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Original Article

Association between nutritional status and cognitive functions of the Korean elderly

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ABSTRACT

Nutrition is one of the factors influencing cognitive functions. But, the role of nutrition on cognitive functions within the elderly is recognized to a lesser degree. The aim of this academic endeavor was to analyze the affiliation between nutritional status and cognitive functions of the elderly in Korea. 316 subjects, of 114 male and 201 female aged above 65 years, were gathered from university hospital clinics, Elderly Welfare Centers, and Health Welfare Centers located in the district of Seoul, Gyeonggi province, and Incheon in Korea. The cognitive function was tested by the Korean-Mini Mental State Examination (K-MMSE) questionnaire. Nutrition intake was assessed by a 24-hour recall, a food frequency questionnaire (FFQ). Nutrition adequacy and quality were assessed by the Nutrition Screening Initiative (NSI) checklist, the nutritional adequacy ratio (NAR), and the mean adequacy ratio (MAR). The elderly with normal cognitive function status displayed significantly higher levels of calcium, riboflavin, thiamin, folate, vitamin C, vitamin E, vitamin B6, phosphorous, potassium, iron, niacin, zinc, animal fat, animal protein, polyunsaturated fatty acids, total protein, vegetable oil, vegetable protein, fiber than levels of the elderly with moderate cognitive impairment. The K-MMSE score positively correlated with of high consumption of pork, white radish, sea mustard, tomato, tangerine, grape, apple, and ice cream, and K-MMSE was negatively associated with high intake of potato, anchovy, fish cake, and mushroom. The findings suggest that nutritional status is affiliated with cognitive function within the elderly of Korea. The consumption of variety of foods and nutrients ensures adequate cognitive function in the Korean elderly.

Keywords cognitive function, nutritional status, The Korean elderly, Korean-Mini Mental State Examination (K-MMSE)

INTRODUCTION

There has been increased growth of the elderly population in the worldwide. The number of the elderly aged more than 60 years is expected to double from 841 million populations in 2030 to more than 2 billion by 2050 (United Nations et al., 2013). Older persons are expected to exceed the number of children for the first time in 20472050 (United Nations et al., 2013). There has also been dramatically increase in the number of elderly population in Korea. The number of the Korean elderly population (aged 65 or older) was 11.3 % in 2010 and it is projected to be doubled, 20.8% by 2026 (Statistics Korea, 2016).

Cognitive impairment is the major health problem in the elderly population. Cognitive impairment in the elderly has been associated with type 2 diabetes, depression, cerebrovascular disease, cardiovascular disease, and mortality. The direct medical cost per person was significantly higher for those elderly with cognitive impairment compared to those without cognitive impairment. Given the increasing number of the elderly population with cognitive impairment, it is urgent need to reduce the number of elderly with cognitive impairment by identifying modifiable determinant such as dietary intake.

Studies have demonstrated that vitamin D (Buell et al., 2009), vitamin C, vitamin E, carotene (Wengreen et al., 2007), and seafood (Nurk et al., 2007) have been protective for the cognitive impairment in the elderly. However, the findings are scattered in terms of different study populations, geography, age groups, and gender distributions. Little attention has been paid to the identification of modifiable determinant, such as diet in relation to cognitive function in the Korean elderly. The objective of this study is to investigate the association between nutrient intake and cognitive function in Korean older adults aged above 65 years. We hypothesized that nutritional status is associated with cognitive functions in the elderly.

MATERIALS AND METHODS

Study subjects

A random sample of 316 (115 men and 201 women), 65 year of

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Table 1. General characteristics of the subjects

	n	%
Sex		
Men	115	36.4
Women	201	63.6
Age (y)		
< 70	79	25.0
70 - 79	189	59.8
80 - 89	42	13.3
≤ 90	6	1.9
Education level		
Illiterate	35	11.1
Quit elementary	28	8.9
Elementary school	99	31.3
Quit middle school	29	9.2
Middle school	62	19.6
High school	57	18.0
University	6	1.9
Family type		
With spouse	130	41.1
With children	116	36.7
Spouse & children	27	8.5
Alone	31	9.8
Others	12	3.8
Total	316	100%

age or older were recruited from March to July 2012. The survey was conducted in the university hospital clinics, the Elderly Welfare Centers, and Health Welfare Center in the district of Seoul, Gyeonggi province, and Incheon. The local ethics committee approved the study **(**KMU IRB 2012-01K**)** and informed consent was obtained.

Dietary assessment

Dietary intake was assessed by one-day 24-hour recall method a trained interviewer and a food frequency questionnaire (FFQ). The FFQ consisted of 41 commonly consumed food in Korea extracted from Korea National Health and Nutrition Examination Survey (KNHANES). The frequency of food intake was divided into 9 categories (none, 1 time/month, 2 - 3 times/month, 1 - 2 times/week, 3 - 4 times/week, 5-6 times/week, 1 time/day, 2 times/day, 3 times/day). Portion size for each food item was determined by 'Food Composition Tables for Convenient Use by General Consumers' by Korea's Rural Development Administration (Rural Development Administration, 2007).

Nutrient intakes assessed by one-day 24-hour recall were calculated using the Computer Aided Nutritional Analysis Program for Professionals 4.0 (Can-Pro 4.0) developed by the Korean Nutrition Society.

Nutrition Adequacy Ratio (NAR) and Mean Adequacy Ratio (MAR)

To estimate nutritional adequacy and quality, Nutrition Adequacy Ratio (NAR) and Mean Adequacy Ratio (MAR) were calculated. Based on a 24-hour recall, average daily intakes of nutrients per person were assessed according to the recommended levels by the Dietary Reference Intakes for Koreans (KDRIs) (The Korean Nutrition Society, 2006) including energy, vitamin A, thiamin, riboflavin, niacin, folate, vitamin B6, folate, vitamin B12, calcium, phosphorous, iron, zinc, and copper. NAR was calculated for each energy and nutrient intake as the ratio of daily individual intake to standard recommended amount of nutrient set by the KDRIs considering each individual's sex and age category. NAR was truncated at 1 so that a nutrient with a high NAR could not compensate for a nutrient with a low NAR (Hatloy et al., 1998). The sum of NARs for all measured nutrients was divided by the number of measured nutrients to calculate the MAR.

Nutrition Screening Initiative (NSI)

The NSI checklist (DETERMINE Your Nutritional Health Checklist) contains a total of 10 yes or no questions covering physical health conditions, eating, dental health, financial condition, social support, and age. If participants answered "yes" to the 10 questions, the participant receives a summation of 21 points.

Based on evaluation standard for the nutrition risk level, 0 – 2 points were given to a good nutritional state

According to the evaluation standard for the nutrition risk level, the good nutritional state was graded out of: 0 to 2 points, moderate nutritional risk state out of: 3 to 5 points and high nutritional risk state out of: 6 and more points. The category of social and biological environment and its effects on the cognitive function influence the NSI checklist (Posner et al., 1993).

Cognitive function assessment

The cognitive function was tested by the Korean version of Mini-Mental State Examination (K-MMSE), the most widely used screening tool to that quantitatively assesses the cognitive status of the elderly population developed by Kwon & Park (Kwon and Park, 1989), adapted from Folstein et al. (1975). The K-MMSE includes 19 items, and the scores ranged from 0-30. The study participants were classified into four groups by score: normal (25 - 30); boundary zone (20 - 24); mild cognitive impairment (15 - 19); and moderate cognitive impairment (10 - 14). The K-MMSE affiliated closely with another brief measure of cognitive functioning, Blessed Orientation Memory-Information (r = .78) (Kang et al., 1997); its outcome further suggested that the K-MMSE is relatively insensitive to the early stage of dementia, causing an increase

Table 2. Distribution of subjects of cognitive function status classified by K-MMSE score

Cognitive function status (K-MMSE score)	Sex		Age (y)				Total n (%)
	Men (%)	Women (%)	< 70	70 - 79	80 - 89	≥ 90	
Normal (25 - 30)	103 (43.0)	136 (57.0)	73 (30.5)	140 (58.6)	22 (9.2)	4 (1.7)	239 (76.0)
Boundary zone (20 - 24)	6 (13.3)	39 (86.7)	6 (13.3)	31 (68.9)	8 (17.8)	0 (0.0)	45 (14.0)
Mild cognitive impairment (15 - 19)	6 (23.0)	20 (77.0)	0 (0.0)	14 (53.8)	10 (38.5)	2 (7.7)	26 (8.0)
Moderate cognitive impairment (10 - 14)	0 (0)	6 (100)	0 (0.0)	4 (66.7)	2 (23.3)	0 (0.0)	6 (2.0)

Table 3. Cognitive function scores by nutrient intake in the Korean elderly

Nutrient	Normal (25 - 30) (n = 239)	Boundary zone (20 - 24) (n = 45)	Mild cognitive impairment (15 - 19) (n = 26)	Moderate cognitive impairment (10 - 14) (n = 6)	P value
Energy (kcal)	1,644.24 ± 292.09[1)]	1964.65 ± 2192.09	1,453.44 ± 400.22	1,259.77 ± 248.78	0.097
Carbohydrate (g)	277.25 ± 40.04[ab2)]	287.04 ± 43.06[a]	256.82 ± 49.87[b]	249.03 ± 45.39[b]	0.012
Vegetable Fat (g)	17.74 ± 8.84[a]	17.23 ± 13.54[a]	11.89 ± 7.70[ab]	8.15 ± 6.38[b]	0.006
Animal Fat (g)	14.04 ± 9.57[a]	8.72 ± 6.58[ab]	11.17 ± 11.63[a]	3.06 ± 2.75[b]	0.0001
Saturated fatty acid (g)	9.67 ± 9.39	10.29 ± 16.44	5.47 ± 7.32	1.14 ± 1.68	0.069
Mono unsaturated fatty acid (g)	12.64 ± 12.34	14.08 ± 23.25	6.58 ± 9.00	1.69 ± 2.57	0.054
Polyunsaturated fatty acid (g)	8.96 ± 5.46[a]	7.64 ± 8.40[a]	5.11 ± 4.77[ab]	2.04 ± 2.56[b]	0.001
Protein (g)	65.80 ± 19.25[a]	62.77 ± 17.71[a]	52.97 ± 23.43[a]	39.32 ± 13.07[b]	0.0001
Vegetable Protein (g)	38.32 ± 7.99[a]	40.99 ± 8.92[a]	32.65 ± 7.96[b]	32.14 ± 7.40[b]	0.0001
Animal Protein (g)	27.48 ± 15.03[a]	21.79 ± 14.94[a]	20.32 ± 18.28[a]	7.18 ± 6.48[b]	0.001
Fiber (g)	24.17 ± 6.55[a]	23.76 ± 6.67[a]	19.74 ± 4.76[ab]	17.21 ± 4.85[b]	0.001
Vitamin A (ug RE)	883.04 ± 519.74	836.14 ± 524.16	581.91 ± 393.87	565.56 ± 508.83	0.024
Vitamin E (mg)	13.68 ± 6.39[a]	10.23 ± 4.06[ab]	10.72 ± 6.15[ab]	7.14 ± 3.72[b]	0.0001
Vitamin C (mg)	115.41 ± 59.60[a]	96.92 ± 34.22[ab]	74.08 ± 34.44[b]	61.63 ± 29.63[b]	0.0001
Thiamin (mg)	1.15 ± 0.34[a]	1.10 ± 0.36[a]	0.92 ± 0.34[ab]	0.82 ± 0.18[b]	0.002
Riboflavin (mg)	1.09 ± 0.41[a]	1.04 ± 0.43[a]	0.77 ± 0.35[b]	0.54 ± 0.28[b]	0.0001
Niacin (mg)	14.63 ± 5.35[a]	13.04 ± 4.65[ab]	10.91 ± 5.26[bc]	8.66 ± 2.90[b]	0.0001
Vitamin B6 (mg)	1.62 ± 0.52[a]	1.50 ± 0.45[a]	1.34 ± 0.49[ab]	1.05 ± 0.26[b]	0.003
Folate (ug)	617.37 ± 218.80[a]	565.50 ± 173.73[a]	475.03 ± 134.53[ab]	359.15 ± 117.01[b]	0.0001
Vitamin B_{12} (ug)	10.66 ± 12.46	9.61±8.19	6.77 ± 7.06	5.80 ± 4.83	0.307
Calcium (mg)	543.32 ± 226.72[a]	523.09 ± 183.32[a]	427.97 ± 134.53[ab]	300.36 ± 165.28[b]	0.006
Phosphorus (mg)	1095.79 ± 327.07[a]	997.67 ± 267.44[ab]	828.75 ± 339.48[bc]	646.70 ± 167.82[c]	0.0001
Sodium (mg)	3473.71 ± 1093.63[a]	3521.61 ± 977.99[a]	2869.29 ± 1142.64[ab]	2234.95 ± 1255.40[b]	0.003
Potassium (mg)	3065.13 ± 952.92[a]	2854.37 ± 821.70[ab]	2326.70 ± 707.58[bc]	2046.63 ± 775.62[c]	0.0001
Iron (mg)	15.02 ± 4.62[a]	14.33 ± 4.31[a]	12.54 ± 4.37[ab]	10.25 ± 2.95[b]	0.007
Zinc (mg)	10.82 ± 3.31[a]	9.61 ± 2.19[a]	8.73 ± 2.87[ab]	6.88 ± 1.58[b]	0.0001

1) Mean ± SD
2) [abc]Different letters within the same row indicate that values are significantly different from each other at $p < 0.05$ by by Duncan's multiple range test.

in false negatives.

Statistical analyses
Analysis of variance (ANOVA) with Duncan's multiple tests was tested to gauge the impacts on different levels of cognitive function from daily nutrient intakes. Pearson's correlation coefficient (r) was calculated to examine the association between food groups and K-MMSE score. All data analyses were performed using the SPSS 12.0.

RESULTS

The distribution of subjects by sex, age, education level, and family type is displayed on Table 1. From 316 total subjects, 63.6% identified as women, 59.8% were aged 70-79y, 31.3% were elementary school graduates, and 41.1% were living with spouse. The allocation of participants by cognitive function

Table 4. Frequency of food group intake by age groups in the elderly

Food Groups		Age (y) < 70 (n = 79)	70 - 79 (n = 189)	80 - 89 (n = 42)	≥ 90 (n = 6)	P-value
Ggrain	Rice	6.96 ± 2.10[1)b2)]	7.67 ± 0.89[ab]	7.67 ± 0.57[ab]	8.00 ± 0.00[a]	0.0001[*]
	Barley/miscellany/ eousgrain	6.25 ± 2.41	6.32 ± 2.61	5.81 ± 2.84	6.33 ± 2.58	0.721
	Ramen	1.53 ± 1.38[a]	0.85 ± 1.15[ab]	0.62 ± 0.91[ab]	0.67 ± 1.03[b]	0.0001[*]
	Noodle	1.52 ± 1.15	1.54 ± 1.22	1.48 ± 1.23	0.67 ± 0.52	0.366
	Bread	1.63 ± 1.56[a]	1.21 ± 1.39[a]	0.76 ± 1.03[a]	1.00 ± 1.55[a]	0.011[*]
	Rice cake	1.72 ± 1.41	1.52 ± 1.14	1.38 ± 1.06	1.00 ± 0.00	0.283
	Snack	1.22 ± 1.45[ab]	0.87 ± 1.31[b]	0.81 ± 1.15[b]	2.00 ± 1.55[a]	0.048[*]
Legumes and potatoes	Tofu/tofu residue	2.99 ± 1.40	3.20 ± 1.43	3.05 ± 1.61	2.67 ± 1.37	0.599
	Pulse	3.37 ± 1.90	3.30 ± 2.20	2.86 ± 2.15	2.33 ± 1.03	0.403
	Soybean	2.29 ± 1.98[ab]	1.71 ± 1.43[b]	1.24 ± 1.43[b]	3.00 ± 2.68[a]	0.001[*]
	Potato	2.11 ± 1.29[a]	2.72 ± 1.28[b]	2.38 ± 1.51[a]	2.00 ± 0.89[a]	0.004[*]
	Sweet potato	2.11 ± 1.39	2.35 ± 1.10	2.10 ± 1.46	1.67 ± 1.03	0.226
Meat and egg	Beef	2.47 ± 1.55	2.22 ± 1.39	1.90 ± 1.28	2.00 ± 0.89	0.202
	Chicken	2.51 ± 1.40[ab]	2.05 ± 1.37[b]	1.76 ± 1.32[b]	3.00 ± 0.00[a]	0.008[*]
	Pork	2.57 ± 1.31[ab]	2.47 ± 1.28[ab]	1.95 ± 1.15[b]	3.00 ± 0.89[a]	0.041[*]
	Ham, sausage	0.43 ± 0.50	0.37 ± 0.48	0.24 ± 0.43	0.33 ± 0.52	0.108
	Egg	3.09 ± 1.54	2.84 ± 1.81	2.90 ± 1.56	2.67 ± 2.07	0.723
Seafood	Mackerel	2.15 ± 1.18	2.38 ± 1.39	1.95 ± 1.34	1.33 ± 1.37	0.068
	Tuna	1.70 ± 1.44	1.78 ± 1.61	1.62 ± 1.31	1.00 ± 0.89	0.612
	Croaker	2.18 ± 1.10	2.36 ± 1.36	2.00 ± 1.08	3.00 ± 0.00	0.147
	Pollack/frozen pollack	2.38 ± 1.57	2.40 ± 1.34	2.05 ± 1.19	2.00 ± 0.89	0.439
	Anchovy	3.80 ± 1.84[a]	2.95 ± 1.91[ab]	2.81 ± 1.84[ab]	2.00 ± 0.89[b]	0.002[*]
	Fish cake	1.82 ± 1.21	1.58 ± 1.43	1.29 ± 1.50	1.00 ± 0.00	0.145
	Squid	1.76 ± 1.27	1.83 ± 1.30	1.76 ± 1.50	1.00 ± 0.89	0.500
	Clam	1.77 ± 1.30	1.81 ± 1.31	1.38 ± 1.01	1.33 ± 0.52	0.203

	Salted fish	1.91 ± 1.64	2.02 ± 1.98	1.62 ± 1.751	1.67 ± 0.52	0.635
Vegetable	Napa cabbage	6.51±1.66[a]	5.96±1.97[a]	6.05±1.96[a]	3.67±2.25[b]	0.003*
	White radish	5.32±2.13[a]	5.32±2.05[a]	4.38±2.18[a]	2.67±1.37[b]	0.001*
	Radish leaves	2.68 ± 1.91	2.97 ± 1.72	2.52 ± 1.94	1.33 ± 0.52	0.069
	Bean sprouts	3.38 ± 1.50	3.39 ± 1.56	3.05 ± 1.55	3.00 ± 0.89	0.232
	Spinach	3.32 ± 1.50	3.39 ± 1.56	3.05 ± 1.55	3.00 ± 0.89	0.587
	Cucumber	2.95 ± 1.32[ab]	3.52 ± 1.46[a]	2.90 ± 1.53[ab]	2.33 ± 1.86[b]	0.002*
	Chili	3.56 ± 1.69	3.41 ± 1.80	2.81 ± 1.55	2.33 ± 1.86	0.061
	Carrot	2.71 ± 1.66	3.25 ± 1.80	2.76 ± 1.65	2.33 ± 1.86	0.058
	Carrot pumpkin	3.03 ± 1.57	3.40 ± 1.60	2.81 ± 1.81	2.67 ± 1.37	0.076
	Cabbage	2.61 ± 1.85	2.73 ± 1.56	2.95 ± 1.89	1.67 ± 1.86	0.325
	Tomato	2.65 ± 2.04	2.39 ± 1.66	2.10 ± 1.36	1.67 ± 1.37	0.262
	Mushroom	2.95 ± 1.62[ab]	3.18 ± 1.67[a]	2.38 ± 1.67[b]	2.67 ± 1.37[ab]	0.039*
Seaweed	Sea mustard	2.82 ± 1.76	2.98 ± 1.59	2.48 ± 1.49	1.67 ± 0.52	0.083
	Laver	4.23 ± 1.61	4.34 ± 1.88	4.62 ± 2.37	3.33 ± 1.86	0.411
Fruit	Tangerine	3.03 ± 2.22[a]	2.54 ± 1.72[ab]	2.14 ± 1.22[ab]	1.67 ± 1.03[b]	0.031*
	Persimmon/dried persimmon	2.20 ± 1.96	2.26 ± 1.63	1.71 ± 1.13	1.33 ± 0.52	0.149
	Pear	2.15 ± 1.66	2.31 ± 1.61	1.86 ± 1.05	1.33 ± 1.37	0.186
	Watermelon	2.53 ± 1.95[a]	2.30 ± 1.68[ab]	1.57±1.06[ab]	1.33 ± 0.52[b]	0.012*
	Oriental melon	2.06 ± 1.60	2.20 ± 1.1.70	1.71 ± 1.04	1.00 ± 0.89	0.116
	Strawberry	2.61 ± 1.78[a]	2.38 ± 1.66[a]	1.90 ± 1.21[ab]	1.00 ± 0.89[b]	0.027*
	Grape	2.25 ± 1.37	2.19 ± 1.75	1.95 ± 1.51	1.00 ± 0.89	0.254
	Peach	2.10 ± 1.76[a]	2.25 ± 1.65[a]	1.19 ± 1.02[b]	1.33 ± 0.52[a]	0.001*
	Apple	2.78 ± 2.07	2.60 ± 1.71	2.43 ± 1.11	1.00 ± 0.89	0.096
	Banana	2.14 ± 1.82	2.24 ± 1.76	2.14 ± 1.18	1.33 ± 0.16	0.620
	Orange	2.18 ± 1.89	2.15 ± 1.76	1.67 ± 1.37	1.00 ± 0.89	0.160
Milk products	Milk	3.30 ± 2.19[a]	2.63 ± 2.30[a]	1.90 ± 1.79[b]	2.33 ± 3.62[a]	0.011*
	Yogurt	2.62 ± 2.39[b]	2.46 ± 1.86[b]	2.00 ± 1.59[b]	4.33 ± 2.73[a]	0.047*
	Ice cream	1.44±1.90[a]	0.98±1.40[ab]	0.38±0.80[b]	1.33±1.37[ab]	0.002*

Beverage	Soda	0.81 ± 1.62	0.74 ± 1.26	0.43 ± 1.06	0.00 ± 0.00	0.246
	Coffee (mix)	4.16 ± 2.67[a]	3.16 ± 2.87[a]	2.52 ± 2.81[b]	3.33 ± 2.73[a]	0.012*
	Green tea	3.03 ± 2.38[a]	2.22 ± 2.25[ab]	1.24 ± 1.97[b]	2.00 ± 3.10[ab]	0.001*
Alcohol	Beer	1.19 ± 1.92[a]	0.40 ± 0.97[ab]	0.38 ± 1.31[ab]	0.00 ± 0.00[b]	0.0001*
	Soju	1.67 ± 2.10[a]	0.71 ± 1.29[a]	0.67 ± 1.22[b]	1.33 ± 1.37[a]	0.0001*
	Makgeolli	1.39 ± 1.87[a]	0.60 ± 1.23[ab]	0.62 ± 1.15[ab]	0.00 ± 0.00[b]	0.0001*
Other food groups	Hamburger	0.33 ± 0.57	0.33 ± 0.69	0.33 ± 0.65	0.00 ± 0.00	0.682
	Pizza	0.43 ± 0.71	0.43 ± 0.78	0.24 ± 0.53	0.00 ± 0.00	0.221
	Fried food	0.58 ± 0.78	0.68 ± 0.94	0.43 ± 0.91	1.00 ± 0.89	0.276

1) Mean ± SD
2) Separation within rows by Duncan's multiple range test at 5% level

scores are displayed on Table 2. From 316 subjects, 239 (76.0%) identified to be normal, 45 (14.0%) boundary zone, 26 (8.0%) mild cognitive impairment, and 6 (2.0%) moderate cognitive impairment.

The dissimilarities in nutrient intakes among participants with different cognitive functions are listed in Table 3. Subjects with mild or moderate cognitive function impairment had significantly higher energy intake from carbohydrates compared to those with boundary zone cognitive function (70.7% or 79.1% vs. 58.4%). Higher polyunsaturated fat intake was found in normal or boundary zone cognitive impairment groups compared to moderate cognitive impairment group (8.96 ± 5.46, 7.64 ± 8.40 vs. 2.04 ± 2.56).

Subjects with normal cognitive function status had significantly higher intakes of: total protein, vegetable protein, vegetable oil, fiber, animal fat, animal protein, fiber, thiamin, riboflavin, niacin, riboflavin, vitamin B6, potassium, folate, zinc, phosphorous, calcium, iron, vitamin B6, vitamin C and vitamin E than those with moderate cognitive impairment.

Frequency of food group intake including grain, legumes and potatoes, meat and egg, seafood, vegetable, seaweed, dairy products, beverage, alcohol, other food groups by different age groups is presented in Table 4. Frequency in intake of rice and snack increased as age advanced. Rice intake was higher in the elderly aged above 90 years compared to the elderly less than 70 years (8.00 ± 0.00 vs. 6.96 ± 2.10, $p < 0.0001$). Soybean intake was higher in the elderly aged more than 90 years compared to the elderly aged between 70 to 89 years. Potato intake was higher in the elderly aged 70 - 79 years compared to the elderly aged less than 90 years. Both chicken and pork were consumed higher in the elderly aged more than 90 years compared to those who were 80 - 89 years. Anchovy was consumed higher in the elderly aged less than 70 years compared to the elderly aged above 90 years. Napa cabbage, white radish, tangerine, watermelon, and strawberry were consumed more in the elderly less than 70 years compared to those aged above 90 years. Cucumber was consumed higher in the elderly between 70 to 79 years compared to those greater than 90 years, and both mushroom and peach were consumed higher in the elderly between 70 to 79 years compared to the elderly between 80 to 89 years. Milk and ice cream were more frequently consumed in the elderly less than 70 years compared to those aged 80 to 89 years. In the meantime, yogurt was consumed higher in the older elderly aged more than 90 years compared to those younger elderly less than 70 years. Coffee and green teas were more frequently consumed in the elderly less than 70 years compared to those aged 80 to 89 years. Beer, makgeolli, and soju were frequently consumed in the elderly less than 70 years compared to those aged above 90 years (Table 4).

The NAR and the MAR of energy and nutrients by age groups in the elderly are presented in Table 5. All elderly groups were assessed as inadequate in calcium, niacin, vitamin A, riboflavin, energy, thiamin, vitamin B6, folate, copper, vitamin B12, vitamin C, phosphorous, iron, zinc, and as indicated by the NAR below 1. The NAR for vitamin C was significantly higher in the elderly aged less than 70 years compared to those aged more than 90 years (0.90 ± 0.18 vs. 0.69 ± 0.20). The MAR analysis revealed that all age groups had inadequate diet quality (Table 5).

Frequencies of food group intakes by the NSI scores are indicated in Table 6. None of the groups intakes significantly differed by NSI scores, except alcohol. Alcohol intake was significantly higher in moderate and low nutritional risk groups compared to high nutritional risk group (Table 6).

Correlations between MMSE-K score and food group are shown in Table 4. K-MMSE was positively correlated with intake of pork, white radish, sea mustard, tomato, tangerine, grape, apple, and ice cream, and K-MMSE was negatively associated with intake of potato, anchovy, fish cake, and mushroom (Table 7).

DISCUSSION

In the present study, we found that the elderly with mild or moderate cognitive impairment had significantly higher energy from carbohydrates compared to those elderly with boundary zone cognitive impairment. In parallel with finding, very low carbohydrate level can briefly improve recollection ability for older adults with susceptibility to Alzheimer's disease, even in a short term (Krikorian et al., 2012). Iron intake was found to be lower in moderate cognitive impairment group compared to normal cognitive impairment group. The Alzheimer's disease is characterized by the same brain regions by the amyloid β peptide (Aβ) accumulation, and it has been reported that iron may increase β-amyloidogenic pep-tide (Silvestri and Camaschella, 2008), and this may eventually prevent the

Table 5. Nutrient adequacy ratio (NAR) and mean adequacy ratio (MAR) of the elderly by age groups

Nutrient	Age				P-value
	< 70	70 - 79	80 -8 9	≥ 90	
	(n = 79)	(n = 189)	(n = 42)	(n = 6)	
Energy	0.89 ± 0.12	0.87 ± 0.13	0.83 ± 0.14	0.87 ± 0.13	0.091
Vitamin A (ug RE)	0.89 ± 0.24	0.81 ± 0.27	0.74 ± 0.32	0.76 ± 0.29	0.097
Vitamin C (mg)	0.90 ± 0.18[a]	0.82 ± 0.26[ab]	0.79 ± 0.26[ab]	0.69 ± 0.20[b]	0.031*
Thiamin (mg)	0.90 ± 0.13	0.86 ± 0.16	0.82 ± 0.16	0.84 ± 0.18	0.173
Riboflavin (mg)	0.77 ± 0.21	0.82 ± 0.24	0.66 ± 0.25	0.66 ± 0.23	0.163
Niacin (mg)	0.85 ± 0.17	0.81 ± 0.20	0.74 ± 0.19	0.81 ± 0.19	0.140
Vitamin B6 (mg)	0.92 ± 0.13	0.89 ± 0.17	0.89 ± 0.15	0.88 ± 0.16	0.681
Folate (ug)	0.98 ± 0.07	0.96 ± 0.11	0.97 ± 0.09	0.95 ± 0.09	0.595
Vitamin B_{12} (ug)	0.90 ± 0.23	0.95 ± 0.17	0.86 ± 0.26	0.88 ± 0.21	0.107
Calcium (mg)	0.72 ± 0.23	0.69 ± 0.23	0.71 ± 0.24	0.63 ± 0.23	0.675
Phosphorus (mg)	0.99 ± 0.64	0.97 ± 0.08	0.96 ± 0.09	0.95 ± 0.11	0.460
Iron (mg)	0.99 ± 0.04	0.99 ± 0.04	0.98 ± 0.07	0.98 ± 0.04	0.460
Zinc (mg)	0.98 ± 0.07	0.96 ± 0.09	0.96 ± 0.10	0.94 ± 0.10	0.425
Copper (mg)	0.99 ± 0.04	0.97 ± 0.08	0.97 ± 0.09	0.95 ± 0.09	0.256
MAR	0.91 ± 0.10	0.88 ± 0.12	0.85 ± 0.14	0.84 ± 0.13	0.120

1) Mean ± SD
2) Separation within rows by Duncan's multiple range test at 5% level.

cognitive impairment.

In the present study, high consumption of vitamin C and E were positively related to better cognitive function within the elderly population. Consistent with our finding, Masaki et al. (2000) found that vitamin E and C supplements may prevent vascular dementia and may later raise cognitive function from a longitudinal study with Japanese-American men residing in Hawaii. An important defensive impact for vascular dementia in men who had reported taking both vitamin C and E supplements was found (Odds Ratio [OR], 0.12, 95% CI, 0.02 to 0.88). The men without dementia who used either vitamin C or E supplements alone in 1988 performed better at the cognitive test performance in the 1991 to 1993 examination (OR, 1.25, 95% CI, 1.04 to 1.50). Vitamin C and E supplementation, however, did not stop cognitive change among women, aged more than 65 years with preexisting cardiovascular disease or its risk factors, from Women's Antioxidant Cardiovascular Study (Kang et al., 2009). Different sources of Vitamin C and E from diet vs. supplements, preexisting morbidity, and different race/ethnicity groups may have yielded inconsistent findings. Calcium intake proved to be much higher in normal cognitive function group in comparison than moderate cognitive impairment group's intake in the current research. Heck et al.(2015) found that calcium signaling was crucial within the hippocampus-dependent human memory processes for cognitive health conditions. Intake of folate was turned out to be higher in normal cognitive function group than moderate cognitive impairment group's intake.

Long-term supplementation of oral folic acid and vitamin B12 promoted greater improvement in a cohort of community-dwelling older adults with elevated psychological distress especially in their cognitive functioning than placebo group's improvement after 2 years (Walker et al., 2012). Parallel with this finding, one long-term intervention of 800ug folic acid per day after 3 years found benefits in memory function in healthy older adults (Durga et al., 2007). Recent findings suggest that folate may benefit the hippocampus, one of the sectors in the brain where cell renewal and DNA replication take place (Fenech, 2010). Polyunsaturated fatty acids such as DHA and EPA are crucial elements for halting cognitive decline, including Alzheimer's. A positive association was found according to the Framingham Offspring Study (Tan et al., 2012) between high concentration of red blood cell DHA and visual memory, executive function, and abstract thinking. DHA and EPA are beneficial for lowering blood pressure (Bonaa et al., 1990), triglycerides (Bradberry and Lilleman, 2013) and reducing the risk of thrombosis (Saravanan et al., 2010) and

Table 6. Frequencies of food groups by the Nutrition Screening Initiative (NSI) score in the elderly population

Food Groups	NSI score Low Risk (0 - 2)	Moderate Risk (3 - 5)	High Risk (≥ 6)	P-value
Grain	2.19 ± 0.90	2.05 ± 0.91	2.04 ± 0.87	0.529
Pulses and potatoes	2.60 ± 1.06	2.64 ± 1.13	2.63 ± 0.96	0.974
Meat and egg	2.23 ± 1.03	2.05 ± 0.91	2.12 ± 0.95	0.550
Seafood	2.22 ± 1.02	2.05 ± 0.92	2.15 ± 0.92	0.549
Vegetable	3.62 ± 0.10	3.32 ± 1.26	3.65 ± 0.98	0.125
Seaweed	3.90 ± 1.62	3.53 ± 1.62	3.66 ± 1.33	0.316
Fruit	2.46 ± 1.68	2.35 ± 1.41	2.37 ± 1.24	0.892
Milk products	1.86 ± 1.29	2.16 ± 1.27	2.28 ± 1.54	0.151
Beverage	2.21 ± 1.24	2.15 ± 1.44	2.08 ± 1.45	0.846
Alcohol	0.53 ± 0.94[b]	1.17 ± 1.41[b]	0.62 ± 1.08[a]	0.001

1) Mean ± SD

inflammation (Calder, 2015), cardiovascular risk factors (Deckelbaum and Torrejon, 2012; Saravanan et al., 2010), which in turn, reducing the risk of dementia.

High consumption of white radish and tomato was positively associated higher cognitive function score in this study. Sea mustard was positively associated with higher cognitive function in the present study. Fucoidan, a complex sulfated polysaccharide from sea mustard is regarded as: anti-inflammatory, anticoagulant, anti-apoptosis, antioxidant, antitumor (Aisa et al., 2005; Wang et al., 2010), and neuroprotective (Gao et al., 2012). Gao et al. (2012) found that it was possible for fucoidan to mitigate the learning and memory skills AB-induced Alzheimer's disease model rats exhibit, by decreasing oxidative stress and blocking the cell apoptosis. High intake of tangerines, grapes and apples was positively related to higher cognitive function in the study. Antioxidants properties of vitamins A and C in fruits may have been beneficial for cognitive functions. Interestingly, Korean rice wine, Makeolli was found to be associated with better cognitive functions. Makeolli is one of the fermented alcoholic beverages in Korea, which has high amounts of protein and vitamin B complexes compared to other alcoholic beverages (Carmel et al., 2003). Vitamin B-12 and folic acid were found to be associated with lowering the concentrations of elevated homocysteine, a risk factor for Alzheimer's disease and enhancing verbal memory function (Kivipelto et al., 2009).

Rice, snack, soybean, chicken, pork, and yogurt were consumed more frequently among the elderly above 90 years in comparison to the elderly less than 70 years. In the meantime, potato, anchovy, Napa cabbage, white radish, tangerine, watermelon, and strawberry, cucumber, milk, ice cream, coffee, green tea, beer, makkeolli, and soju were more frequently consumed in the elderly less than 70 years compared to the those above 90 years. More variety of foods including fruits, vegetables, and beverages were consumed in the younger elderly group.

All of the elderly groups were assessed as inadequate in energy, folate, vitamin C, thiamin, zinc, vitamin A, niacin, vitamin B6, riboflavin, vitamin B12, calcium, iron, copper, and phosphorous. Vitamin C was found to be significantly nutritionally appropriate in the elderly aged less than 70 years compared to those aged more than 90 years. This may be due to the finding that young elderly group had steep intake of fruits and vegetables that contained high amount of vitamin C.

Table 7. Correlation coefficients between K-MMSE score and food groups

Food Groups	K-MMSE r	P-value
Rice	-0.017	0.808
Noodle	-0.032	0.614
Potato	-0.176*	0.037
Sweet Potato	0.143	0.090
Tofu	-0.035	0.603
Beef	-0.158	0.055
Chicken	-0.047	0.547
Pork	0.277*	0.037
Egg	0.016	0.814
Anchovy	-0.221*	0,003
Fish cake	-0.191*	0.024
Mackerel	0.153	0.074
Tuna	0.144	0.228
White Radish	0.208*	0,025
Bean Sprouts	0.011	0.904
Spinach	-0.034	0.714
Tomato	0.238*	0,001
Mushroom	-0.118	0,152
Sea mustard	0.149*	0,049
Tangerine	0.269*	0.010
Persimmon	-0.187	0.124
Grape	0.265*	0.039
Apple	0.269*	0.011
Makgeolli	0.196*	0.002
Ice cream	0.196*	0.002
Milk	0.064	0.289

*$p < 0.05$

Alcohol level was significantly greater in moderate and low nutritional risk group than high nutritional risk group's level. The elderly with better nutrition and health conditions consume alcohols compared to the elderly with high-risk nutrition group.

In conclusion, the findings suggest that nutritional status is affiliated with cognitive function within the elderly of Korea. Variety of foods and nutrients guarantee appropriate cognitive function in the elderly of Korea. The elderly are nutritionally inadequate in terms of specific nutrients such as vitamin B, vitamin c, iron, calcium, and zinc, and nutrition intervention and programs are needed to improve nutritional status and cognitive functioning of the elderly.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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