Effects of Consumption Frequency of 10 Food Groups on Activities of Daily Living in Elderly Japanese Women: A Longitudinal Cohort Study

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Abstract

Background

This study aimed to examine the effects of the consumption frequency of 10 food groups on activities of daily living (ADL) in elderly Japanese women.

Methods

This was a four-year longitudinal cohort study conducted in Itabashi Ward, Tokyo. Participants were 1,111 community-dwelling elderly women aged 75 to 85 years, without baseline ADL disability or missing values. The main outcome measures were the relationship between the baseline consumption frequency of 10 food groups and future incidence of ADL disability. The relationship between baseline consumption frequency of 10 food groups and change in ADL status was analyzed through logistic regression analyses.

Results

The incidence rate of ADL disability was 7.6%. The trend tests show that less-frequent consumption of soy products, colored vegetables, and fats/oils leads to a significantly higher odds ratio of ADL disability incidence whether adjusted or not ($p < 0.005$, $p = 0.03$, and $p = 0.02$, respectively, when adjusted).

Conclusions

Our results suggest that in community-dwelling elderly Japanese women, lower consumption frequency of soy products, colored vegetables, or fats/oils are risk factors for future incidence of ADL disability.

Background

Many foods and ingredients have been proposed as effective for maintaining cognitive or physical functions in old age. Epidemiological studies have suggested, for example, that choline [1], cocoa flavanols [2], concord grape juice [3], and caffeine [4, 5] may support the maintenance of cognitive functions. Consumption of extra proteins or essential amino acids is effective for maintaining physical function; the Framingham Offspring Cohort study suggested that sufficient protein intake helps preserve muscle strength or volume [6]. However, it is still unknown whether the ingredients that contribute to cognitive function necessarily contribute to physical function and vice versa. From the viewpoint of independent living in old age, studies focusing on relationships between consuming specific foods and “total” daily life capacities are warranted.

Several cohort studies have reported increased risks of frailty in people who follow certain dietary patterns compared to those with healthy dietary patterns [7–10]. Adherence to the “prudent” pattern characterized by high intake of olive oil and vegetables was associated with a low incidence of frailty, while adherence to the “westernized” pattern characterized by high intake of refined bread, dairy products, red and/or processed meat was associated with a high incidence of frailty [7]. The higher the intake of vegetables and fruits, the lower the incidence of frailty [8]. Researchers have reported that, in longitudinal studies, people with “biscuits and snacking” patterns and “pasta” patterns were at higher risk of developing frailty [9] and activities of daily living (ADL) disability [10].

However, cohort studies revealing the effects of the intake of certain food groups, rather than of dietary patterns, on ADL status among the elderly Japanese are lacking.

Methods

Aim

The present study aimed to identify specific food groups that may promote or prevent the onset of ADL disability among elderly women in Japan. We examined the baseline consumption frequency of 10 food groups (fruits, colored vegetables, soy products, milk, seaweed, fats/oil, seafood, potatoes, eggs, and meat) and studied the relationship between the baseline food consumption and incidence of ADL disability four years later.

Study Design

This four-year longitudinal cohort study was conducted with a follow-up of community-dwelling elderly women without baseline ADL disability. Baseline and follow-up measurements were conducted in autumn 2008 and 2012, respectively. Independent variables included the consumption frequencies of the 10 food groups at baseline, while the dependent variable was the incidence of ADL disability over 4 years.

Participants

The longitudinal analysis targeted 1,111 community-dwelling elderly women without ADL disability at baseline and without any missing data at follow-up. The selection process commenced in 2008, when an invitation letter was sent to all women born between October 1, 1923, and November 30, 1933, living in the southeastern area of Itabashi Ward, Tokyo (N = 10,948). Of the 1,670 respondents with the intention to participate, 1,289 attended a baseline examination from October 15 to November 3, 2008. Of the 1,289 participants, 10 had baseline ADL disability and one lacked information on ADL, resulting in 1,278 participants without baseline ADL disability. Researchers conducted the follow-up survey in October 2012. Of the 1,278 participants, 50 did not participate in the 2012 surveys, resulting in 1,228 participants who were followed up with. Of those participants, 117 lacked information regarding ADL. Thus, complete pairs of information on ADL status both at baseline and follow-up were obtained for 1,111 participants. For these participants, follow-up time ranged from 1,449 to 1,476 days, (coefficient of variation: 0.004,

median: 1,461 days); we believe that the variation was small enough not to require inclusion as a covariate. The Ethics Committee of Tokyo Metropolitan Institute of Gerontology (TMIG) approved the study protocol. All participants provided written informed consent regarding academic usage of their data.

Setting

Researchers conducted the baseline data collection through on-site interviews at TMIG and partly through mail/telephone surveys at follow-up. TMIG conducts annual physical/medical examinations for elderly people in the community, the present study used data from the 2008 (baseline) and 2012 (follow-up) examinations.

Measurements

At the baseline examination, researchers determined consumption frequency of the 10 food groups and ADL status through structured interviews conducted by trained research associates with no prior knowledge about each participant's profile. At the follow-up examination, the researchers determined ADL status through interviews for the on-site participants and through mail/telephone surveys for the others. Researchers evaluated ADL status through five of the six questions (omitting "continence") from the Katz Index [11]; inquiries into independence regarding five activities (i.e., walking, eating, bathing, dressing, and toileting) were conducted. The initial part of the printed questionnaire on ADL consisted of a main sentence: "Concerning activities of daily living, please choose one alternative for each of the following items." This was followed by individual questions and alternatives:

Q1. Can you walk by yourself? Q2. Can you feed yourself? Q3. Can you take a bath by yourself? Q4. Can you change clothes yourself? Q5. Can you go to the bathroom by yourself and use it?

ADL disability was defined as the inability to implement at least one of the above five activities without assistance.

A food-frequency questionnaire, which was originally developed to measure the dietary variety of Japanese people, was used to measure the consumption frequency of each of the 10 food groups (i.e., seafood, meat, eggs, milk, soy products, colored vegetables, seaweed, potatoes, fruits, and fats/oils) [12]. The initial part of the printed questionnaire consisted of a main question: "How often do you consume each of the following food groups?" and a note to the interviewer: "Ask about the situation in the past week or so," followed by the individual names of the food groups. The individual names of the food groups were presented with a supplementary explanation in parenthesis as follows: A. Seafood (raw or processed: all fish and shellfish); B. Meat (raw or processed: all meat); C. Eggs (chicken eggs and quail eggs. Fish eggs should be classified as "A. Seafood"); D. Milk (excluding coffee/fruit-flavored milk); E. Soy products (foods using soybeans, such as tofu and natto); F. Colored vegetables (dark vegetables such as carrots, spinach, pumpkins, and tomatoes); G. Seaweed (regardless of raw or dried); H. Potatoes, I. Fruits (regardless of fresh or canned. Tomatoes should be classified as "F. Colored vegetables"); and J.

Fats/oils (count dishes that use oil, such as stir-fry, butter- or margarine-coated bread). The 10 specific food groups were selected by excluding the daily foods eaten by almost all elderly Japanese: rice, miso soup, pickled vegetables, bread, and noodles, from the original 15 food groups commonly consumed in Japan [13]. The individual names of the food groups were followed by four alternatives: “1. almost every day,” “2. once every two days,” “3. once or twice a week,” and “4. almost never.” Non-fasting blood samples were also collected during the baseline assessment. The specific assays included serum albumin (bromocresol green).

Statistical Analysis

The incidence of ADL disability, depending on the baseline consumption frequency of each food group, was examined through logistic regression analyses. Univariate and multivariate logistic regression analyses were conducted with the incidence of ADL disability as the dependent variable. In the multivariate analyses, using the forced entry method, researchers adjusted the odds ratios by variables that might potentially affect both dietary habits and ADL: baseline age; binary conversion of body mass index (BMI) (1 when $23 \leq \text{BMI} \leq 29$, 2 otherwise [14]); regular exercise and sports (yes/no); current lifestyle-related diseases including diabetes, osteoporosis, stroke, and heart disease; and the intake frequency of the other food groups. For each food group, the “almost every day” category was set as the reference. Researchers conducted all statistical analyses using SPSS Statistics 17.0 (SPSS Inc., Chicago, IL).

Results

Basic Characteristics of the Participants

The baseline characteristics, such as age and body size, and consumption frequency of the 10 food groups among the 1,111 participants without baseline ADL disability or missing values at follow-up are shown in Tables 1 and 2, respectively. Serum albumin levels were between 3.5 and 5.0 g/dL: no participant was classified as hypoalbuminemic (serum concentration of albumin less than 3.5, as defined by previous studies [15]).

Table 1
Baseline Characteristics of Participants without Baseline ADL Disability (n = 1111)

<i>Characteristics</i>	Baseline		Follow up	
	Mean $\pm$ SD Number (%)	Valid responses	Mean $\pm$ SD Number (%)	Valid responses
Sex (female, %)	1111 (100.0 %)	1111	1111 (100.0 %)	1111
Age, years	78.4 $\pm$ 2.7	1111	82.5 $\pm$ 2.7	1111
Height, cm	148.0 $\pm$ 5.4	1111	147.3 $\pm$ 5.5	572
Weight, kg	49.9 $\pm$ 7.9	1111	49.3 $\pm$ 8.2	572
BMI	22.8 $\pm$ 3.3	1111	22.7 $\pm$ 3.5	572
Serum albumin, g/dL	4.3 $\pm$ 0.2	1107	Not measured	
ADL disability (yes, %)	0 (0.0 %)	1111	84 (7.6 %)	1111
Exercise and sports (yes, %)	369 (33.2 %)	1111	347 (32.4 %)	1072
Diabetes, (yes, %)	103 (9.3 %)	1111	48 (8.4 %)	572
Osteoporosis, (yes, %)	342 (30.8 %)	1111	214 (37.5 %)	571
Stroke, (yes, %)	60 (5.4 %)	1111	36 (6.3 %)	572
Heart disease (yes, %)	205 (18.5 %)	1111	123 (21.5 %)	572
Abbreviations: SD, standard deviation; ADL, activities of daily living; BMI, body mass index.				

Table 2
Baseline Distribution of Consumption Frequency for Each Food Group

<i>Food groups</i>	Almost every day		Once every two days		Once or twice a week		Almost never		Valid responses
Fruits (%)	968	(87.1)	76	(76.0)	51	(4.6)	16	(1.4)	1111
Colored vegetables (%)	959	(86.5)	96	(8.7)	45	(4.1)	9	(0.8)	1109
Soy products (%)	746	(67.1)	197	(17.7)	144	(13.0)	24	(2.2)	1111
Milk (%)	675	(60.8)	82	(7.4)	61	(5.5)	293	(26.4)	1111
Seaweed (%)	598	(53.8)	259	(23.3)	211	(19.0)	43	(3.9)	1111
Fats/oils (%)	564	(50.8)	259	(23.3)	227	(20.5)	60	(5.4)	1110
Seafood (%)	502	(45.2)	419	(37.7)	167	(15.0)	23	(2.1)	1111
Potatoes (%)	475	(42.8)	352	(31.7)	260	(23.4)	24	(2.2)	1111
Eggs (%)	395	(35.6)	315	(28.4)	308	(27.7)	93	(8.4)	1111
Meat (%)	241	(21.7)	411	(37.0)	378	(34.0)	81	(7.3)	1111

The Incidence Rate Of Adl Disability At Follow-up

Of the 1,111 participants without ADL disability at baseline and without missing values on ADL status at follow-up, 84 (7.6%) had ADL disability at follow-up while 1,027 (92%) did not; the incidence rate of ADL disability calculated using 2-point snapshots was 7.6%.

Effects of Baseline Consumption Frequency on the Incidence of ADL Disability

Crude or adjusted odds ratios of ADL disability incidence and p-values corresponding to the odds ratios for each food group and each consumption frequency are shown in Table 3. For soy products, colored vegetables, and fats/oils, overall p-values, adjusted or not, were less than 0.05. For soy products, the adjusted odds ratios corresponding to “once every two days” (OR = 2.0, 95% CI: 1.1–3.7, p = 0.03) or “once or twice a week” (OR = 2.6, 95% CI: 1.3–5.2, p = 0.01) were significantly higher than that of the reference category (“almost every day”). For colored vegetables, the adjusted odds ratio corresponding to “almost never” was significantly higher (OR = 15.2, 95% CI: 3.1–74.1, p < 0.005) than that of the reference category. For fats/oils, the adjusted odds ratio corresponding to “once or twice a week” was significantly higher (OR = 1.9, 95% CI: 1.0–3.7, p = 0.04) than that of the reference category (Table 3).

Table 3
Risk of ADL Disability at Follow-up, Depending on Baseline Consumption Frequency of Food Groups

	Crude OR (95% CI)				P-Value	Adjusted OR (95% CI)				P-Value
Seafood										
Almost every day	Reference				0.48	Reference				0.62
Once every two days	0.8	(0.5	-	1.4)	0.44	0.9	(0.5	-	1.7)	0.80
Once or twice a week	1.1	(0.6	-	2.1)	0.80	0.8	(0.4	-	1.7)	0.58
Almost never	2.5	(0.8	-	7.7)	0.11	1.2	(0.3	-	4.5)	0.83
Meat										
Almost every day	Reference				0.57	Reference				0.90
Once every two days	0.7	(0.4	-	1.4)	0.34	1.0	(0.5	-	2.0)	0.92
Once or twice a week	0.9	(0.5	-	1.7)	0.78	1.0	(0.5	-	2.1)	0.91
Almost never	1.4	(0.6	-	3.2)	0.45	1.4	(0.5	-	3.8)	0.50
Eggs										
Almost every day	Reference				0.39	Reference				0.27
Once every two days	0.6	(0.3	-	1.1)	0.07	0.7	(0.4	-	1.3)	0.23
Once or twice a week	0.7	(0.4	-	1.2)	0.23	0.6	(0.3	-	1.2)	0.16
Almost never	0.9	(0.4	-	2.0)	0.82	0.8	(0.3	-	1.9)	0.60
Milk										
Almost every day	Reference				0.30	Reference				0.53
Once every two days	0.7	(0.2	-	1.9)	0.45	0.6	(0.2	-	1.9)	0.39
Once or twice a week	1.4	(0.6	-	3.5)	0.44	1.4	(0.5	-	3.6)	0.51
Almost never	1.3	(0.8	-	2.1)	0.34	1.1	(0.7	-	2.0)	0.64
Soy products										
Almost every day	Reference				< 0.005	Reference				< 0.005

	Crude OR (95% CI)				P-Value	Adjusted OR (95% CI)				P-Value
Once every two days	1.6	(0.9	-	2.9)	0.09	2.0	(1.1	-	3.7)	0.03
Once or twice a week	2.5	(1.4	-	4.4)	< 0.005	2.6	(1.3	-	5.2)	0.01
Almost never	3.3	(1.1	-	10.0)	0.04	1.9	(0.5	-	7.8)	0.37
Colored vegetables										
Almost every day	Reference				< 0.005	Reference				0.03
Once every two days	0.9	(0.4	-	2.1)	0.76	0.8	(0.3	-	2.1)	0.68
Once or twice a week	1.6	(0.6	-	4.3)	0.32	1.4	(0.5	-	4.0)	0.57
Almost never	16.4	(4.3	-	62.4)	< 0.005	15.2	(3.1	-	74.1)	< 0.005
Seaweed										
Almost every day	Reference				0.51	Reference				0.04
Once every two days	0.7	(0.4	-	1.3)	0.27	0.7	(0.3	-	1.2)	0.20
Once or twice a week	0.8	(0.4	-	1.4)	0.43	0.5	(0.2	-	1.1)	0.08
Almost never	1.1	(0.4	-	3.3)	0.83	0.6	(0.2	-	2.2)	0.43
Potatoes										
Almost every day	Reference				0.75	Reference				0.23
Once every two days	0.8	(0.5	-	1.3)	0.37	0.9	(0.5	-	1.6)	0.65
Once or twice a week	0.9	(0.5	-	1.6)	0.81	0.7	(0.4	-	1.3)	0.28
Almost never	1.0	(0.2	-	4.5)	0.98	0.6	(0.1	-	3.6)	0.60
Fruits										
Almost every day	Reference				0.45	Reference				0.66
Once every two days	0.9	(0.3	-	2.2)	0.76	1.0	(0.4	-	2.6)	0.93
Once or twice a week	0.5	(0.1	-	2.1)	0.34	0.5	(0.1	-	2.2)	0.32

	Crude OR (95% CI)			P-Value	Adjusted OR (95% CI)			P-Value
Almost never	4.1	(1.3	- 13.0)	0.02	2.8	(0.7	- 10.6)	0.14
Fats/oils								
Almost every day	Reference			0.01	Reference			0.02
Once every two days	1.2	(0.6	- 2.1)	0.61	1.4	(0.7	- 2.6)	0.36
Once or twice a week	1.8	(1.1	- 3.2)	0.03	1.9	(1.0	- 3.7)	0.04
Almost never	2.4	(1.1	- 5.5)	0.04	1.8	(0.7	- 4.7)	0.23
<p>Abbreviations: ADL, activities of daily living; OR, odds ratio; CI, confidence interval.</p> <p>Notes: In the adjusted model, each variable was adjusted by baseline age, binary conversion of body mass index (1 when $23 \leq \text{BMI} \leq 29$, 2 otherwise); regular exercise and sports (yes/no); ongoing illness of four lifestyle diseases (i.e., diabetes, osteoporosis, stroke, heart disease); as well as consumption frequency of the other food groups. The p-values in the lines corresponding to "Reference" represent the linear trend.</p>								

[Insert Table 3 here]

Discussion

The results revealed that lower consumption frequency of soy products, colored vegetables, or fats/oils can be risk factors for future incidence of ADL disability in older Japanese women.

Why Was Consumption of Soy Products Related to ADL Maintenance?

Since Japanese soy products, such as tofu, miso (soybean paste), natto (fermented soybeans), and shoyu (soy sauce), contain a variety of nutritional contents, such as proteins, lecithin, oligosaccharides, saponins, isoflavones, and vitamin K2, their regular consumption is expected to help elderly people maintain their health [16]. In a placebo-controlled intervention study of hypercholesterolemic patients, for example, a significant reduction in low-density lipoprotein (LDL) cholesterol was observed in a group administered with soy lecithin [17], suggesting that daily soy lecithin consumption may help prevent arteriosclerosis. Soy saponins have also been given considerable attention recently as being potential antioxidants [18] and for having anticancer effects [19]. Soy isoflavones, which are polyphenols with estrogenic properties, are also notable for their effects of lowering total/LDL cholesterol levels, preventing osteoporosis, and reducing hot flashes in postmenopausal women [20]. Considering that articular disease and fractures are the main causes of the need for assistance in Japan [21], consumption of natto, characterized by its high vitamin K2 content [22], may have also had some effects because vitamin K2

plays an important role in bone metabolism [23]. It is suggested that subclinical vitamin K deficiency [24] or insufficient consumption of soy products [25] are predictors of knee osteoarthritis.

Why Was Consumption of Colored Vegetables Related to ADL Maintenance?

“Colored vegetables,” based on the standard by the government, are “vegetables that contain no less than 600 µg of β-carotene per 100 g of edible part” and generally include carrots, pumpkins, and spinach [26]. A meta-analysis of 20 prospective cohort studies showed that the risk of stroke decreases by 11% for every 200 g increment per day in vegetable consumption [27]. This may be because of the antioxidant effect of the β-carotene or vitamin C that prevents arteriosclerosis by inhibiting the oxidation of LDL cholesterol in the vascular wall. Further, a longitudinal cohort study demonstrated that older adults with low plasma carotenoid levels have a higher risk of developing poor muscle strength [28]. Inadequate intake of colored vegetables may lead to a decrease in plasma carotenoid concentration, which in turn may lead to ADL disability.

Why Was Consumption Of Fats/oils Related To Adl Maintenance?

The trend test suggested that more frequent intake of oils/fats was associated with less ADL decline, though we have no information on the type of oils/fats. The discussion can be complex because oils/fats consumed by our participants may consist of olive oil, which contains more polyphenol, which is potentially effective in heart disease prevention [29]; flaxseed oil, which is potentially effective for prevention of hypertension with its ω-3 fatty acid [30]; and margarine or fat spread, with more industrial trans fatty acids, which reportedly is associated with a higher risk of heart disease [31]. Generally speaking, however, our result may simply suggest that those who did not go into a “too simple” meal style with only rice and miso soup and were obtaining sufficient oils/fats from various sources maintained good physical/mental conditions.

Effect of Consumption of Other Food Groups on ADL Maintenance

Although intake frequency was not related to the incidence of ADL disability in food groups other than soybean products, colored vegetables, and fats/oils, the potential influence of the other food groups cannot be denied. Generally, when the intake frequency of a food group is not related to ADL disability, it may mean that intake of that food group was sufficient for almost all participants. Furthermore, in cases of animal protein food groups, such as seafood, meat, and eggs, although the effect was not observed for each food group, overall animal protein intake frequency may be relevant, since several cohort studies have demonstrated that high-frequency protein intake is effective for preventing muscle strength decline in older persons [32–34].

Limitations

The first limitation in this study is that any discussion on the effects of dietary patterns on ADL must involve a number of speculations because ADL can reflect many physical/cognitive/disease factors that are also determined by lifestyle factors other than diet. Secondly, since the dietary survey results were based on self-reports, participants' reporting may be biased in some ways. Third, since the questionnaire enquired into the frequency of ingestion only and not portion size, we cannot discuss the actual quantity of consumption. Fourth, since our target participants were limited to elderly Japanese women, the results may not be sufficiently applicable to men or to people with other cultural backgrounds. As soy isoflavones may compensate for estrogen deficiency and help prevent problems associated with menopause in women [35], the results of this study may be sex-specific. Fifth, difficulty in following up with some participants, in some cases due to their deaths, could have had some impact on the results.

Conclusions

In older Japanese women, lower consumption frequency of soy products, colored vegetables, or fats/oils are risk factors of future incidence of ADL disability. This study provides insights that may be helpful when designing strategic interventions to elderly Japanese women's dietary patterns. Researchers found that, to help older women maintain their independent life, it is important to confirm whether they regularly ingest soy products, colored vegetables, and fats/oils.

List Of Abbreviations

ADL – Activities of daily living

BMI – Body mass index

Declarations

Ethics approval and consent to participate

The Ethics Committee of TMIG approved the study protocol. All methods were performed in accordance with the relevant guidelines and regulations, including that all participants provided written informed consent regarding participation.

Consent for publication

All participants provided written informed consent regarding academic usage of their data.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request via e-mail.

Competing interests

The authors declare that they have no competing interestsTMIG

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This study was conducted using ordinary research expenses of TMIG, for all the processes of the design, data collection, analysis, interpretation of data and writing the manuscript.

Authors' contributions

NK contributed to the study concept and design, analyzed and interpreted the data, and prepared the manuscript; MK assisted with data collection and interpretation of the data; KS assisted with data collection and interpretation; YY assisted with data collection and interpretation; HH supervised the survey and assisted with data collection; SO supervised the survey and assisted with data collection and interpretation; HS assisted with data collection and interpretation; TS supervised the survey; IS assisted with data collection and interpretation; HK assisted with study concept and design, subject recruitment, and analysis and interpretation of the data. All authors read and approved the final manuscript.

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Other

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