Effect of Dental Status and Masticatory Ability on Decreased Frequency of Fruit and Vegetable Intake in Elderly Japanese Subjects

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Purpose: The aim of this study was to investigate the association of masticatory ability and dental status with intake of fruits and vegetables after adjusting for other factors in independently living elderly Japanese subjects. ***Materials and Methods:*** The study population consisted of 1,535 community-dwelling, independent elderly subjects over the age of 60 years. Self-assessed general health, financial status, dental status, self-assessed masticatory ability by food acceptance, and frequency of food intake were evaluated from responses to a questionnaire. Multiple logistic regression analysis for shortage of food intake was carried out. ***Results:*** Of the participants, 29% had natural dentitions in both the maxilla and mandible and 15% were edentulous in at least one arch and wearing a complete denture. Percentages of participants with nutrient shortages of meat, fish and seafood, green and yellow vegetables, other vegetables, and fruits were 44%, 17%, 30%, 33%, and 12%, respectively. Multiple logistic regression analysis showed that men and subjects with a poor financial status had significant associations with shortages of dietary intake. In addition, shortages of meat, green and yellow vegetables, other vegetables, and fruit were significantly related to poor masticatory ability but not to dental status. Masticatory ability was significantly associated with shortages of green and yellow vegetables. ***Conclusion:*** Multivariate analyses showed that after adjusting for age, sex, and financial status, self-assessed masticatory ability rather than dental status by itself was significantly associated with shortages in vegetable and fruit intake in independently living elderly Japanese subjects. *Int J Prosthodont 2012;25:368–375.*

Good nutrition—an adequate, well-balanced diet combined with regular physical activity—is a cornerstone of good health. Poor nutrition can lead to reduced immunity, increased susceptibility to disease, impaired physical and mental development, and reduced productivity.[1] Keller et al[2] reported that elderly individuals with high nutritional risk had fewer good physical health days and decreased life satisfaction compared with those at low risk. They concluded that nutritional risk is an independent predictor of change in health-related quality of life.

Masticatory disorder or the mere perception of compromised oral function, as may occur with tooth loss or dentures, can lead to avoidance of foods considered difficult to chew and a preference for soft, easily chewed foods.[3–6] In any case, unbalanced food selection habits may result in poor diets high in calories but low in fiber, vitamins, and protein, by which elderly subjects may succumb to certain diseases and frailty.[7] Several studies have established associations among nutrient intake, nutritional status, and various systemic diseases. Recent studies have clearly demonstrated the inverse association between fruit and vegetable intake and the development of cardiovascular disease[8–11] and risk of stroke.[12,13] Multiple studies have also suggested a protective role of fruits and vegetables toward cancer.[7,14–17] Regarding the intake of both fruits and vegetables and individual vitamins

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and minerals, reduction in disease outcomes occurs through several mechanisms, including protection against free radical damage, modulation of cytokine production, enhancement of endothelial function, and alteration of coagulation parameters.[18–20]

Elderly individuals have been identified as a group at risk for malnutrition in many countries. Several studies have suggested that age-related tooth loss or denture wearing was often associated with consumption of food.[21–23] National surveys in both the United Kingdom and United States showed that edentulous individuals were at a nutritional disadvantage compared with dentate individuals, even after adjustment for demographic factors.[24–27] In a national survey of Japanese dentists, the intake of carotene, vitamins A and C, milk and dairy products, and green and yellow vegetables decreased with increasing numbers of lost teeth.[6] Tsakos et al[27] reported that considerable numbers of respondents reported difficulty in eating a wide range of nutritious foods. This difficulty was further reflected in their low overall fruit and vegetable consumption. It was stated that the use of subjective scales assessing masticatory ability would have provided more sensitive measurements.

As previously indicated, several studies have been performed on the relationship between tooth loss or denture wearing and consumption of food; however, there have been few studies on dietary intake in relation to masticatory ability, which supposedly acts more directly than dental status. Tooth loss or denture wearing and masticatory ability are associated naturally, but masticatory ability is multifactorial, and denture wearers do not necessarily have lessened masticatory ability than individuals with natural dentitions.[28,29]

The authors hypothesized that perceived masticatory ability would be more relevant to dietary intake than tooth loss or wearing dentures. The aim of this study was to investigate the association of masticatory ability and dental status with dietary intake after controlling for other factors in independently living elderly Japanese subjects. In particular, this study assessed whether poor food acceptance negatively relates to the consumption of fruits and vegetables.

Materials and Methods

The subjects in this study consisted of 1,535 participants of the Senior Citizen's College of Osaka Prefecture, Osaka, Japan. This college is one of the adult educational systems supported by the government of Osaka Prefecture, which enrolls volunteers for a period of 1 year. The study population comprised community-dwelling, independent elderly individuals over the age of 60 years who attended lectures once a week and finished the entire 1-year course.

Dental Status

The maxilla and mandible were classified separately into four categories: edentulous arch with a complete denture, partially edentulous arch with a removable partial denture, partially edentulous arch without a replacement, and natural dentition. In this study, natural dentition was defined as an arch with at least 12 teeth between and including the first molars, which could include spaces restored with fixed prostheses. The volunteers were shown typical photographs of each arch and asked to indicate which of the photographs best described their mouths. No participant had an edentulous arch without a replacement.

Self-assessed General Health and Family Financial Status

Self-assessed general health and family financial status were evaluated from responses to the question, "How do you feel about your present general health condition/family financial status?" Participants were asked to respond by indicating good, fairly good, or bad/poor. To assess associations with categoric independent variables, the responses to the three items were reduced to a dichotomy variable "good" by combination with "fairly good." The proportion of bad/poor responses was treated as the independent variable in these analyses.

Self-assessed Masticatory Ability by Food Acceptance

Masticatory ability was evaluated from responses to a question regarding three foods: "Can you chew apples, cooked beef, or hard rice crackers without difficulty?"[30] These foods were identified as three of the most difficult to chew among 20 common Japanese foods that had been identified from answers to preliminary questions tested in 40 patients in a pilot study.[29] In addition, these three foods are eaten in different ways; that is, apples must be bitten with the anterior teeth, rice crackers must be crunched, and beef must be ground. The volunteers were asked to answer these questions with yes or no.

Frequency of Food Intake

The frequency of food selections from various food groups was investigated using a specially structured questionnaire for Japanese subjects.[31] Attention was paid to the intake of meat, fish and seafood, vegetables, and fruits as food groups essential to health. The recommended intake frequency was defined for each food. Nutrient shortage for meat, fish and seafood,

Table 1 Association of Dental Status with Masticatory Ability (n = 1,535)

	Masticatory ability (%)		
Dental status	Good	Moderate	Poor
CD	9.7	42.3	48.0
RPD	29.5	39.0	31.6
No replacement	58.8	26.3	14.8
Natural dentition	74.3	22.5	3.2
Total	44.3	32.7	23.1

CD = complete denture; RPD = removable partial denture.

and fruits was defined as twice per week or less, while that for green and yellow vegetables and other vegetables was less than once a day.[32]

Data Analysis

The initial evaluations involved frequency distribution tables for nutrient shortage of each food followed by chi-square tests of independence. Multiple logistic regression analysis was carried out to test each explanatory variable's relationship with the outcome variable after controlling for other factors. The proportion of subjects with nutrient shortage of each food was used as the dependent variable for logistic regression analysis. For these analyses, sex, age, and self-assessed general health and financial status were transformed into binary independent variables as follows: women = 0, men = 1; age 60 to 69 years = 0, ≥ 70 years = 1; and self-assessed general health/financial status good or fairly good = 0, bad/poor = 1. For dental status, dummy variables were used; persons with natural dentitions (reference category) = 0 and those with at least one edentulous arch wearing a complete denture, with a partially edentulous arch with a removable partial denture, and with at least one partially edentulous arch without a replacement = 1. For masticatory ability, ability to chew all three foods (apples, cooked beef, and hard rice crackers) without difficulty (defined as good masticatory ability [reference category]) = 0 and unable to chew one or two foods without difficulty (moderate masticatory ability) and unable to chew all three foods without difficulty (poor masticatory ability) = 1. All independent variables were entered into the model.

Data analyses were accomplished using SPSS 14.0 for Windows (IBM). *P* values of ≤ .05 were considered to be statistically significant.

Table 2 Percentage of Participants with Nutrient Shortages

	% of total	Meat[†]	
Category	population	Participants (%)	*P*
Age			
60–69 y	75.5	43.1	.548
≥ 70 y	24.5	44.9	
Sex			
Male	53.5	**49.3**	**< .001**
Female	46.5	**36.9**	
General health			
Good/fairly good	90.2	43.2	.460
Bad	9.8	46.4	
Family finance			
Good/fairly good	77.6	**41.4**	**.002**
Poor	22.4	**51.0**	
Dental status			
CD	14.8	44.9	.660
RPD	40.4	41.9	
No replacement	15.9	46.3	
Natural dentition	29.0	43.7	
Masticatory ability by food acceptance			
Good	44.3	41.8	.177
Moderate	32.6	42.9	
Poor	23.1	47.7	
Total	100.0	43.5	

CD = complete denture; RPD = removable partial denture.
*Bold numbers signify statistical significance.
[†]Shortage defined as twice a week or less.
[‡]Shortage defined as less than once per day.

Results

Participant Demographics

The mean age of participants was 66.6 ± 4.3 years. A total of 75.5% of subjects were in their 60s, and 53.5% were men. More than 90% of subjects reported that their self-assessed general health was good or fairly good. Sociodemographically, 77.6% of participants evaluated their present family financial status as good or fairly good.

Dental Status

It was found that 29.0% of participants had natural dentitions in both the maxilla and mandible. A total of 14.8% were edentulous in at least one arch, and all wore complete maxillary and mandibular dentures. A total of 40.4% of subjects wore a removable partial denture in at least one arch and were not included in the complete

Defined as Decreased Frequency of Dietary Intake by Various Factors (n = 1,535)*

Fish and seafood†		Green and yellow vegetables‡		Other vegetables‡		Fruits†	
Participants (%)	*P*	Participants (%)	*P*	Participants (%)	*P*	Participants (%)	*P*
16.6	.415	28.5	.065	32.6	.419	11.7	.973
18.4		33.5		34.9		11.7	
21.0	**< .001**	**39.8**	**< .001**	**40.9**	**< .001**	**17.2**	**< .001**
12.6		**18.4**		**24.2**		**5.4**	
16.5	.067	**28.9**	**.023**	32.8	.395	11.7	.924
22.4		**37.7**		36.3		11.9	
15.8	**.012**	**27.9**	**.003**	32.0	.059	**10.7**	**.011**
21.7		**36.4**		37.6		**15.7**	
20.4	.294	**35.1**	**.032**	37.6	.335	13.0	.809
17.8		**30.9**		33.8		10.8	
16.1		**30.6**		32.2		12.4	
14.9		**24.8**		30.7		12.0	
14.6	.061	**25.2**	**< .001**	**27.9**	**.001**	9.6	.070
18.4		**30.8**		**37.2**		13.0	
19.9		**36.8**		**37.7**		13.8	
17.1		29.7		33.2		11.7	

denture group. A total of 15.9% did not have any replacement of missing teeth (no replacement).

Self-assessed Masticatory Ability

Self-assessed masticatory ability of the test foods was significantly associated with dental status ($P < .001$). Overall, 65.5% of participants reported an ability to chew apples without difficulty, 52.0% reported that they could chew hard rice crackers without difficulty, and 72.9% reported that they could chew cooked beef without difficulty. A total of 44.3% of subjects stated that they could eat all three foods without difficulty.

Masticatory ability was impaired in individuals wearing complete dentures compared with individuals with natural dentitions. Only 9.7% of those with complete dentures reported that they were able to eat all three foods without difficulty compared with 74.3% of those with natural dentitions (Table 1).

Frequency of Food Intake

The percentages of participants with shortages of meat, fish and seafood, green and yellow vegetables, other vegetables, and fruits were 43.5%, 17.1%, 29.7%, 33.2%, and 11.7%, respectively (Table 2).

Bivariate Analysis

Nutrient shortages of all foods were found more in men than in women; however, age was not significantly associated with nutrient shortage of any food (Table 2). Shortages of meat, fish and seafood, green and yellow vegetables, and fruit were associated with financial status. Additionally, shortage of green and yellow vegetables was significantly associated with sex, self-assessed general health, financial status, dental status, and masticatory ability. Subjects wearing complete dentures had the least frequent intake

Table 3 Multiple Logistic Regression Analysis for Nutrient Shortage of Meat

Variables	B	SE	*P**	Odds ratio	95% CI
Male	0.485	0.107	**< .001**	1.62	1.32 to 2.00
≥ 70 y	0.005	0.126	.970	1.00	0.79 to 1.29
Poor general health	0.013	0.178	.585	1.06	0.86 to 1.31
Poor family finance	0.368	0.126	**.004**	1.44	1.12 to 1.84
Dental status (reference category: natural dentition)					
CD	−0.165	0.190	.385	0.85	0.58 to 1.23
RPD	−0.183	0.141	.193	0.83	0.63 to 1.10
No replacement	0.027	0.165	.872	1.03	0.74 to 1.42
Masticatory ability (reference category: good)					
Moderate	0.131	0.131	.315	1.14	0.88 to 1.47
Poor	0.312	0.154	**.044**	1.37	1.01 to 1.85

SE = standard error; CI = confidence interval; CD = complete denture; RPD = removable partial denture.
*Bold *P* values indicate statistical significance.

Table 4 Multiple Logistic Regression Analysis for Nutrient Shortage of Fish and Seafood

Variables	B	SE	*P**	Odds ratio	95% CI
Male	0.621	0.145	**< .001**	1.86	1.40 to 2.47
≥ 70 y	0.007	0.162	.965	1.01	0.73 to 1.38
Poor general health	0.238	0.215	.270	1.27	0.83 to 1.93
Poor family finance	0.353	0.157	**.025**	1.42	1.05 to 1.94
Dental status (reference category: natural dentition)					
CD	0.140	0.244	.566	1.15	0.71 to 1.86
RPD	0.095	0.188	.612	1.10	0.76 to 1.59
No replacement	−0.037	0.226	.871	0.96	0.62 to 1.50
Masticatory ability (reference category: good)					
Moderate	0.263	0.172	.126	1.30	0.93 to 1.82
Poor	0.265	0.201	.188	1.30	0.88 to 1.93

SE = standard error; CI = confidence interval; CD = complete denture; RPD = removable partial denture.
*Bold *P* values indicate statistical significance.

of green and yellow vegetables. Shortage of other vegetables had significant associations with women and masticatory ability. Shortage of fruits had significant associations with women and financial status.

Multivariate Analysis

Multiple logistic regression analysis showed that men had significant associations with shortages of all five food groups, but age was not associated with any food group (Tables 3 to 7). Multiple logistic regression analysis showed that shortages of meat, fish and seafood, green and yellow vegetables, and fruits were significantly associated with poor financial status; however, these associations were not found with general health. In addition, shortages of meat, green and yellow vegetables, other vegetables, and fruits were significantly related to poor masticatory ability but not dental status. With control of other variables, shortage of green and yellow vegetables was significantly associated with masticatory ability (Table 5; odds ratio [OR]: 1.38 for moderate masticatory ability, 1.68 for poor masticatory ability), as was that of other vegetables (Table 6; OR: 1.59 for moderate masticatory ability, 1.64 for poor masticatory ability), fruits (Table 7; OR: 1.69 for moderate masticatory ability, 1.91 for poor masticatory ability), and meat (Table 3; OR: 1.37 for poor masticatory ability). There was no significant difference in the frequency of fish intake in terms of masticatory ability after controlling for other factors (Table 4).

Table 5 Multiple Logistic Regression Analysis for Nutrient Shortage of Green and Yellow Vegetables

Variables	B	SE	*P**	Odds ratio	95% CI
Male	1.079	0.123	**< .001**	2.94	2.31 to 3.74
≥ 70 y	0.029	0.137	.835	1.03	0.79 to 1.35
Poor general health	0.236	0.188	.209	1.27	0.88 to 1.83
Poor family finance	0.353	0.136	**.010**	1.42	1.09 to 1.86
Dental status (reference category: natural dentition)					
CD	0.116	0.208	.578	1.12	0.75 to 1.69
RPD	0.117	0.159	.462	1.12	0.82 to 1.53
No replacement	0.091	0.187	.627	1.09	0.76 to 1.58
Masticatory ability (reference category: good)					
Moderate	0.320	0.145	**.028**	1.38	1.04 to 1.83
Poor	0.516	0.169	**.002**	1.68	1.20 to 2.33

SE = standard error; CI = confidence interval; CD = complete denture; RPD = removable partial denture.
*Bold *P* values indicate statistical significance.

Table 6 Multiple Logistic Regression Analysis for Nutrient Shortage of Other Vegetables

Variables	B	SE	*P**	Odds ratio	95% CI
Male	0.804	0.117	**< .001**	2.23	1.78 to 2.81
≥ 70 y	−0.017	0.134	.899	0.98	0.76 to 1.28
Poor general health	0.001	0.189	.994	1.00	0.69 to 1.45
Poor family finance	0.215	0.134	.108	1.24	0.95 to 1.61
Dental status (reference category: natural dentition)					
CD	−0.067	0.202	.739	0.93	0.63 to 1.39
RPD	−0.076	0.152	.619	0.93	0.69 to 1.25
No replacement	−0.097	0.181	.591	0.91	0.64 to 1.29
Masticatory ability (reference category: good)					
Moderate	0.466	0.141	**.001**	1.59	1.21 to 2.10
Poor	0.497	0.166	**.003**	1.64	1.19 to 2.27

SE = standard error; CI = confidence interval; CD = complete denture; RPD = removable partial denture.
*Bold *P* values indicate statistical significance.

Table 7 Multiple Logistic Regression Analysis for Nutrient Shortage of Fruit

Variables	B	SE	*P**	Odds ratio	95% CI
Male	1.302	0.191	**< .001**	3.68	2.53 to 5.35
≥ 70 y	−0.132	0.194	.497	0.88	0.60 to 1.28
Poor general health	−0.152	0.274	.579	0.86	0.50 to 1.47
Poor family finance	0.399	0.183	**.029**	1.49	1.04 to 2.13
Dental status (reference category: natural dentition)					
CD	−0.339	0.286	.237	0.71	0.41 to 1.25
RPD	−0.372	0.221	.092	0.69	0.45 to 1.06
No replacement	−0.158	0.253	.532	0.85	0.52 to 1.40
Masticatory ability (reference category: good)					
Moderate	0.526	0.203	**.010**	1.69	1.14 to 2.52
Poor	0.647	0.239	**.007**	1.91	1.20 to 3.05

SE = standard error; CI = confidence interval; CD = complete denture; RPD = removable partial denture.
*Bold *P* values indicate statistical significance.

Discussion

Food choice is influenced by an array of political, environmental, social, and individual factors.[33] Therefore, nutrition research should be conducted individually by each country and culture. Although several studies have investigated the association between dental status and nutritional intake in Western countries, fewer studies have shown this association in other countries. The Japanese food culture is considerably different from that of Western countries; therefore, the associations of dental status and masticatory ability with dietary intake were examined.

Participants in this study were nonclinical, noninstitutionalized, community-dwelling elderly Japanese individuals, most of whom were physically and cognitively healthy. Notably, this group may not reflect the average group in similarly aged Japanese individuals; the study population may be in the middle class or richer and considered healthier and more highly educated than the average older adult in Japan. Therefore, the results are likely to underestimate the impact of oral health among the general elderly population in Japan. However, the purpose of this study was to examine nutrient intake in terms of oral health, not to determine the average dietary intake of Japanese elderly individuals. Therefore, it is beneficial that there were fewer other burdens and significant differences among participants, with the exception of oral health. Those who exhibited compromised cognitive function were not included in this group because their answers may have been less reliable. For these reasons, the selected study population was thought to be appropriate for the objectives of this study.

Nutrition is defined in multiple ways.[5] Nutritional health includes both the quality and quantity of dietary intake and nutritional status. Dietary intake comprises the types of food groups ingested (such as fruits, vegetables, or dairy products) and the nutrient composition of the food eaten (micronutrients [vitamins and minerals], macronutrients, and proportion of calories consumed as proteins, carbohydrates, and fats). In this study, a structured questionnaire of food frequency developed by a Japanese researcher[31] was used; the questionnaire was validated by comparing the frequency of food intake with a quantity of nutrient valued by weight. This evaluation method proposed a recommended intake frequency for each food group for a healthy life for Japanese individuals.

Previous literature suggests that tooth loss affects dietary quality and nutrient intake.[5] Some studies did not adjust for factors other than age, sex, and region. As anticipated, the present findings showed that intake frequencies of meat, fish, green and yellow vegetables, and fruits were associated with family financial status, even in elderly subjects who were of the middle class, healthier, and more highly educated. A possible reason that shortage of other vegetables alone was not influenced by financial status is that they are cheaper than the other foods. In addition, financial status may influence the quality of dental status, although Japan established a universal health insurance system in 1961 that includes dental care. Therefore, it was reconfirmed that financial status must be included as an adjusting variable in research addressing nutrient intake.

A group of studies compared edentulous subjects wearing complete dentures with dentate subjects and suggested that the presence of dentures contributes to poorer intake across multiple nutrients.[34–36] However, several studies did not reveal a significant difference in nutrient content between denture wearers and dentate individuals.[37–39] The multivariate analyses in this study showed that dental status was not significantly associated with dietary intake, contrary to the authors' expectations; however, masticatory ability was significantly associated with intake of meat, vegetables, and fruits. In other words, self-rated masticatory ability is much more relevant than dental status itself. A possible reason is that food selection is considerably influenced by the perception of acceptance for mastication. It is reasonable that shortage of fish intake was not significantly associated with masticatory ability because of the ease of chewing associated with it. This study suggested that dental status is a confounding factor of masticatory ability in terms of dietary intake.

After adjusting for other variables, poor masticatory ability rather than denture wearing was significantly associated with shortages of intake of vegetables and fruits. This means that in subjects with the same dental status, poor masticatory ability is likely to result in a lower dietary intake than in those with better masticatory ability, and in individuals with similar masticatory abilities, a different dental status does not create a significant difference regarding dietary intake.

In terms of other limitations, data on the number of teeth, clinical conditions of the dentition, quality of dentures, and measured masticatory function were not collected. The authors plan to examine these objective variables in a future study.

Conclusion

Multivariate analyses showed that after adjusting for age, sex, and financial status as recognized confounding factors, self-assessed masticatory ability rather than dental status itself was significantly associated with shortages of vegetable and fruit intake in independently living elderly Japanese subjects.

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