ORIGINAL ARTICLE

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Relationship between prosthodontic status and nutritional intake in the elderly in Korea: National Health and Nutrition Examination Survey (NHANES IV)

Abstract: Objectives: Many health issues have been reported to be associated with poor nutritional status. We sought to examine the association between nutritional intake and oral health status in elderly people. Methods: The association between perceived disability in mastication and prosthodontic status was analysed using multiple logistic regression. Multiple linear regression was used to analyse the association between prosthodontic status and nutritional intake. Results: The elderly subjects with partial or full dentures reported chewing difficulties 1.62-fold more frequently (95% CI: 1.06-2.49) than those with natural teeth or a fixed prosthesis after adjusting for gender, TMD (temporomandibular disorder), household income and education level. Additionally, daily nutritional intakes of energy, protein, fat, ash, calcium, phosphorus and thiamine were decreased significantly in elderly with partial or full dentures compared with those with no prosthesis or with a fixed prosthesis (P < 0.05). Conclusions: Our findings underline oral health status and perceived disability in mastication are associated with dietary imbalances in the elderly. We suggest that the evaluation of patients' nutritional status should be considered as a part of an overall plan for dental hygiene care.

Key words: elderly people; National Health and Nutrition Examination Survey; nutrition; oral health

Introduction

Korea became an 'ageing society' in 2000; more than 7% of the population was aged 65 and older. Furthermore, it will become an 'aged society', in which the proportion of aged people comprises 14% of the population, in 2018 and will progress, with unprecedented speed, towards becoming a super-aged society in 2026. The number of people aged 65 and older in Korea in 2007 was 4.81 million, accounting for 9.9% of the population. Thus, interest in promoting the quality of life and health in the elderly (1) has increased, and various studies have examined the causes of nutrition-related problems in the elderly.

According to a nutrition survey conducted in the Korea National Health and Nutrition Examination Survey (KNHANES) in 2005, the nutrient intake of people aged 65 and older was significantly poor (2). The nutrient intake of the elderly seemed to be affected by and closely associated with a range of factors, such as socioeconomic status, healthcare utilization, psychological status and health status generally. In particular, in some studies, oral health was related to nutrient intake in the elderly (3, 4). The risk of malnutrition was highly dependent on dental health status, missing teeth and denture condition (5, 6). Also, periodontitis, gingival recession, tooth mobility and the number of teeth appeared to contribute to poor nutrition in the elderly (7, 8).

Elderly people with poor oral health status are likely to complain regarding their mastication ability, and thus, the chances they will select softer food may be higher. However, it is questionable whether choices based on such issues will be balanced in terms of nutrition. Thus, poor oral health status can affect nutrient intake and general health (9).

To our knowledge, some studies have shown that health factors in the elderly are associated with nutrition or their oral health, but few studies have examined the relationship between oral health and nutritional intake. Thus, the purpose of this study was to examine the relationship between the oral health and nutritional intake of people aged 65 and older, based on the results from KNHANES in 2007.

Methods

Study population and methodology

Data in this study were derived from the 4th Korea National Health and Nutrition Examination Survey ('KNHANES IV', 2007). KNHANES is a survey that aims to determine the Korean population's health and nutrition status to aid in evaluation and policy making for the National Health Promotion Plan. In total, 6455 people above 2 years of age in 100 survey plots were targeted for the survey, and 4594 people (71.2%) participated. There were 3751 (81.7%) respondents who answered both the health check-up and nutrition questionnaire. Finally, of them, 722 people aged 65 and older were included in this study.

To determine the quantity and type of nutrients, the 24-h dietary recall method was used. This method enabled us to estimate the intake of water (g) and 18 'nutrients': energy (kcal), protein (g), fat (g), carbohydrate (g), fibre (g), ash (g), calcium (mg), phosphorus (mg), iron (mg), sodium (mg), potassium (mg), vitamin A (μ gRE), carotene (μ g), retinol (μ g), thiamin (mg), riboflavin (mg), niacin (mg) and vitamin C (mg). All dishes eaten during the day before the survey were recorded. Recipes were considered when nutrients were calculated because households have varying nutrient information despite nominally eating the 'same' meals.

Prosthodontic status was determined by trained dentists and was used as an indicator of oral health status. We dichotomized prosthodontic status: 'without or fixed prosthesis' and 'partial or full denture'. Elderly people with 'partial or full denture' were those with partial or full dentures. Those with 'without or fixed prosthesis' were those with sound teeth, filled teeth, a single crown or a bridge.

We considered potential confounders, such as gender, income (household), education, temporomandibular disorder

(TMD), and perceived disability in mastication. Household income was transformed to quartiles and categorized from the first (the lowest) to fourth (the highest) quartile. Education levels were also categorized into four groups on the basis of the highest education level completed: elementary school, middle school, high school and college. In addition, both TMD and the perceived disability in mastication were dichotomous variables, coded as 'yes' or 'no'.

Statistical analysis

The statistical analysis was conducted in two main stages: (i) to confirm the relationship between prosthodontic status and perceived disability in mastication, and (ii) to examine the association between prosthodontic status and nutrition intake. First, we assessed whether there was any relationship between prosthodontic status and perceived disability in mastication to determine whether prosthodontic status was a valid factor. Thus, we established a multiple logistic regression model in which perceived disability in mastication was used as the dependent variable. The effects of gender, age, TMD, income, education and prosthodontic status were then estimated using odds ratios (OR) and 95% confidence intervals (CI). Second, we estimated the effects of prosthodontic status on the intake of the 18 nutrients and water, adjusting for gender and income, by multiple linear regression. All nutrients and water were natural logarithm-transformed, and gender and income were selected by stepwise approaches.

The KNHANES data provided a complex sample design and weights representing the health and nutrition status of Koreans. Thus, we used the 'survey procedure' in SAS (ver. 9.1, SAS Institute Inc., Cary, NC, USA), which was developed for complex sample designs. Additionally, the association weight of three kinds of survey parts (the health questionnaire, the health examination results regarding prosthodontic status and nutritional intake) was considered in the statistical models.

Results

Table 1 lists the demographical background of the 722 participants aged 65 and older, 302 were males and 420 were females. The first quartile of the participants' income level included 52.8% of the study participants. Additionally, 77.3% of the elderly had graduated from elementary school (the lowest level of education), and 56.0% of them had subjective problems with mastication, while the remaining 43.9% reported no symptoms. After analysing prosthodontic status, 55.1% of the elderly subjects had no prosthesis or a fixed prosthesis, and 44.8% of them had partial or full dentures.

We found an association between perceived disability in mastication and oral health status; the elderly subjects with partial or full dentures reported chewing difficulties 1.62-fold more frequently (95% CI: 1.06–2.49) than those with natural teeth or a fixed prosthesis, after adjusting for gender, TMD, household income and education level (Table 2). Additionally, the elderly categorized in the first quartile of income reported

Table 1. Distributions of the demographical characteristics and prosthodontic status

Categories	No. of subjects (722)	Weighted percent (SE)*			
Sex					
Male	302	40.3 (2.2)			
Female	420	59.6 (2.2)			
Age (≥65)	722	13 (0.8)†			
Income (household)					
1st quartile	372	52.8 (3.0)			
2nd quartile	155	21.9 (2.3)			
3rd quartile	76	13.6 (2.1)			
4th quartile	57	11.5 (1.9)			
Education (graduated)					
Elementary school	553	77.3 (2.4)			
Middle school	60	8.5 (1.5)			
High school	71	9.6 (1.3)			
College	33	4.4 (1.0)			
Temporomandibular disorder (TMD)					
Yes	7	0.7 (0.3)			
No	715	99.2 (0.3)			
Perceived ability in mastication					
Discomfort	416	56.0 (2.4)			
Comfort	305	43.9 (2.4)			
Prosthodontic status					
Without or fixed prosthesis ‡	392	55.1 (2.4)			
Partial or full denture	320	44.8 (2.4)			

SE, standard error of the mean.

*Weighted percent was calculated based on the complex sample design and weights.

 $^{\dagger} \text{These}$ figures indicate the percentage of elderly among all subjects.

[‡]Fixed prosthesis includes filled teeth, a single crown or a bridge.

more disability in mastication than those in the fourth quartile (OR: 2.25, 95% CI: 1.12–4.50), while females reported less disability in mastication than males (OR: 0.55, 95% CI: 0.36–0.83). No association was observed between TMD or education level.

Table 3 shows the results of the comparison of oral health status and daily nutritional intake. Elderly subjects with partial or full dentures were more likely to have poorer nutritional intake than those without a prosthesis or with a fixed prosthesis, even after adjusting for gender and household income. In particular, the intakes of energy, protein, fat, ash, calcium, phosphorus and thiamin were decreased significantly in elderly subjects with partial or full dentures compared with those with no prosthesis or with a fixed prosthesis (P < 0.05).

Discussion

In this study, we examined the relationship between the oral health status of elderly subjects, aged 65 and older, in terms of their perceived disabilities in mastication and nutritional intake. Malnutrition due to inappropriate dietary habits and insufficient food intake can cause physical disease in the elderly. Reasons for such malnutrition can include the influence of the ability to chew in comfort on choice of foods (10). Additionally, oral disease in the elderly can lead to tooth loss, which eventually reduces their ability to chew; thus, their food choices can be limited, and the intake of necessary nutrients not guaranteed. Thus, their physical health cannot be sustained (11). It is known that oral health is associated with nutrition and whole-body health (9). A previous study showed that patients who had periodontitis or were edentulous had a higher risk of malnutrition than those without these conditions (5). A greater number of existing teeth in a subject were linked to a higher nutritional intake even with the same nutrition consumption (12). Oral health status, nutrition status and food intake are closely related, affecting whole-body health (13). Loker and Slade (14) and Wong *et al.* (15) reported that a low level of perceived oral health in the elderly was proportionally related to the degree of deterioration in oral health status, which affected food choice and, consequently, quality of life.

In this study, oral health status in the elderly, based on data from KNHANES, was examined by analysing prosthodontic status, to determine any relationship between prosthodontic status and nutritional intake. The correlation between perceived disability in mastication and oral health status was also considered. Healthy teeth and the presence of a fixed prosthesis were grouped together under the same status, and partial and full dentures were categorized in a second group for the analysis. Thus, in terms of oral health status, dentures were considered inferior to a fixed prosthesis.

In this study, elderly persons with partial or full dentures complained of disability in mastication 1.6-fold more frequently than those without dentures, with natural teeth or with fixed prostheses. That is, self-reported oral health was associated with the prosthodontic status observed. According to Jung *et al.* (16), disability in mastication was reportedly experienced by people with poor oral health status, less education and no employment. Additionally, Allen *et al.* (17) examined how elderly people living in Britain were affected by the type of prosthesis and found that their oral health–related quality of life was usually low due to deteriorated oral health status and less awareness of oral health.

In this study, it was assumed that any masticatory problem was clearly related to oral health status. In addition, financial status and education level in the elderly were found to have significant influences on mastication status.

As shown in Table 3, elderly subjects with partial or full dentures consumed less nutrition than those without a prosthesis or with a fixed prostheses. In particular, there was a significant difference in the intake of energy, protein, fat, ash, calcium, phosphorus and thiamin, depending on prosthodontic status (P < 0.05). A previous study demonstrated significant differences between edentate and dentate subjects, because nutrients, such as protein, calcium, riboflavin and vitamin C, were ingested more readily by dentate people (18). Another study reported similar results, showing that edentulous people were less likely to consume meat, nuts, tomatoes and carrots compared with dentate people. That is, nutrients such as protein, vitamins and fibre are more difficult for edentate people to ingest (19). Moreover, according to Papas *et al.* (20), the intake of protein, calcium, vitamin A, vitamin C and vitamin

	Perceived disability of mastication							
	No. of subjects			M III - Colo OD				
Predictors	Yes	No	(95% CI)	(95% CI)				
Gender								
Male	176	125	1.0	1.0				
Female	240	180	0.73 (0.50, 1.06)	0.55 (0.36, 0.83)				
Age (≥65)	72.17*	72.14*	0.98 (0.95, 1.01)	0.98 (0.95, 1.02)				
Temporomandibular disorder (TMD)								
Yes	5	2	0.51 (0.16, 1.59)	1.36 (0.38, 4.76)				
No	411	303	1.0	1.0				
Income (household)								
1st quartile	242	130	2.60 (1.43, 4.72)	2.25 (1.12, 4.50)				
2nd quartile	91	63	2.17 (1.03, 4.56)	1.90 (0.84, 4.30)				
3rd quartile	32	44	1.23 (0.52, 2.89)	1.27 (0.53, 3.05)				
4th quartile	24	33	1.0	1.0				
Education (graduated)								
Elementary	333	219	1.0	1.0				
Middle school	36	24	1.48 (0.79, 2.74)	0.98 (0.46, 2.08)				
High school	31	40	0.51 (0.29, 0.91)	0.37 (0.19, 0.70)				
College	12	21	0.40 (0.19, 0.84)	0.46 (0.19, 1.11)				
Prosthodontic status								
Without or fixed prosthesis	207	185	1.0	1.0				
Partial or full denture	200	119	1.41 (0.96, 2.07)	1.62 (1.06, 2.49)				

 Table 2 Relationship between perceived disability in mastication and prosthodontic status

Multiple logistic regression analyses were performed in the complex sample design and weight, adjusting for gender, age, TMD (temporomandibular disorder), education and income. CI, confidence interval; OR, odds ratio.

*Mean age.

	Prosthodontic status			
Nutrients	Without or fixed prosthesis mean (SD) (<i>n</i> = 368)	Partial or full denture mean (SD) (n = 293)	Regression coefficient (SE)	Significance level
Energy (kcal)	1494 (573)	1397 (511)	-0.10 (0.04)	<0.05
Water (g)	620 (427)	563 (412)	-0.10 (0.06)	0.12
Protein (g)	49.76 (26.97)	44.44 (24.46)	-0.10 (0.04)	<0.05
Fat (g)	19.72 (16.84)	16.26 (13.47)	-0.18 (0.07)	<0.05
Carbohydrate (g)	275 (102)	264 (93)	-0.04 (0.04)	0.24
Fiber (g)	6.29 (5.08)	5.52 (3.37)	-0.08 (0.05)	0.11
Ash (g)	15.50 (9.09)	14.25 (9.83)	-0.11 (0.05)	<0.05
Calcium (mg)	394 (315)	342 (270)	-0.14 (0.06)	<0.05
Phosphorus (mg)	904 (413)	833 (390)	-0.08 (0.04)	<0.05
Iron (mg)	12.13 (10.85)	11.29 (11.49)	-0.10 (0.07)	0.17
Sodium (mg)	3627 (2189)	3488 (2595)	-0.07 (0.05)	0.22
Potassium (mg)	2324 (1437)	2155 (1190)	-0.08 (0.05)	0.12
Vitamin A (µgRE)	517 (618)	497 (625)	-0.14 (0.11)	0.21
Carotene (µg)	2753 (3474)	2684 (3544)	-0.13 (0.11)	0.24
Retinol (µg)	37.58 (61.03)	35.03 (91.71)	-0.33 (0.27)	0.22
Thiamin (mg)	0.92 (0.55)	0.81 (0.47)	-0.11 (0.04)	< 0.05
Riboflavin (mg)	0.72 (0.45)	0.66 (0.45)	-0.10 (0.06)	0.08
Niacin (mg)	11.39 (5.84)	10.63 (5.89)	-0.08 (0.04)	0.08
Vitamin C (mg)	77.22 (70.19)	69.72 (64.20)	-0.10 (0.08)	0.20

SD, standard deviation; SE, standard error.

Regression coefficients were estimated by multiple linear regression in the complex sample design and weight, adjusting for gender and income. All nutrients and water were natural logarithm-transformed.

B6 by the elderly with dentures is considerably lower than that by dentate people. As a result, there is a significant relationship between the prosthodontic status and nutritional intake. Additionally, an analysis of the rate of nutritional intake deficiency among the Korean elderly showed that the edentulous group, with poor oral health status, had the highest rate of

 Table 3 Relationship between prosthodontic status

 and daily intake of nutrients

nutritional intake deficiency of all nutrients, compared with a group with 1–19 teeth and a group with 20 or more teeth, with significant differences in all nutrients except calcium and riboflavin (21).

An overall review of the results of this study and other related studies leads to the conclusion that oral health status influences nutritional intake status in the elderly and that the dietary imbalances arising from this influence can be a risk factor for the overall health of the elderly. The limitations of this study, however, included the lack of an assessment of the relationship between the nutrient intake status and detailed oral health data, such as information about missing teeth, gingival recession, denture condition, periodontal disease, gingival recession and previous history of caries. Further research is needed to examine the nutritional intake status according to the food types that the elderly consume with various indicators of oral health status.

Because our review of previous studies confirmed that prosthodontic status is an important indicator for oral health in the elderly, our use of prosthodontic status as a proxy measurement for oral health status in the elderly was considered adequate to provide our study with sufficient validity. Furthermore, the results were obtained from a population sample that can be used to represent the country, using statistical data provided by KNHANES. Although there are relatively few studies on the oral health status in the elderly and their nutritional intake, these results, to some extent, support the theory that oral health status can contribute to maintaining whole-body health and nutrition.

Further studies of the dietary intake of the elderly are warranted, such as which foods are generally consumed and which foods are deficient with regard to oral health status. The elderly should also be educated on how a nutritionally balanced diet can help to improve their oral health. Constant efforts should be made in this regard, because the oral health status in the elderly has a substantial impact on overall health.

By enhancing the status of the fixed prosthesis, as opposed to partial or full dentures, perceived disability in mastication can be reduced to ensure consumption of a more nutritionally balanced diet. Efforts to improve the oral health status in the elderly should be made a part of programmes aimed at improving overall health.

Conclusions

In this study, an analysis of correlations between the prosthodontic status of the elderly and their nutritional intake status, using data from the 2007 KNHANES, showed that the nutritional intake status was lower in the elderly with partial or full dentures than in those with natural teeth or fixed prosthodontics and that the elderly with partial or full dentures complained more frequently about their perceived disability in mastication than those with natural teeth or fixed prosthodontics. Taken together, our data suggest that oral health status and perceived disability in mastication are associated with dietary imbalances in the elderly.

Clinical relevance

The evaluation of patients' nutritional status should be considered as a part of an overall plan for dental hygiene care. The role of a dental hygienist is to inform the patients about possible risks for overall health by analysing their oral health status and to provide dietary counselling (22). To this effect, such results may provide clinical dental hygienists with a basis for predicting and ascertaining the nutrients most likely to be insufficiently consumed by the elderly, depending on their oral health status, thus helping them to implement adequate dietary education while accounting for the patients' oral health status.

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