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Comparison of nutrient intakes by nutritional anemia and the association between nutritional anemia and chronic diseases in Korean elderly: Based on the 2013-2015 Korea National Health and Nutrition Examination Survey Data

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BACKGROUND/OBJECTIVES: The elderly are reported to have a high prevalence of nutritional anemia when they have lower intakes of nutrients or chronic diseases. This study was conducted to compare nutritional status according to nutritional anemia and to determine associations between nutritional anemia and chronic diseases in Korean elderly.
SUBJECTS/METHODS: This study utilized data on 3,258 elderly aged ≥ 65 years gathered during the 6th Korea National Health and Nutrition Examination Survey 2013-2015. Subjects were divided into nutritional anemia (NA) group (n = 415) and non-NA group (n = 2,843) by hemoglobin concentration. Nutrient intakes were assessed using dietary intake data obtained using the 24-hour recall method. The odds ratios (ORs) for nutritional anemia by chronic diseases were determined. Statistical analysis was performed using SPSS Ver. 23.0.
RESULTS: Of 3,258 subjects, 12.7% had nutritional anemia. Intakes of potatoes, pulses, and mushrooms by males and potatoes, fruits, meats, eggs, and seafood by females were significantly lower in NA group than in non-NA group. The proportion of the subjects whose intakes of protein, vitamin A, vitamin B_1, vitamin B_2, niacin, and iron less than estimated average requirement (EAR) were significantly higher in NA group compared to non-NA group. After adjusting for age, the number of family members, energy intake, and alcohol drinking, ORs for nutritional anemia in the subjects with diabetes and myocardial infarction or angina pectoris were significantly higher by 1.74 times and 1.59 times as compared to the subjects without those diseases, respectively. However, ORs for nutritional anemia in the subjects with obesity, abdominal obesity, and hypertriglyceridemia were significantly lower by 0.64 times, 0.60 times, and 0.59 times as compared to the subjects without those diseases, respectively.
CONCLUSIONS: The results of this study suggested that nutritional management should be done to enable the Korean elderly to consume foods with high hematopoietic nutrients density to prevent nutritional anemia. Korean elderly need to make regular efforts to check for nutritional anemia.

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INTRODUCTION

Nutritional anemia is defined as a condition in which hemoglobin concentration falls below a criteria level due to insufficient storage of hematopoietic nutrients required for the synthesis or metabolism of hemoglobin and erythrocytes [1]. In the United Nations, people aged 65 years and older are classified as the elderly [2], and nutritional anemia in the elderly is determined by a hemoglobin concentration below 13 g/dL for male and below 12 g/dL for female according to the World Health Organization (WHO) [1,3]. However, generally, hemoglobin concentrations in blood decreased with age, but lower hemoglobin concentrations were reported to be associated with increased risk of hospitalization, morbidity, and mortality [4,5]. The prevalence of anemia in the elderly has been reported to be between 8% and 25% and to be 20% more than in those aged 85 years over [6,7].

In the National Health and Nutrition Examination Survey (NHANES, 1991-1994) [6], 34.3% of the elderly with anemia was caused by nutritional deficiency anemia and in 32.1% of their anemia was associated with chronic diseases. Hemoglobin concentrations of elderly patients with nutritional anemia were 8 to 10 g/dL, and usually had mild to moderate anemia. In fact, nutritional anemia in elderly patients accounts for one-third of all anemia [8]. The most common type of nutritional anemia is iron-deficiency anemia, which accounts for ≥ 60% of cases,

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and its causes are known to be chronic gastrointestinal blood loss caused by drug taking, gastritis, esophagitis, other chronic diseases, impaired efficiency of iron absorption, decreased physical functional capacity, and inflammation. In addition to iron deficiency, nutritional anemia in the elderly is associated with poor intake of folic acid, vitamin B_{12}, protein, vitamin B_2, vitamin C [6,9]. In addition, nutritional anemia in the elderly was associated with aging-associated masticatory, deglutition, and digestion disorders [10] and associated with meal skipping or the lack of micronutrient intakes due to living alone with age [11]. Percentage of elderly is rapidly increasing worldwide (8.2% in 2015 and predicted to increase to 11.6% in 2030) [12], so the prevalence of nutritional anemia is expected to increase continuously in the elderly and to pose a considerable healthcare burden. Recently in Korea, for example, the prevalence of nutritional anemia in 2011 and 2016 were 7.4% and 8.0%, respectively, 16.8% for those in their 60s and 17.9% for those in their 70s [13].

The elderly population ratio in Korea was 14.3% in 2018 and is expected to exceed 20% in 2025 and the speed rate of population aging is greatest in OECD countries [12,14]. In Korea, life expectancy increased from 64.6 years in 1976 to 82.4 years in 2016, but healthy span, which now stands at 64.9 years, has shown little change over the past 40 years [15]. In 2017, about 90% of Korean elderly had a chronic disease, 73% of them had two or more chronic diseases [16], and in about 33% of Korean elderly with chronic disease were accompanied by nutritional anemia [17]. In elderly patients with chronic disease, nutritional anemia can lead to health problems such as aggravated symptoms of chronic disease, increased mortality, and decreased exercise resulting in decreased muscle mass [18]. Thus, the study of nutritional anemia in Korean elderly should be considered inadequate nutrient intakes and chronic diseases.

Although nutritional anemia has become an important health problem in Korea due to population aging, few studies have investigated its relations with nutrient intakes status and chronic diseases according to nutritional anemia in the elderly. Therefore, the purpose of this study was conducted to investigate the associations between nutritional anemia and nutrient intakes status and chronic diseases in Korean elderly by analyzing data collected the 6th Korea National Health and Nutrition Examination Survey (KNHANES) 2013-2015.

SUBJECTS AND METHODS

Study population and design

This study used data from the 6th KNHANES (2013-2015) conducted by the Korea Centers for Disease Control and Prevention (KCDC) of the Ministry of Health and Welfare. This survey was approved by the institutional review board (IRB) of the KCDC (IRB approval number in 2013 and 2014: 2013-07CON-03-4C and 2013-12EXP-03-5C). Following the Bioethics and Safety Act in Korea, KNHANES as the study conducted by the government for public welfare has been conducted without any review by IRB since 2015. Raw data used in this study were obtained on May 30, 2018, after obtaining approval from the KNHANES website.

As shown in Fig. 1, 3,258 participants aged 65 years and older were selected from the 22,948 participants that participated in 6th KNHANES; 18,439 participants were excluded for age under 65, 183 participants for missing data on nutrient intakes, 46 participants for reporting implausible dietary intakes (< 500 kcal

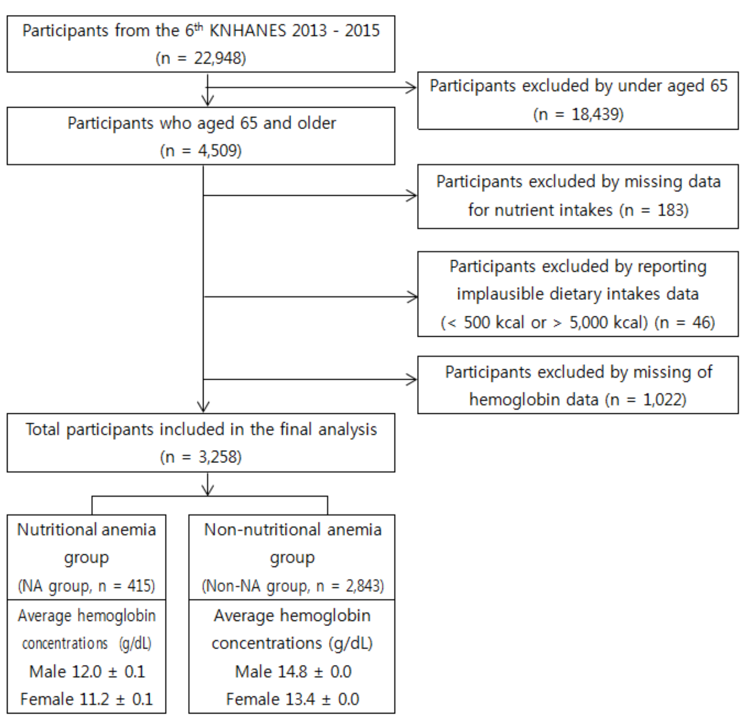

Fig. 1. Flow chart of participants included in the analysis

or > 5,000 kcal per day) [19], and 1,022 participants for no hemoglobin data. Nutritional anemia group (NA group) and non-NA group were classified by hemoglobin concentration in blood (< 13 g/dL for male and < 12 g/dL for female) [2]. Hemoglobin concentration in blood was determined by using an XE-2100D analyzer (Sysmex, Japan) in 2013-2014 and an XN-9000 analyzer (Sysmex, Japan) in 2015. Average hemoglobin concentrations in blood of male and female subjects were 12.0 g/dL and 11.2 g/dL in NA group, 14.8 g/dL and 13.4 g/dL in non-NA group, respectively ($P < 0.001$). Thus, subjects were divided into 415 subjects with nutritional anemia (12.7%) in NA group and 2,843 subjects without nutritional anemia (83.7%) in non-NA group.

General characteristics

General characteristics were obtained from gender, age, region, educational level, income level, and the number of family members included in the basic variables data of KNHANES. Age groups were classified as 65 to 74 years and aged 75 years and older [2,20]. Region was classified as urban or rural, and educational level was classified as elementary school or less, middle school, high school, or college graduate or more. Income level was divided into quartiles by mean values of age and gender subgroups, and the number of family members was classified as single or more than two persons.

Anthropometric and blood pressure data

Anthropometric data were obtained from values of height, body weight, waist circumference, and body mass index (BMI) included in the anthropometric measurement data of KNHANES. Height, body weight, and waist circumference were measured using extensometer (SECA 200, SECA, Germany), body weight scale (GL-6000-20, G-TECH, Korea), and tape measure (SECA 200, SECA, Germany), respectively. BMI was calculated by dividing body weight (kg) by height squared (m^2).

Blood pressure data were obtained from values of final systolic and diastolic blood pressure (average values of the second and third blood pressure measurements taken over 3 separate sessions) included in blood pressure measurement data of KNHANES. Blood pressure was measured using a sphygmomanometer (Baumanometer Wall Unit 33, Baum, USA) after a five-minute rest.

Biochemical data in blood

Biochemical data in blood were obtained from levels of fasting blood glucose and serum lipid profiles (total cholesterol, TC; high-density lipoprotein cholesterol, HDL-C; triglyceride, TG; low-density lipoprotein cholesterol, LDL-C) included in blood test of KNHANES. Blood was obtained from participants in the morning after at least 8-hour of fasting overnight. Fasting blood glucose, serum lipid, and serum creatinine levels were determined by using a Hitachi Automatic Analyzer 7600-210 (Hitachi, JAPAN). Blood analyses were performed by the Neodin Medical Institute; a laboratory certified by the Korea Centers for Disease Control & Prevention.

Dietary intake assessment

Intakes of major food groups, energy, nutrients, and dietary fiber were obtained from values included in the nutrition survey of the KNHANES. Survey of dietary intake was completed by using a 24-hour recall method by a face-to-face interview with trained staff. Major food groups were categorized into 17 items based on the Korean Food Composition Table 9th Revision by the Rural Development Administration [21]. Intakes of energy, nutrients, and dietary fiber were assessed and the proportions of the subjects consuming nutrients less than the EAR using the 2015 dietary reference intakes for Korean (KDRIs) were compared according to nutritional anemia [20].

Health-related lifestyle habits

Health-related lifestyle habits were obtained from values included in the nutrition survey of the KNHANES. They included alcohol drinking, smoking status, and walking frequency. Alcohol drinking, smoking status, and walking frequency were assessed using yes or no responses to 'less than 1 glass/month', 'current smoking', and 'more than 30 min per day and 5 days per week', respectively.

Criteria for the diagnosis of chronic diseases

Chronic diseases in this study included obesity as determined by BMI, abdominal obesity, hypertension, diabetes, hypercholesterolemia, hypertriglyceridemia, myocardial infarction or angina, and osteoarthritis or rheumatoid arthritis [22]. Based on criteria in the guidebook for the KNHANES Raw Data, these chronic diseases were defined [23]. Obesity as determined by BMI and abdominal obesity were defined as BMI of $\geq$ 25.0 kg/m^2 and waist circumference of $\geq$ 90 cm for male and $\geq$ 85 cm for female. Hypertension was defined as systolic or diastolic blood pressure of $\geq$ 140 or 90 mmHg, respectively, or taking of hypertension medication. Diabetes was defined as fasting blood glucose level of $\geq$ 126 mg/dL or taking of diabetes medication. Cholesterolemia, low HDL cholesterolemia, hypertriglyceridemia, and high LDL cholesterolemia were defined as TC level of $\geq$ 240 mg/dL or taking of cholesterol-lowering drugs, as HDL-C level of $\leq$ 40 mg/dL, as TG level of $\geq$ 200 mg/dL, and as LDL-C level of $\geq$ 130 mg/dL, respectively. Myocardial infarction or angina pectoris, osteoarthritis or rheumatoid arthritis, and kidney failure were diagnosed with the presence of them depending on diagnosis by a doctor.

Statistical analysis

Because the KNHANES data were collected using a complex sampling design involving cluster and stratified samplings, 6th KNHANES data were analyzed by applying primary sampling units (PSU), strata (Kstrata), and integrated weights. Continuous variables presented as mean ± standard error (SE) and categorical variables presented as percentage and SE were verified for significance using complex sample general linear model t-test and complex sample chi-square test according to the prevalence of nutritional anemia, respectively. Relationships between nutritional anemia and nutrient intakes and chronic diseases were analyzed using multiple logistic regression analysis. This analysis was performed to obtain the odds ratio (OR) and 95% confidence interval (CI) adjusted for confounding variables. Three models were presented in ways as follows: Model 1 was not adjusted for confounding variables; Model 2 was adjusted for age and the number of family members; Model 3 was adjusted for age, the number of family members, energy intake, and alcohol drinking.

Statistical analyses of data were conducted using IBM SPSS Statistics for Windows version 23.0 program (Armonk, NY, USA: IBM Corp.), and the level of statistical significance levels was set at $P < 0.05$.

RESULTS

General characteristics of the subjects by nutritional anemia

General characteristics of the subjects by the presence of nutritional anemia are shown in Table 1. Percentage of male and female subjects was 43.4% and 56.6% in NA group and 45.2% and 54.8% in non-NA group, respectively. Percentages of the subjects aged 65 to 74 years and ≥ 75 years were 56.8% and 43.2% in NA group (average age 73.3) and 70.1% and 29.9% in non-NA group (average age 71.7), respectively ($P < 0.001$). For the number of family members, percentage of the subjects living alone in NA and non-NA groups was 26.0% and 19.2%, respectively ($P < 0.01$).

Anthropometric and blood pressure data of the subjects by nutritional anemia and gender

Differences in anthropometric and blood pressure data in NA and non-NA groups by gender are shown in Table 2. Average BMI and waist circumference in NA and non-NA groups were 22.6 kg/m^2 and 82.8 cm and 23.8 kg/m^2 and 86.2 cm for male subjects ($P < 0.001$) and 23.8 kg/m^2 and 81.5 cm and 24.5 kg/m^2 and 84.1 cm for female subjects ($P < 0.01$), respectively. Average diastolic blood pressure in NA group (66.2 mmHg for males and 68.8 mmHg for females) was significantly lower compared to non-NA group (73.1 mmHg for males and 72.7 mmHg for females, $P < 0.001$), but there was no difference in average systolic blood pressure.

Biochemical data in blood of the subjects by nutritional anemia and gender

As shown in Table 3, average serum TC ($P < 0.001$) and serum HDL-C ($P < 0.05$) levels in NA group were significantly lower compared to non-NA group. Average serum TG levels of females were 120.3 mg/dL in NA group and 141.7 mg/dL in non-NA group ($P < 0.001$) and average serum LDL-C levels of males were 92.1 mg/dL in NA group and 107.8 mg/dL in non-NA group ($P < 0.001$). Average serum creatinine levels in NA group were significantly higher compared to non-NA group in both male ($P < 0.05$) and female ($P < 0.001$).

Table 1. General characteristics of the subjects by nutritional anemia

Variables	NA group (n = 415)[1]	Non-NA group (n = 2,843)	χ^2 or t-value
Gender			
Male	43.4 (2.5)[2]	45.2 (0.9)	0.434
Female	56.6 (2.5)	54.8 (0.9)	
Age (yrs)	73.3 ± 0.3[3]	71.7 ± 0.1	6.298***[4]
65-74	56.8 (2.6)	70.1 (1.0)	25.834***
≥ 75	43.2 (2.6)	29.9 (1.0)	
Residence region			
Urban	73.5 (3.1)	73.9 (2.3)	0.024
Rural	26.5 (3.1)	26.1 (2.3)	
Educational level			
≤ Elementary school	64.4 (2.7)	60.2 (1.2)	1.104
Middle school	12.5 (1.9)	13.9 (0.8)	
High school	16.6 (2.1)	17.3 (0.8)	
≥ College	6.5 (1.3)	8.7 (0.7)	
Income level			
Low	48.6 (2.8)	46.4 (1.3)	0.926
Mid-low	29.0 (2.5)	27.4 (1.0)	
Mid-high	14.1 (1.9)	15.7 (0.9)	
High	8.3 (1.6)	10.5 (0.8)	
Number of family members			
Single	26.0 (2.4)	19.2 (0.8)	8.568**
≥ 2	74.0 (2.4)	80.8 (0.8)	

NA: Nutritional Anemia
[1] N was represented by the unweighted sample size
[2] % (SE)
[3] Mean ± SE
[4] *** $P < 0.001$, ** $P < 0.01$; P-values were analyzed by complex sample chi-square test or complex sample general linear model t-test

Major food group intakes of the subjects by nutritional anemia and gender

Major food group intakes of the subjects are shown in Table 4. For males, intakes of potatoes, pulses ($P < 0.05$), and mushrooms ($P < 0.01$) in NA group (6.8, 12.4, and 0.7 g, respectively) were significantly lower compared to non-NA group (11.8, 19.7, and

Table 2. Anthropometric and blood pressure data of the subjects by nutritional anemia and gender

Variables	Male (n = 1,474)[1]			Female (n = 1,784)		
	NA group (n = 182)	Non-NA group (n = 1,292)	t-value	NA group (n = 233)	Non-NA group (n = 1,551)	t-value
Height (cm)	164.1 ± 0.5[2]	165.3 ± 0.2	-2.425*[3]	150.1 ± 0.6	151.7 ± 0.2	-2.827**
Body weight (kg)	61.1 ± 0.8	65.0 ± 0.3	-5.040***	53.6 ± 0.7	56.5 ± 0.3	-4.088***
Body mass index (kg/m^2)	22.6 ± 0.3	23.8 ± 0.1	-4.347***	23.8 ± 0.3	24.5 ± 0.1	-2.920**
Waist circumference (cm)	82.8 ± 0.8	86.2 ± 0.3	-4.254***	81.5 ± 0.8	84.1 ± 0.3	-3.084**
Systolic blood pressure (mmHg)	125.5 ± 1.6	126.6 ± 0.6	-0.607	129.2 ± 1.5	129.4 ± 0.5	-0.095
Diastolic blood pressure (mmHg)	66.2 ± 0.9	73.1 ± 0.3	-7.171***	68.8 ± 0.9	72.7 ± 0.3	-4.258***

NA: Nutritional Anemia
[1] N was represented by the unweighted sample
[2] Mean ± SE
[3] *** $P < 0.001$, ** $P < 0.01$, * $P < 0.05$; P-values were analyzed by complex sample general linear model t-test

Table 3. Biochemical data in blood of the subjects by nutritional anemia and gender

Variables	Male (n = 1,474)[1]			Female (n = 1,784)		
	NA group (n = 182)	Non-NA group (n = 1,292)	t-value	NA group (n = 233)	Non-NA group (n = 1,551)	t-value
Fasting blood glucose (mg/dL)	112.4 ± 3.1[2]	107.3 ± 0.8	1.643	104.2 ± 1.6	106.7 ± 0.8	-1.407
Serum total cholesterol (mg/dL)	163.6 ± 2.9	180.7 ± 1.1	-5.566***	181.4 ± 2.9	194.8 ± 1.1	-4.406***
Serum HDL-cholesterol (mg/dL)	44.5 ± 0.9	46.5 ± 0.4	-1.996*[3]	47.1 ± 0.9	49.4 ± 0.3	-2.310*
Serum triglyceride (mg/dL)	118.2 ± 10.6	138.7 ± 2.6	-1.872	120.3 ± 4.3	141.7 ± 2.3	-4.499***
Serum LDL-cholesterol (mg/dL)	92.1 ± 3.7	107.8 ± 1.8	-3.912***	110.4 ± 4.1	117.0 ± 1.4	-1.531
Serum creatinine (mg/dL)	0.77 ± 0.02	0.73 ± 0.0	2.201*	0.86 ± 0.02	0.75 ± 0.01	5.126***

NA: Nutritional Anemia
[1] N was represented by the unweighted sample
[2] Mean ± SE
[3] *** $P < 0.001$, * $P < 0.05$; P-values were analyzed by complex sample general linear model t-test

Table 4. Major food group intakes of the subjects by nutritional anemia and gender

Variables	Male (n = 1,474)[1]			Female (n = 1,784)		
	NA group (n = 182)	Non-NA group (n = 1,292)	t-value	NA group (n = 233)	Non-NA group (n = 1,551)	t-value
Grains (g)	309.5 ± 11.0[2]	320.7 ± 4.5	-0.962	269.6 ± 9.3	277.9 ± 4.6	-0.797
Potatoes (g)	6.8 ± 1.9	11.8 ± 1.8	-1.972*[3]	5.3 ± 1.3	14.3 ± 2.3	-3.512***
Saccharides (g)	4.8 ± 0.9	4.3 ± 0.6	0.552	3.0 ± 0.4	2.6 ± 0.3	-1.312
Pulses (g)	12.4 ± 2.7	19.7 ± 2.5	-2.125*	10.9 ± 2.6	11.8 ± 1.3	-0.310
Nuts (g)	3.0 ± 1.2	4.1 ± 0.8	-0.732	1.5 ± 0.7	3.0 ± 0.5	-1.637
Vegetables (g)	136.1 ± 17.6	132.8 ± 10.7	0.185	109.6 ± 17.8	108.0 ± 9.0	0.092
Mushrooms (g)	0.7 ± 0.3	1.8 ± 0.4	-2.703**	0.9 ± 0.5	1.3 ± 0.3	-0.732
Fruits (g)	69.8 ± 14.1	75.5 ± 8.0	-0.367	55.0 ± 10.8	80.8 ± 8.2	-2.271*
Seaweed (g)	14.2 ± 5.1	15.3 ± 2.8	-0.189	6.6 ± 3.2	14.2 ± 2.8	-1.783
Seasonings (g)	12.3 ± 1.8	11.7 ± 1.1	0.309	8.3 ± 1.5	8.1 ± 0.7	0.161
Other vegetables (g)	0.2 ± 0.1	0.4 ± 0.2	-1.228	0.4 ± 0.4	0.2 ± 0.1	0.550
Meats (g)	22.5 ± 4.8	27.8 ± 3.7	-0.961	11.4 ± 2.7	18.7 ± 2.2	-2.182*
Eggs (g)	5.5 ± 1.4	6.5 ± 0.9	-0.691	2.9 ± 0.8	4.9 ± 0.6	-2.269*
Seafood (g)	37.4 ± 10.6	40.0 ± 4.5	-0.238	19.2 ± 5.2	32.7 ± 4.3	-2.209*
Milk/dairy products (g)	16.3 ± 4.5	14.8 ± 2.0	0.305	28.1 ± 6.4	21.4 ± 2.7	1.000
Beverages (g)	26.2 ± 6.4	17.4 ± 2.2	1.382	12.4 ± 3.3	15.3 ± 1.9	-0.793
Alcohol (g)	40.4 ± 18.0	31.0 ± 5.0	0.506	5.6 ± 4.7	3.9 ± 1.2	0.351

NA: Nutritional Anemia
[1] N was represented by the unweighted sample
[2] Mean ± SE
[3] *** $P < 0.001$, * $P < 0.05$; P-values were analyzed by complex sample general linear model t-test

1.8 g, respectively). For females, intakes of potatoes ($P < 0.001$), fruits, meats, eggs, and seafood ($P < 0.05$) in NA group (5.3, 55.0, 11.4, 2.9, and 19.2 g, respectively) were significantly lower compared to non-NA group (14.3, 80.8, 18.7, 4.9, and 32.7 g, respectively).

Nutrient intakes of the subjects by nutritional anemia and gender

Nutrient intakes of the subjects and proportions of the subjects less than EAR of nutrients by nutritional anemia and gender are shown in Table 5. Energy intake in NA and non-NA groups were 1,785.7 and 1,991.8 kcal for male subjects ($P < 0.001$) and 1,398.9 and 1,548.4 kcal for female subjects ($P < 0.01$), respectively. As for differences in intakes of nutrients to support hematopoiesis, in males, significant differences were observed between NA and non-NA groups for intakes of protein (55.7 and 65.8g), vitamin B_2 (1.0 and 1.2 mg), niacin (13.1 and 15.2 mg NE) ($P < 0.001$), iron (16.2 and 18.3 mg, $P < 0.01$), respectively. In females, significant differences were observed between NA and non-NA groups for intakes of protein (41.7 and 48.6 g), niacin (9.5 and 11.5 mg NE), iron (12.7 and 15.6 mg) ($P < 0.001$), vitamin B_2 (0.8 and 0.9 mg), vitamin C (76.1 and 102.0 mg) ($P < 0.01$), and vitamin A (466.0 and 600.8 μgRAE) ($P < 0.05$), respectively.

To observe the intakes level of nutrient to support hematopoiesis, the proportion of subjects whose nutrient intakes less than EAR of KDRIs was analyzed according to nutritional anemia. In total subjects, the proportion of the subjects whose protein (48.3% and 36.2%), vitamin B_2 (77.6% and 64.9%), niacin (63.8% and 49.3%) ($P < 0.001$), vitamin A (63.9% and 56.0%, $P < 0.01$), and iron (9.5% and 5.9%, $P < 0.05$) intakes less than EAR were significantly higher in NA group compared to non-NA group. Nutrients to support hematopoiesis that were more than 40% of the proportion of the subjects less than EAR were vitamin A, vitamin B_2, niacin, vitamin C, and protein (only in NA group).

Table 5. Comparison of nutrient intakes and proportions of the subjects whose nutrient intake less than EAR of KDRIs by nutritional anemia and gender

Variables	Male (n = 1,474)[1]			Female (n = 1,784)			Total (n = 3,258)		
	NA group (n = 182)	Non-NA group (n = 1,292)	t or χ^2-value	NA group (n = 233)	Non-NA group (n = 1,551)	t or χ^2-value	NA group (n = 233)	Non-NA group (n = 1,551)	χ^2-value
Energy (kcal)	1,785.7 ± 49.6[2]	1,991.8 ± 23.0	-3.681***[4]	1,398.9 ± 39.1	1,548.4 ± 18.4	-3.457**			
Carbohydrate (g)	317.2 ± 9.2	333.5 ± 3.9	-1.643	262.7 ± 7.1	284.4 ± 3.6	-2.748**			
Fat (g)	24.1 ± 1.3	31.6 ± 0.8	-2.092***	18.1 ± 1.0	22.0 ± 0.6	-3.361**			
Protein (g)	55.7 ± 1.9	65.8 ± 1.0	-4.668***	41.7 ± 1.4	48.6 ± 0.8	-4.240***			
EAR M < 45, F < 40	42.4 (4.2)[3]	28.0 (1.5)	11.164**	52.6 (3.4)	42.7 (1.5)	6.650*	48.3 (2.7)	36.2 (1.1)	17.981***
Vitamin A (μgRAE)	749.2 ± 99.7	690.8 ± 28.0	0.588	466.0 ± 47.0	600.8 ± 24.7	-2.513*			
EAR M < 500, F < 410	63.6 (3.8)	55.4 (1.7)	3.656	64.1 (3.6)	56.5 (1.4)	4.005*	63.9 (2.6)	56.0 (1.1)	7.650**
Vitamin B_1 (mg)	1.7 ± 0.1	2.0 ± 0.0	-4.365***	1.4 ± 0.0	1.6 ± 0.0	-2.705**			
EAR M < 1.0, F < 0.9	15.5 (3.0)	8.1 (0.9)	7.563**	24.0 (3.2)	14.2 (1.1)	9.451**	20.4 (2.2)	11.5 (0.7)	17.058***
Vitamin B_2 (mg)	1.0 ± 0.0	1.2 ± 0.0	-3.855***	0.8 ± 0.1	0.9 ± 0.0	-3.055**			
EAR M < 1.3, F < 1.0	82.0 (2.8)	64.7 (1.6)	23.752***	74.4 (3.1)	65.0 (1.5)	7.528**	77.6 (2.1)	64.9 (1.1)	25.621***
Niacin (mg NE)	13.1 ± 0.5	15.2 ± 0.3	-3.712***	9.5 ± 0.3	11.5 ± 0.2	-4.806***			
EAR M < 12, F < 11	53.7 (4.2)	38.5 (1.6)	10.762***	71.1 (3.4)	58.0 (1.5)	11.401**	63.8 (2.7)	49.3 (1.1)	22.860***
Vitamin C (mg)	100.0 ± 9.4	101.6 ± 4.0	-0.157	76.1 ± 7.5	102.0 ± 4.2	-3.043**			
EAR M < 75, F < 75	58.8 (4.2)	57.8 (1.7)	0.051	64.4 (3.9)	57.0 (1.6)	3.003*	62.1 (2.9)	57.4 (1.2)	2.274
Calcium (mg)	406.9 ± 19.2	478.5 ± 11.8	-3.173**	335.3 ± 16.2	381.9 ± 8.1	-2.607**			
EAR M < 570, F < 560	81.1 (3.2)	74.5 (1.5)	3.172	89.2 (2.5)	82.4 (1.2)	5.288*	85.8 (2.0)	78.9 (0.9)	8.776*
Phosphorus (mg)	897.4 ± 28.7	1,051.8 ± 15.4	-4.655***	692.4 ± 24.2	802.7 ± 13.3	-4.060***			
EAR M < 580, F < 580	18.4 (3.3)	11.5 (1.0)	4.957*	44.5 (3.6)	31.8 (1.5)	11.314**	33.5 (2.6)	22.8 (0.9)	16.826***
Iron (mg)	16.2 ± 0.6	18.3 ± 0.3	-3.032**	12.7 ± 0.5	15.6 ± 0.7	-3.557***			
EAR M < 7, F less than 75 years old < 6 or more than 75 years old < 5	7.1 (2.2)	5.4 (0.7)	0.620	11.3 (2.3)	6.2 (0.7)	5.737*	9.5 (1.6)	5.9 (0.5)	5.762*
Sodium (mg)	3,238.0 ± 148.6	3,852.3 ± 79.1	-3.528***	2,634.1 ± 136.6	2,803.4 ± 64.6	-1.094			
Potassium (mg)	2,713.1 ± 94.9	3,069.3 ± 51.5	-3.248**	2,125.8 ± 74.7	2,576.5 ± 47.1	-5.241***			
Dietary fiber (g)	23.9 ± 1.1	26.3 ± 0.5*	-2.037*	18.8 ± 0.8	22.3 ± 0.4	-3.969***			

NA, Nutritional Anemia; KDRIs 2015, dietary reference intakes for Koreans 2015; EAR, estimated average requirements; M, male; F, female
1) N was represented by the unweighted sample
2) Mean ± SE
3) % (SE), proportions of the subjects whose nutrient intake less than EAR of KDRIs 2015
4) *** $P < 0.001$, ** $P < 0.01$, * $P < 0.05$; P-values were analyzed by complex sample general linear model t-test

Table 6. Health-related lifestyle habits of the subjects by nutritional anemia and gender

Variables	Male (n = 1,474)[1]			Female (n = 1,784)			Total (n = 3,258)		
	NA group (n = 182)	Non-NA group (n = 1,292)	χ^2-value	NA group (n = 233)	Non-NA group (n = 1,551)	χ^2-value	NA group (n = 415)	Non-NA group (n = 2,843)	χ^2-value
Alcohol drinking[2]									
Yes	46.2 (4.5)[5]	59.9 (1.7)	8.383**[6]	14.8 (2.7)	18.9 (1.2)	1.595	27.6 (2.5)	37.3 (1.0)	10.832**[6]
No	53.8 (4.5)	40.1 (1.7)		85.2 (2.7)	81.1 (1.2)		72.4 (2.5)	62.7 (1.0)	
Smoking[3]									
Yes	18.6 (3.2)	21.2 (1.5)	0.518	2.2 (1.0)	2.9 (0.6)	0.304	8.8 (1.5)	11.1 (0.8)	1.576
No	81.4 (3.2)	78.8 (1.5)		97.8 (1.0)	97.1 (0.6)		91.2 (1.5)	88.9 (0.8)	
Walking frequency[4]									
Yes	7.8 (2.1)	6.5 (1.0)	0.338	10.3 (2.5)	6.9 (0.9)	2.141	9.3 (1.8)	6.7 (0.7)	2.046
No	92.2 (2.1)	93.5 (1.0)		89.7 (2.5)	93.1 (0.9)		90.7 (1.8)	93.3 (0.7)	

NA: Nutritional Anemia
[1] N was represented by the unweighted sample
[2] < 1 glass/month
[3] Current smoking status
[4] ≥ 30 min/day and ≥ 5 days/week
[5] % (SE)
[6] *** $P < 0.001$, ** $P < 0.01$, * $P < 0.05$; *P*-values were analyzed by complex sample chi-square test

Table 7. Prevalence rate of chronic diseases in the subjects by nutritional anemia and gender

Variables	Male (n = 1,474)[1]			Female (n = 1,784)			Total (n = 3,258)		
	NA group (n = 182)	Non-NA group (n = 1,292)	χ^2-value	NA group (n = 233)	Non-NA group (n = 1,551)	χ^2-value	NA group (n = 415)	Non-NA group (n = 2,843)	χ^2-value
Obesity as determined by BMI (body mass index ≥ 25 kg/m²)									
With	21.3 (3.3)[2]	32.5 (1.5)	8.501**[3]	33.8 (34)	42.2 (1.5)	5.050*	28.6 (2.6)	37.9 (1.0)	11.080**
Without	78.7 (3.3)	67.5 (1.5)		66.2 (3.4)	57.8 (1.5)		71.4 (2.6)	62.1 (1.0)	
Abdominal obesity (waist circumference ≥ 90 cm for male and ≥ 85 cm for female)									
With	24.8 (3.7)	33.7 (1.6)	4.419*	34.0 (3.5)	45.5 (1.6)	8.435**	30.1 (2.6)	40.2 (1.2)	12.392***
Without	75.2 (3.7)	66.3 (1.6)		66.0 (3.5)	54.5 (1.6)		69.9 (2.6)	59.8 (1.2)	
Hypertension (systolic blood pressure or diastolic blood pressure ≥ 140 or 90 mmHg, drug taker)									
With	64.5 (4.1)	55.9 (1.7)	3.980*	66.4 (4.3)	62.2 (1.5)	0.915	65.6 (3.1)	59.4 (1.1)	3.987*
Without	35.5 (4.1)	44.1 (1.7)		33.6 (4.3)	37.8 (1.5)		34.4 (3.1)	40.6 (1.1)	
Diabetes (fasting blood glucose ≥ 126 mg/dL, drug taker, insulin injection)									
With	39.9 (4.3)	22.0 (1.4)	19.492***	31.0 (3.9)	23.1 (1.4)	4.286*	34.7 (2.8)	22.6 (1.0)	21.093***
Without	60.1 (4.3)	78.0 (1.4)		69.0 (3.9)	76.9 (1.4)		65.3 (2.8)	77.4 (1.0)	
Hypercholesterolemia (serum total cholesterol ≥ 240 mg/dL, drug taker)									
With	18.2 (3.7)	17.5 (1.2)	0.033	29.7 (3.5)	35.8 (1.4)	2.456	25.0 (2.7)	27.6 (1.0)	0.807
Without	81.8 (3.7)	82.5 (1.2)		70.3 (3.5)	64.2 (1.4)		75.0 (2.7)	72.4 (1.0)	
Hypertriglyceridemia (serum triglyceride ≥ 200 mg/dL)									
With	8.4 (2.5)	15.3 (2.5)	4.734*	10.2 (2.5)	15.7 (1.1)	3.223	9.4 (1.7)	15.5 (0.9)	7.997**
Without	91.6 (1.3)	84.7 (1.3)		89.8 (2.5)	84.3 (1.1)		90.6 (1.7)	84.5 (0.9)	
Myocardial infarction or angina pectoris (doctor's diagnosis)									
With	12.8 (2.6)	7.0 (0.8)	5.593*	9.2 (2.5)	6.5 (0.8)	1.271	10.7 (1.8)	6.7 (0.5)	5.731*
Without	87.2 (2.6)	93.0 (0.8)		90.8 (2.5)	93.5 (0.8)		89.3 (1.8)	93.3 (0.5)	
Osteoarthritis or rheumatoid arthritis (doctor's diagnosis)									
With	18.0 (3.4)	14.1 (1.2)	1.277	54.7 (3.8)	44.8 (1.6)	6.051*	39.2 (2.9)	31.2 (1.1)	7.546**
Without	82.0 (3.4)	85.9 (1.2)		45.3 (3.8)	55.2 (1.6)		60.8 (2.9)	68.8 (1.1)	
Kidney failure (doctor's diagnosis)									
With	0 (0.0)	0.4 (0.2)	1.217	0.6 (0.4)	0.6 (0.2)	0.000	0.3 (0.2)	0.5 (0.1)	0.248
Without	100.0 (0.0)	99.6 (0.2)		99.4 (0.4)	99.4 (0.2)		99.7 (0.2)	99.5 (0.1)	

NA: Nutritional Anemia
[1] N was represented by the unweighted sample
[2] % (SE)
[3] *** $P < 0.001$, ** $P < 0.01$, * $P < 0.05$ by complex sample chi-square test

Table 8. Odds ratios for nutritional anemia according to chronic diseases

Variables		Nutritional anemia		
		Model 1 OR (95% CI)	Model 2 OR (95% CI)	Model 3 OR (95% CI)
Obesity as determined by body mass index				
Male	With	0.56 (0.38-0.84)**[1)]	0.61 (0.41-0.92)*	0.66 (0.43-1.00)
	Without (ref)			
Female	With	0.70 (0.51-0.96)*	0.71 (0.52-0.98)*	0.89 (0.58-1.36)
	Without (ref)			
Total	With	0.65 (0.51-0.85)**	0.68 (0.52-0.88)**	0.64 (0.49-0.84)**
	Without (ref)			
Abdominal obesity				
Male	With	0.65 (0.43-0.98)*	0.66 (0.43-0.99)*	0.71 (0.12-1.10)
	Without (ref)			
Female	With	0.62 (0.44-0.86)**	0.61 (0.43-0.85)**	0.56 (0.40-0.78)**
	Without (ref)			
Total	With	0.64 (0.50-0.83)**	0.63 (0.49-0.81)***	0.60 (0.46-0.79)***
	Without (ref)			
Hypertension				
Male	With	1.44 (1.00-2.06)*	1.37 (0.96-1.97)	1.52 (1.03-2.24)*
	Without (ref)			
Female	With	1.20 (0.82-1.77)	1.12 (0.76-1.65)	0.86 (0.51-1.44)
	Without (ref)			
Total	With	1.31 (1.00-1.71)*	1.22 (0.94-1.59)	1.27 (0.96-1.67)
	Without (ref)			
Diabetes				
Male	With	2.36 (1.63-3.43)***	2.64 (1.81-3.86)***	2.54 (1.71-3.77)***
	Without (ref)			
Female	With	1.50 (1.03-2.18)*	1.44 (0.99-2.09)	1.36 (0.93-1.99)
	Without (ref)			
Total	With	1.82 (1.42-2.34)***	1.82 (1.42-2.34)***	1.74 (1.35-2.25)***
	Without (ref)			
Hypertriglyceridemia				
Male	With	0.51 (0.26-0.99)*	0.52 (0.27-1.03)	0.61 (0.31-1.19)
	Without (ref)			
Female	With	0.61 (0.35-1.08)	0.63 (0.35-1.12)	0.59 (0.33-1.06)
	Without (ref)			
Total	With	0.57 (0.37-0.86)**	0.58 (0.38-0.89)*	0.59 (0.39-0.91)*
	Without (ref)			
Myocardial infarction or angina pectoris				
Male	With	1.95 (1.16-3.31)*	1.81 (1.07-3.05)*	1.80 (1.04-3.09)*
	Without (ref)			
Female	With	1.46 (0.77-2.76)	1.38 (0.72-2.64)	1.37 (0.71-2.64)
	Without (ref)			
Total	With	1.67 (1.12-2.49)*	1.57 (1.04-2.37)*	1.59 (1.05-2.41)*
	Without (ref)			
Osteoarthritis or rheumatoid arthritis				
Male	With	1.33 (0.82-2.18)	1.21 (0.72-2.03)	1.16 (0.68-1.98)
	Without (ref)			
Female	With	1.49 (1.08-2.05)*	1.42 (1.02-1.98)*	1.38 (0.99-1.93)
	Without (ref)			
Total	With	1.43 (1.11-1.83)**	1.32 (1.01-1.73)	1.21 (0.92-1.61)
	Without (ref)			

NA, Nutritional Anemia; OR, odds ratio; CI, confidence interval
Model 1: without adjustment; Model 2: adjusted for age and the number of family members; Model 3: adjusted for age, the number of family members, energy intake, and alcohol drinking
[1)] *** $P < 0.001$, ** $P < 0.01$, * $P < 0.05$ by Logistic regression for nutritional anemia with chronic diseases

However, in both groups, the proportion of iron intake was less than 10% of EAR and was in good intake level.

Health-related lifestyle habits of the subjects by nutritional anemia and gender

As shown in Table 6, in male subjects, the percentage of alcohol drinking in NA group was significantly lower compared to non-NA group ($P < 0.01$). Percentages of smokers and walking frequency were similar in the two groups; 8.8% in NA group and 11.1% in non-NA group were smokers, and 9.3% in NA group and 6.7% in non-NA group walked for more than 30 minutes per day for 5 days per week.

Odds ratios for nutritional anemia according to chronic diseases

As shown in Table 7, the prevalence of hypertension ($P < 0.05$ in male and total), diabetes ($P < 0.001$ in male and total, $P < 0.05$ in female), myocardial infarction or angina pectoris ($P < 0.05$ in male and total), and osteoarthritis or rheumatoid arthritis ($P < 0.05$ in female, $P < 0.01$ in total) in NA group were significantly higher compared to non-NA group. However, the prevalence of obesity as determined by BMI ($P < 0.01$ in male and total, $P < 0.05$ in female), abdominal obesity ($P < 0.05$ in male, $P < 0.01$ in female, $P < 0.001$ in total), and hypertriglyceridemia ($P < 0.05$ in male, $P < 0.01$ in total) in NA group were significantly lower compared to non-NA group. There was no significant difference in hypercholesterolemia and kidney failure between NA and non-NA groups.

Except for hypercholesterolemia and chronic kidney failure, the degree of risk exerted by chronic diseases on nutritional anemia is shown in Table 8. In males, for model 1 as risk in crude ORs for chronic diseases, obesity as determined by BMI, abdominal obesity, and hypertriglyceridemia were associated with a decrease in the prevalence of nutritional anemia. After controlling for age and the number of family members (model 2), obesity as determined by BMI and abdominal obesity were significantly decreased the prevalence of nutritional anemia, but age and the number of family members were significantly contributed to hypertriglyceridemia. Whereas in males, for model 1, hypertension, diabetes, and myocardial infarction or angina pectoris were associated with an increase in the prevalence of nutritional anemia. For model 2, diabetes and myocardial infarction or angina pectoris were significantly increased the prevalence of nutritional anemia, but age and the number of family members were significantly contributed to hypertension. After controlling for age, the number of family members, energy intake, and alcohol drinking (model 3), hypertension (1.52 times, 95% CI = 1.03-2.24), diabetes (2.54 times, 95% CI = 1.71-3.77), myocardial infarction or angina pectoris (1.80 times, 95% CI = 1.04-3.09) were significantly increased the prevalence of nutritional anemia.

In Females, for model 1, obesity as determined by BMI and abdominal obesity were associated with a decrease in the prevalence of nutritional anemia. For model 2, obesity as determined by BMI and abdominal obesity were significantly decreased the prevalence of nutritional anemia. For model 3, abdominal obesity (0.56 times, 95% CI = 0.40-0.78) was significantly decreased the prevalence of nutritional anemia but age and the number of family members were significantly contributed to obesity as determined by BMI. Whereas in females, for model 1, diabetes and osteoarthritis or rheumatoid arthritis were associated with an increase in the prevalence of nutritional anemia. For model 2, osteoarthritis or rheumatoid arthritis was significantly increased the prevalence of nutritional anemia, but age and the number of family members were significantly contributed to diabetes.

In total subjects, for obesity as determined by BMI (0.64 times, 95% CI = 0.49-0.84), abdominal obesity (0.60 times, 95% CI = 0.46-0.79), and hypertriglyceridemia (0.59 times, 95% CI = 0.39-0.91) were significantly decreased the prevalence of nutritional anemia. Whereas in total subjects, for model 1, hypertension, diabetes, myocardial infarction or angina pectoris, and osteoarthritis or rheumatoid arthritis were associated with an increase in the prevalence of nutritional anemia. For model 2, diabetes and myocardial infarction or angina pectoris were significantly increased the prevalence of nutritional anemia, but age and the number of family members were significantly contributed to hypertension and osteoarthritis or rheumatoid arthritis. For model 3, diabetes (1.74 times, 95% CI = 1.35-2.25) and myocardial infarction or angina pectoris (1.59 times, 95% CI = 1.05-2.41) were significantly increased the prevalence of nutritional anemia.

DISCUSSION

Nutritional anemia in the elderly is known to be affected by poor quality and/or monotonous diet, gastrointestinal blood loss, and poor nutrient absorption due to demographics and health factors, etc. The purpose of this study was conducted to compare nutritional status according to nutritional anemia and to determine associations between nutritional anemia and chronic diseases in Korean elderly using 6^{th} KNHANES data.

Average age in NA group was two years older than in non-NA group and proportion of the subjects aged ≥ 75 was also higher. With age, average hemoglobin concentration declined and the prevalence of anemia also increased [4,24]. Furthermore, nutrients utilization is poorer in the elderly due to physiological aging and drugs taking to treat various diseases, and thus, hematologic changes including reductions in hemoglobin concentration may occur [4,25]. In this study, the proportion of elderly living alone was significantly higher in NA group than in Non-NA group. The dietary lifestyle of the elderly were closely related to the number of family members, and it was reported that the quality of nutrient intakes by elderly living alone was significantly lower than that of elderly living with family due to low-income levels and high meal costs [26,27]. This means that poor nutrient intake due to poor quality and monotonous diet of elderly living alone or getting older may cause nutritional anemia.

In this study, intakes of most foods and nutrients in NA group were significantly lower than in non-NA group, and proportions of the subjects whose nutrient intake less than EAR was also significantly higher in the NA group. Nutritional anemia in the elderly is known to be due to lack of storage of these in blood caused by inadequate intake and incomplete absorption and utilization of hematopoietic nutrients [28]. It was reported that hemoglobin concentration was positively associated with energy and nutrient intakes [29] and there was a difference in blood iron and ferritin levels depending on the degree of meat consumption [30]. However, in this study, we found intakes of potatoes, pulses, fruits, meats, eggs, and seafood, which are rich in nutrients for hematopoiesis, were significantly lower in NA group than in non-NA group. In Doyle *et al.* [31] study, the lower iron storage status in the British aged 65 years and older, intakes of vitamin C and consumption of meat, fish, vegetables, and potatoes were lower. Furthermore, because the consumption of food is reported to be related to masticatory abilities, the elderly with chewing difficulties may be decreased iron storage status. In the elderly with masticatory difficulty, it is possible that food is swallowed without chewing, which would result in poor nutrients absorption due to gastric distress and indigestion. Since nutritional anemia is assessed by the concentration of hemoglobin, ferritin, transferrin, iron, folic acid, and vitamin B_{12} in the blood, foods with high nutrient density should be selected and taken [5]. As a result, it is considered to be related to the lack of nutrient intakes and lack of food (meat, fruit, and egg, etc.) intakes in the elderly, so individualized nutrition education and management should be done on how to eat foods appropriately for deficient nutrient intakes.

Meanwhile, it was reported that nutritional anemia in the elderly accounted for 30 to 40% of all anemia cases and that iron-deficiency anemia was associated with about two-thirds of nutritional anemia cases [8]. Although iron intake in NA group was significantly lower than in non-NA group, average iron intake of NA group was 2.2 times higher than EAR of KDRIs and proportion of the subjects whose iron intake less than EAR in NA group was 7.1% of males and 11.3% of females. In Huang *et al.* [32] study, Taiwanese elderly were average iron intake more than 10 mg higher than the daily recommended dietary iron intake level, but iron storage level in blood was not significantly associated with iron intake. This is due to a decrease in impaired efficiency of iron absorption in the elderly by causes as food type, aging, the presence of gastrointestinal lesions by chronic disease, etc. [8,33]. Iron bioavailability depends on the chemical nature of the iron and on the kinds of nutrients consumed. In particular, the availability of non-heme iron was influenced by meat, poultry, fish, and vitamin C intakes [34], which are lower in elderly with anemia. In addition, the most common cause of iron deficiency anemia in the elderly is a decrease in hemoglobin due to gastrointestinal blood loss [18]. Therefore, it is necessary to consume balanced hematopoietic nutrients to improve the iron storage in blood, and it is necessary to perform periodic health screening management to check for the occurrence cause of iron deficiency anemia due to chronic diseases.

Alcohol drinking rate of NA group was significantly lower compared to non-NA group ($P < 0.01$). In Teresa *et al.* [35] study, the degree of alcohol drinking was significantly higher in the group with high hemoglobin concentration and in Yun *et al.* [36] study, Korean female adults who drink alcohol showed 0.62 times significantly lower anemia prevalence compared to non-drinker. Alcohol can cause a change in iron metabolism, but it can quickly return to normal when drinker stops alcohol drinking [37]. However, chronic drinking can result in gastrointestinal bleeding as gastritis and gastric ulcers, which may lead to iron loss and the result of vitamin B_{12} and folate deficiency [38], so excessive drinking should be avoided.

The subjects of this study showed significant differences according to age, the number of family members, energy intake and alcohol drinking according to nutritional anemia. In previous studies [39,40], these factors were reported to affect anemia. Thus, the ORs of nutritional anemia by chronic diseases was analyzed by adjusting confounding factors as age, the number of family members, energy intake and alcohol drinking.

This study showed that obesity, hypertension, diabetes, hypertriglyceridemia, myocardial infarction or angina pectoris, and osteoarthritis or rheumatoid arthritis were associated with nutritional anemia. As regards obesity as determined by BMI, it was significantly less prevalent in NA group (21.3% in males, 33.8% in females) than in non-NA group (32.5% in males, 42.2% in females). Kim *et al.* [41] reported the prevalence of anemia in Korean elderly was negatively associated with body weight and BMI, and that hemoglobin concentration was positively correlated with BMI. Similarly, in this study, the prevalence of abdominal obesity in NA group (24.8% in males, 34.0% in females) was significantly lower compared to non-NA group (33.7% in males, 45.5% in females). In Chinese study, the average waist circumference of elderly women living in rural areas was lower than observed for female subjects in this study, but it was also found average waist circumference was significantly lower in anemic women than in normal controls (75.8 vs. 79.1 cm) [42]. In the elderly, BMI exhibits a high positive correlation with nutritional status [43], and BMI loss due to poor nutrient intakes may result in diminished immune function, muscle loss, and possibly nutritional anemia [44]. Therefore, elderly need to consume quality foods rich in protein, vitamins, and minerals and should be careful not to reduce food intake to lose body weight unconditionally.

Analysis showed the prevalence of hypertension, diabetes, myocardial infarction or angina pectoris, and osteoarthritis or rheumatoid arthritis was significantly higher in NA group. The ORs for nutritional anemia according to the presence of diabetes (1.738 times) and of myocardial infarction or angina pectoris (1.590 times) after adjustment appeared significant positive associations. NHANES III (1991-1994) [45] showed the prevalence of diabetes and osteoarthritis was significantly higher in elderly with nutritional anemia than in elderly without nutritional anemia. In the KNHANHS (2013-2014) [19], the OR of nutritional anemia was 1.66 times for the presence of osteoarthritis in Korean elderly (95% CI = 1.10-2.54). For diabetic patients, it was reported to be at high risk for nutritional anemia because hemoglobin concentrations were reduced caused by microvascular disease [46] and diabetic drugs taking were prone to depletion of folic acid and vitamin B_{12} [47]. For osteoarthritis or rheumatoid arthritis patients, clinical symptoms related to anemia may occur because arthritis drugs can inhibit hematopoiesis [48]. For myocardial infarction or angina pectoris patients, an increase in the oxygen demand of the body can lead to nutritional anemia by lower hemoglobin concentrations due to heavy oxygen transport [49]. These findings suggest the elderly need to consume foods rich in iron, vitamins, and protein to prevent nutritional anemia as complications of chronic diseases. And, because more than 30% of elderly people have more than two chronic diseases [19], if the elderly with chronic diseases know the cause of nutritional anemia through doctor's screening, it will be helpful in treatment of nutritional anemia.

This study has limitations. Because data collected for 6th KNHANES on food and nutrient consumption were obtained by the 24-hour recall method, this study could not assess usual daily intake amounts of the subjects. KNHANES is a cross-sectional study, which has the disadvantage of not being able to determine the causal relationship, although the association can be suggested. The data of this study dealt with only quantitative intakes, thus there was a limitation in delineating the relationship directly between chewing, digestion, and absorption and quantitative intakes. Thus, further study is required to determine the cause of nutritional anemia. Despite these limitations, this study provides scientific evidence regarding health problems associated with food intakes and relations between chronic diseases and nutritional anemia in the elderly. We believe this study data could be utilized for implementing health promotion related to nutritional anemia and chronic diseases for the elderly in the future.

In summary, our findings suggest nutrient intakes and chronic diseases in Korean elderly are related to the prevalence of nutritional anemia and the elderly with older age or elderly living alone are more likely to the prevalence of nutritional anemia. Nutritional anemia is generally treated by supplementation of nutrients but is diagnosed by biochemical assessment in blood, so the elderly need to choose foods that have high nutrient density and improve the quality of their diet. Therefore, in order to prevent nutritional anemia of Korean elderly, systematic, individualized, nutritional management and education programs that meet their social and economic conditions should be provided and implemented so that hematopoietic nutrients such as iron, protein, and vitamin B_2 are consumed. In addition, since nutritional anemia due to chronic diseases may occur, additional efforts should be considered to ensure check the elderly for nutritional anemia during the health screening.

CONFLICT OF INTEREST

The authors declare no potential conflicts of interests.

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