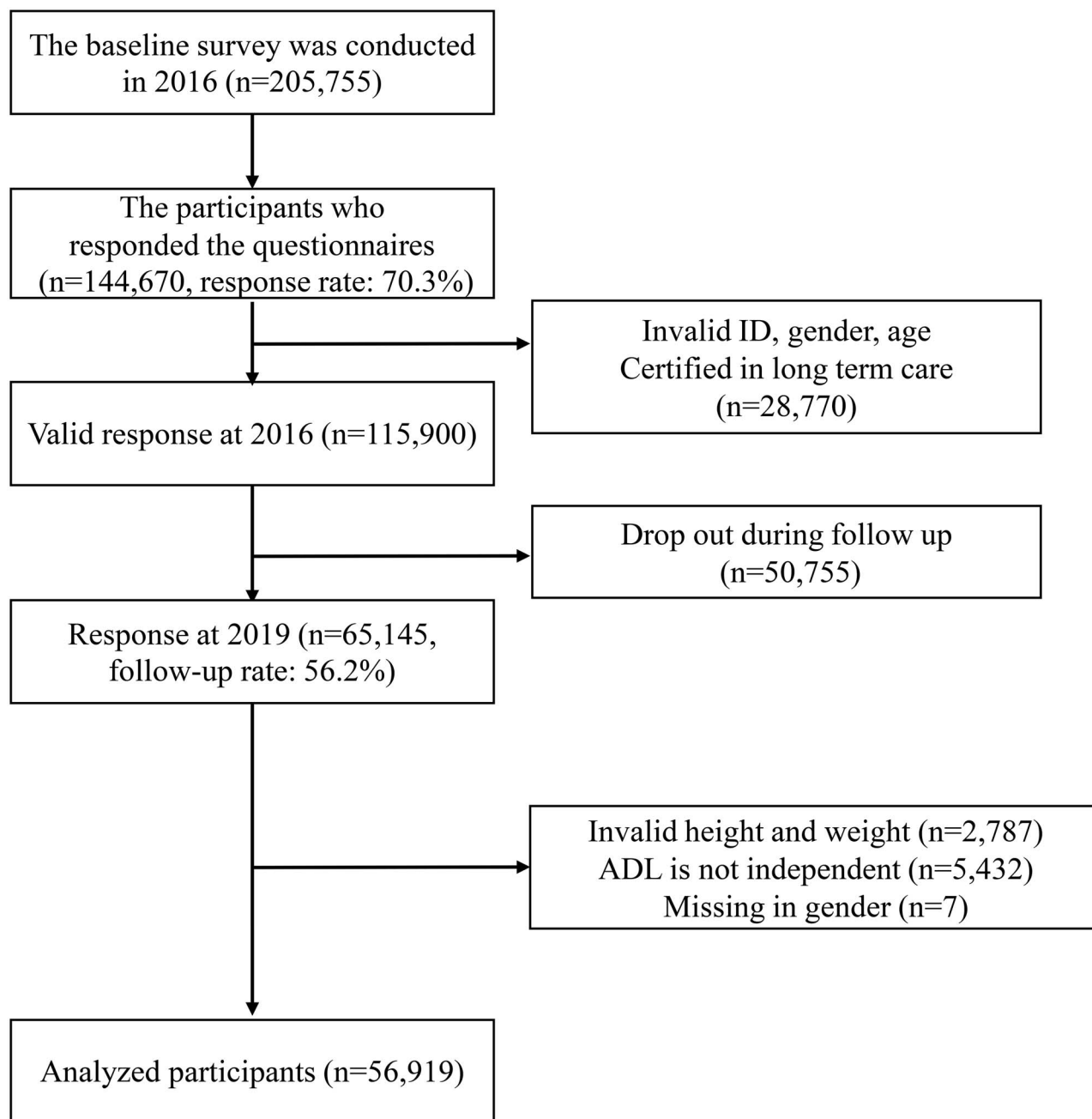
Figure 1. The participants flow for analytic sample (n=56,919).

the dichotomous variable suggested that the frequency of eating together 'less than several times a month' were higher risk of >5% weight loss compared to 'several times a month or more' (RR = 1.08, 95% CI = 1.03–1.13) (Supplementary Table S4).

We also evaluated the interaction effect between gender or living status and the frequency of eating together. However, the interaction effects of both variables on the multiplicative scale were not significant (all $P > 0.1$) (Supplementary Tables S5 and S6). Table 4 shows the results stratified by gender and living status.

Discussion

The present study results revealed that among independent older adults, those who had the opportunity to eat together less than several times a month were at an increased risk of clinically significant level of weight loss. Further, the association remained statistically significant even after adjusting for social isolation and daily diet. We could not find a significant effect modification by gender and living status in the association between the frequency of eating together and weight loss.

Table 1. Descriptive characteristics of the participants at baseline after multiple imputations

Characteristics n(%)	All participants (n = 56,919)	Weight loss during three-year follow-up	
		≤5% (n = 48,323)	>5% (n = 8,596)
Frequency of eating together			
Everyday	20,818 (36.6)	17,846 (36.9)	2,972 (34.6)
Several times a week	5,895 (10.3)	5,020 (10.4)	875 (10.2)
Several times a month	15,271 (26.8)	13,035 (27.0)	2,236 (26.0)
Several times a year	11,656 (20.5)	9,766 (20.2)	1,890 (22.0)
Seldom	3,279 (5.8)	2,656 (5.5)	623 (7.2)
Gender			
Male	27,259 (47.9)	23,164 (47.9)	4,095 (47.6)
Female	29,660 (52.1)	25,159 (52.1)	4,501 (52.4)
Age at 2016			
65–69	18,992 (33.4)	16,610 (34.4)	2,382 (27.7)
70–74	17,113 (30.0)	14,771 (30.6)	2,342 (27.3)
75–79	13,078 (23.0)	10,969 (22.7)	2,109 (24.5)
80–84	5,986 (10.5)	4,686 (9.7)	1,300 (15.1)
≥85	1,750 (3.1)	1,287 (2.6)	463 (5.4)
Living status			
Living with someone	48,579 (85.3)	41,200 (85.3)	7,379 (85.8)
Living alone	8,340 (14.7)	7,123 (14.7)	1,217 (14.2)
Marital status			
With spouse	43,263 (76.0)	36,838 (76.2)	6,425 (74.7)
Without spouse	13,656 (24.0)	11,485 (23.8)	2,171 (25.3)
Equivalent income (100 JPY ≈ 1 USD)			
<200 million JPY	25,995 (45.7)	21,729 (45.0)	4,266 (49.6)
200–399 million JPY	24,044 (42.2)	20,637 (42.7)	3,407 (39.7)
≥400 million JPY	6,880 (12.1)	5,957 (12.3)	923 (10.7)
Education			
≤9 years	14,167 (24.9)	11,695 (24.2)	2,472 (28.8)
10–12 years	24,971 (43.9)	21,316 (44.1)	3,655 (42.5)
≥13 years	17,781 (31.2)	15,312 (31.7)	2,469 (28.7)
Comorbidities			
Stroke	1,242 (2.2)	1,039 (2.2)	203 (2.4)
Diabetes	7,014 (12.3)	5,607 (11.6)	1,407 (16.4)
Cancer	2,138 (3.8)	1,790 (3.7)	348 (4.1)
Dementia	62 (0.1)	49 (0.1)	13 (0.2)
Number of teeth			
≥20	34,570 (60.7)	29,849 (61.8)	4,721 (54.9)
≤19	22,349 (39.3)	18,474 (38.2)	3,875 (45.1)
Instrumental activities of daily living			
Good	34,686 (60.9)	29,716 (61.5)	4,970 (57.8)
Poor	22,233 (39.1)	18,607 (38.5)	3,626 (42.2)
Cognitive decline			
No	40,206 (70.6)	34,331 (71.0)	5,875 (68.3)
Yes	16,713 (29.4)	13,992 (29.0)	2,721 (31.7)
Depressive symptoms			
GDS-15 ≤ 4	46,847 (82.3)	40,043 (82.9)	6,804 (79.2)
GDS-15 ≥ 5	10,072 (17.7)	8,280 (17.1)	1,792 (20.8)
Frequency of meeting friends			
≥1 time/week	28,974 (50.9)	24,847 (51.4)	4,127 (48.0)
≥1 time/month	13,399 (23.5)	11,402 (23.6)	1,997 (23.2)
Several times a year/seldom	14,546 (25.6)	12,074 (25.0)	2,472 (28.8)
Frequency of vegetable/fruits intake			
≥1 time/day	46,906 (82.4)	40,033 (82.8)	6,873 (80.0)
<1 time/day	10,013 (17.6)	8,290 (17.2)	1,723 (20.0)
Frequency of meat/fish intake			
≥1 time/day	30,961 (54.4)	26,517 (54.9)	4,444 (51.7)
<1 time/day	25,958 (45.6)	21,806 (45.1)	4,152 (48.3)
BMI at baseline			
Mean (SD)	22.8 (3.0)	22.7 (3.0)	23.5 (3.3)

NOTE: Each response was the average of 20 imputed datasets. Abbreviation: GDS-15, geriatric depressive scale-15.

Table 2. The proportion of those who experienced weight loss during follow-up by the frequency of eating together (n = 56,919)

% (n)	Frequency of eating together					
	Everyday	Several times a week	Several times a month	Several times a year	Seldom	Total
Weight loss during the follow-up						
>5%	14.3 (2,972)	14.8 (875)	14.6 (2,236)	16.2 (1,890)	19.0 (623)	15.1 (8,596)
≤5%	85.7 (17,846)	85.2 (5,020)	85.4 (13,035)	83.8 (9,766)	81.0 (2,656)	84.9 (48,323)
>10%	4.5 (927)	4.8 (283)	4.5 (689)	5.2 (611)	6.9 (227)	4.8 (2,736)
≤10%	95.5 (19,891)	95.2 (5,612)	95.5 (14,582)	94.8 (11,045)	93.1 (3,052)	95.2 (54,183)
Total	100.0 (20,818)	100.0 (5,895)	100.0 (15,271)	100.0 (11,656)	100.0 (3,279)	100.0 (56,919)

NOTE: Each response was the average of 20 imputed datasets. Bold values indicate $P < 0.05$

Table 3. The association between weight loss and the frequency of eating together ($n = 56,919$)

	Model 1[a]		Model 2[b]		Model 3[c]	
	>5% weight loss RR (95% CI)	>10% weight loss OR (95% CI)	>5% weight loss RR (95% CI)	>10% weight loss OR (95% CI)	>5% weight loss RR (95% CI)	>10% weight loss OR (95% CI)
Frequency of eating together						
Everyday	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Several times a week	1.04 (0.97–1.11)	1.08 (0.94–1.24)	1.02 (0.95–1.09)	1.06 (0.92–1.21)	1.05 (0.98–1.13)	1.09 (0.95–1.26)
Several times a month	1.03 (0.97–1.08)	1.01 (0.92–1.12)	0.99 (0.94–1.04)	0.97 (0.87–1.07)	1.01 (0.96–1.07)	1.00 (0.90–1.11)
Several times a year	**1.14 (1.08–1.20)*****	**1.19 (1.07–1.32)****	**1.08 (1.03–1.14)****	1.11 (1.00–1.23)	**1.07 (1.01–1.13)***	1.08 (0.97–1.21)
Seldom	**1.33 (1.23–1.44)*****	**1.60 (1.37–1.86)*****	**1.26 (1.16–1.36)*****	**1.46 (1.25–1.70)*****	**1.17 (1.08–1.27)*****	**1.29 (1.10–1.52)****

Abbreviations: RR, relative risk; OR, odds ratio; 95% CI, 95% confidence interval. [a]Model 1: Crude model. [b]Model 2: Adjusted for gender and age. [c]Model 3: Adjusted for gender, age, living status, marital status, equivalent income, education, number of teeth, comorbidities (stroke, diabetes, cancer and dementia), instrumental activities of daily living, cognitive decline, depressive symptoms, frequency of meeting friends, frequency of vegetable/fruits intake, frequency of meat/fish intake and BMI at baseline. *P < 0.05. **P < 0.01. ***P < 0.001. Bold values indicate $P < 0.05$

A previous cross-sectional study revealed that eating alone was associated with underweight among community-dwelling older adults [20]. Our cohort study also confirmed the longitudinal relationship between eating alone/together and the increased risk of a clinically significant level of weight loss. Most studies investigating the association between eating alone/together and health conditions did not consider the frequency of eating together [14]. The present study considered the frequency of eating together, and we evaluated the dose–response relationship between the frequency of eating together and the risk of weight loss. However, a clear dose–response relationship could not be observed. When the frequency of eating together was less than several times a month, the risk of weight loss was statistically significant. A previous study also reported this kind of non-linear association between the frequency of eating together and nutritional status [32]. The study suggested that those who have the opportunity to eat together less than once a month reported significantly lower dietary intake of foods and, among those having the opportunity to eat together one or more times a month, a significant difference was not observed.

From the result of the present study, the association between the frequency of eating together and weight loss was observed even after controlling for social isolation and daily diet. There is the possibility that general social interaction

or daily intake of foods may not have contributed to the mechanism between eating together and weight loss. One possible mechanism that explains the relationship between the frequency of eating together and weight loss is 'social facilitation of eating'. It is a phenomenon in which when people eat with others, they tend to eat more food than when they eat alone [33]. Among older adults, anorexia (the lack of appetite) is a prevalent health problem, and anorexia in later life is caused by physiological changes due to ageing, multiple medications, comorbidities and social isolation [34]. Subsequently, it increases the risk of malnutrition in older adults [35]. Therefore, it can be considered that, intrinsically, most older adults are at risk of malnutrition due to anorexia. However, the opportunity to eat together could increase the energy and nutrient intake through the social facilitation of eating and protect against the risk of weight loss due to anorexia. The effect may prolong after the opportunity to eat together. A higher protein intake was associated with a lower risk of weight loss [36]. Previous studies have reported that the intake of protein or meat was higher when eating with others than when eating alone [37, 38].

We did not observe a linear dose–response relationship between the frequency of eating together and the risk of weight loss. The result implied no difference in the risk of weight loss within the frequency of eating together several times a month or more. A previous qualitative study also

Table 4. The association between weight loss and the frequency of eating together by gender and living status

Stratified by gender	>5% weight loss		>10% weight loss	
	Male (n = 27,259)	Female (n = 29,660)	Male (n = 27,259)	Female (n = 29,660)
	RR (95% CI)[a]	RR (95% CI)[a]	OR (95% CI)[a]	OR (95% CI)[a]
Frequency of having the meal with someone				
Everyday	Ref.	Ref.	Ref.	Ref.
Several times a week	1.08 (0.97–1.21)	1.03 (0.94–1.14)	1.22 (0.99–1.50)	1.01 (0.83–1.23)
Several times a month	0.99 (0.92–1.07)	1.03 (0.96–1.10)	1.01 (0.86–1.17)	0.98 (0.85–1.14)
Several times a year	1.05 (0.97–1.13)	**1.09 (1.01–1.18)***	1.04 (0.90–1.21)	1.12 (0.96–1.32)
Seldom	**1.17 (1.05–1.30)****	**1.16 (1.02–1.32)***	**1.26 (1.02–1.56)***	**1.37 (1.07–1.77)***
Stratified by living status	>5% weight loss		>10% weight loss	
	Living with someone (n = 48,579)	Living alone (n = 8,340)	Living with someone (n = 48,579)	Living alone (n = 8,340)
	RR (95% CI)[b]	RR (95% CI)[b]	OR (95% CI)[b]	OR (95% CI)[b]
Frequency of having the meal with someone				
Everyday	Ref.	1.10 (0.87–1.40)	Ref.	1.11 (0.66–1.86)
Several times a week	1.08 (1.00–1.17)	0.98 (0.85–1.14)	1.04 (0.88–1.22)	1.33 (1.00–1.76)
Several times a month	1.01 (0.96–1.07)	Ref.[c]	1.01 (0.90–1.13)	Ref.[c]
Several times a year	**1.06 (1.00–1.12)***	1.10 (0.96–1.27)	1.10 (0.99–1.24)	0.99 (0.73–1.33)
Seldom	**1.18 (1.07–1.29)****	1.11 (0.92–1.33)	**1.27 (1.06–1.53)***	1.38 (0.97–1.96)

Abbreviations: RR, relative risk; OR, odds ratio; 95% CI, 95% confidence interval. [a]Adjusted for age, living status, marital status, equivalent income, education, number of teeth, comorbidities (stroke, diabetes, cancer and dementia), instrumental activities of daily living, cognitive decline, depressive symptoms, frequency of meeting friends, frequency of vegetable/fruits intake, frequency of meat/fish intake and BMI at baseline. [b]Adjusted for gender, age, marital status, equivalent income, education, number of teeth, comorbidities (stroke, diabetes, cancer and dementia), instrumental activities of daily living, cognitive decline, depressive symptoms, frequency of meeting friends, frequency of vegetable/fruits intake, frequency of meat/fish intake and BMI at baseline. [c]The reference category was changed to 'Several times a month' because, among the living alone stratum, the most significant number of participants was included in this category. *$P < 0.05$. **$P < 0.01$. ***$P < 0.001$.

reported that eating alone does not necessarily mean a lonely thing but felt autonomous for community-dwelling older adults living alone [10]. Additionally, a previous study did not find differences in food intake among those whose frequency of eating together was more than once a month [32]. Based on the discussion so far, there is the possibility that the frequent opportunity of eating together would contribute to preventing malnutrition among older adults; meanwhile, the frequency may not need to be high, such as every day.

Among those living alone, we could not observe a clear association between the frequency of eating together and weight loss. We consider that there are two explanations for the present result. One is that small sample size and random error affected the estimates, and the other is that the context of eating together differs between those living alone and those living with others. Further analysis with the more detailed survey for the eating circumstance among those living alone would provide new insight.

From a public health perspective, maintaining or providing opportunities to eat together for older adults would contribute to keeping their nutritional status. Even under the pandemic of airborne infectious disease, effective prevention measures in the restaurant or dining room, including limiting the number of people and ventilation, would maintain the opportunities to eat together [39, 40].

The present study has several limitations. First, we used self-reported weight and frequency of eating together as the outcome variable and explanatory variable, respectively. The accuracy of weight in JAGES was confirmed elsewhere, and the proportional change of weight of an individual was used in the present study, which may have reduced information bias [18]. The variable we used to measure the frequency of eating together is not validated; however, a similar ordinal variable was also used in the previous studies [32]. The self-reported measure generally leads to misclassification. In the present study, we consider that the misclassification of outcome and explanatory variable were non-differential, and it would have biased the estimates towards the null. Second, we evaluated only the frequency of eating together and did not consider who they ate with. The type of person whom one eats with may have different effects on individual nutritional status. A previous meta-analysis suggested that social facilitation of eating was observed when 'eating with friends' compared to 'eating alone' and not when 'eating with stranger or acquaintance' was compared [33]. Therefore, further research considering the person one eats with is required to elucidate the relationship between eating together and nutritional status. Third, for representativeness, although the baseline survey included large populations from many municipalities in Japan, the follow-up rate of the present study was not high. Possible reasons for loss to follow-up were considered to be death, being certified in long-term care, moving to other municipalities, non-response or not being included in the participants at the follow-up survey.

The distribution of baseline characteristics showed that those lost to follow-up tended to be older and had a risk factor for deteriorating health conditions (Supplementary Table S7). Both the lack of eating together and weight loss increase the risk of mortality [4, 12, 13]. Therefore, the risk of weight loss among those who had less opportunity to eat together may be underestimated because those who had less opportunity to eat together were considered to be lost due to death. The estimated RR of the present study may also be underestimated. Fourth, there is the concern about the influence of time-varying exposure on the estimates. We checked the association between the frequency of eating together at baseline and follow-up (Supplementary Table S8). The frequency of eating together changed over the period among almost half of the participants. Suppose there are time-varying confounders in the association between the frequency of eating together and weight loss. In that case, the marginal structural model with three-point-panel data will provide more appropriate estimates [41]. Lastly, we included possible confounders as covariates based on the hypothesized causal diagram. However, the existence of unknown confounders or residual confounding may have affected the estimates. The strengths of the present study are as follows: first, it used a longitudinal design, and we could infer the temporal association between the frequency of eating together and weight loss. Second, as we already mentioned, our results were consistent with the knowledge obtained from previous studies on eating together and the social facilitation of eating [14, 33]. They contribute to the generalizability of our results.

Conclusion

The present study revealed the temporal association between the lack of opportunity to eat together and increased risk of weight loss among independent older adults using a large prospective cohort data. However, significant differences in the risk of weight loss were not observed within the frequency of eating together several times in a month or more.

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