

Association between frailty and dietary quality in community-dwelling elderly: data from the 6th Korea National Health and Nutrition Examination Survey (2014–2015)

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Frailty is a progressive age-related disorder associated with odds ratio for subsequent falls, disability, and mortality. This study analyzed the association between frailty odds ratios and diet quality using the Korean Healthy Eating Index in older individuals. Data were obtained for 2,660 community-dwelling individuals aged ≥ 60 years who participated in the 6th Korea National Health and Nutrition Survey (2014–2015). Frailty was diagnosed following the Fried phenotype index based on five criteria: unintentional weight loss, emotional exhaustion, low physical activity, slow walking speed, and weak grip strength. The participants were categorized as normal, pre-frail, and frail. Diet quality was assessed using Korean Healthy Eating Index scores calculated based on 24-h dietary recall. Compared to the group with the highest Korean Healthy Eating Index score, the group with low Korean Healthy Eating Index showed a 1.71-fold higher pre-frail odds ratio (95% CI 1.31–2.22, $p < 0.001$) and 1.87-fold higher frail odds ratio (95% CI 1.21–2.91, $p = 0.009$). Also, compared to the group with the highest adequacy score, the group with the lowest score showed a 1.51-fold higher pre-frail odds ratio (95% CI 1.16–1.96, $p = 0.010$) and a 2.39-fold higher frail odds ratio (95% CI 1.48–3.86, $p = 0.002$). The findings of this study suggested that a high-quality diet, as assessed by Korean Healthy Eating Index, was negatively associated with the odds ratio of frailty.

Key Words: frail, elderly, diet, public health, Korean

In Korea, elderly aged ≥ 65 years accounted for 14.9% of the total population in 2019, a proportion that is predicted to increase to 39.8% by 2050.⁽¹⁾ This increase in the elderly population leads to increases in the population requiring support or with disease caused by aging, resulting in rising costs of welfare and health care.^(2,3) Thus, the efforts to improve the healthy life expectancy of the elderly will not only enhance the quality of life in the elderly but also provide a method to reduce loss through welfare and health care costs on the national level.

While the incidence of disease may seem like a key factor influencing reduced healthy life expectancy in the elderly, frailty is also an influencing factor.⁽⁴⁾ Frailty refers to the state of reduced functions in the body overall, with slow recovery from stress, rather than the state of a simple reduction in muscle quality or quantity such as in sarcopenia.⁽⁵⁾ The consequence is increased risks of reduced psychological function, fall, hospitalization, and mortality, which necessitates functional dependency or long-term care.⁽⁵⁾ Advanced countries including Japan define frailty as a disease on the national level and various studies are ongoing regarding frailty prevention and management.^(6–9) However, the

definition of frailty in Korea remains ambiguous and studies are currently developing frailty prevention and management guidelines and investigating the correlations with the factors influencing frailty in the elderly.

The factors that influence frailty include old age, disease, household income, marital status, hospitalization, fall,^(10,11) and diet.⁽¹²⁾ Studies on the associations between frailty and dietary factors have generally focused on individual food groups such as nutrients including proteins,⁽¹³⁾ fruits and vegetables,⁽¹⁴⁾ and dairy products,⁽¹⁵⁾ as well as energy consumption. Recently, the Healthy Eating Index (HEI), Diet Quality Index (DQI), Mediterranean Diet Score (MDS), and Dietary Approach to Stop Hypertension (DASH) diet score have been used in studies examining the correlations with diet quality evaluation. Numerous studies have reported that the frailty risk increases in individuals with low diet quality, based on results from the HEI,⁽¹⁶⁾ DQI-I,⁽¹⁷⁾ and MDS.⁽¹⁸⁾

Among these tools, the HEI is an indicator developed based on the recommended daily intake in the US and it is one of the most commonly used indicators in many countries.^(19,20) However, as the HEI reflects the recommended intake for people in the US, its application in evaluating people in Korea or other Asian countries with different physical conditions and dietary lifestyles could be problematic. Thus, the Korea Centers for Disease Prevention and Control developed the Korean Healthy Eating Index (KHEI) that incorporates the 2015 Dietary Reference Intakes for Koreans to allow the evaluation of the overall dietary lifestyles and diet quality in Koreans.⁽²¹⁾ While a number of studies have investigated the correlations between these factors and metabolic syndrome, hypertension, and mortality,^(22,23) there is a general lack of studies regarding the association with frailty.

Therefore, the present study investigated the association between diet quality and frailty using the KHEI and data from individuals aged ≥ 60 years who had participated in the Korea National Health and Examination Survey (KNHANES), a well-known national community-based survey. This study aimed to provide basic data for frailty prevention and management among the elderly in Korea.

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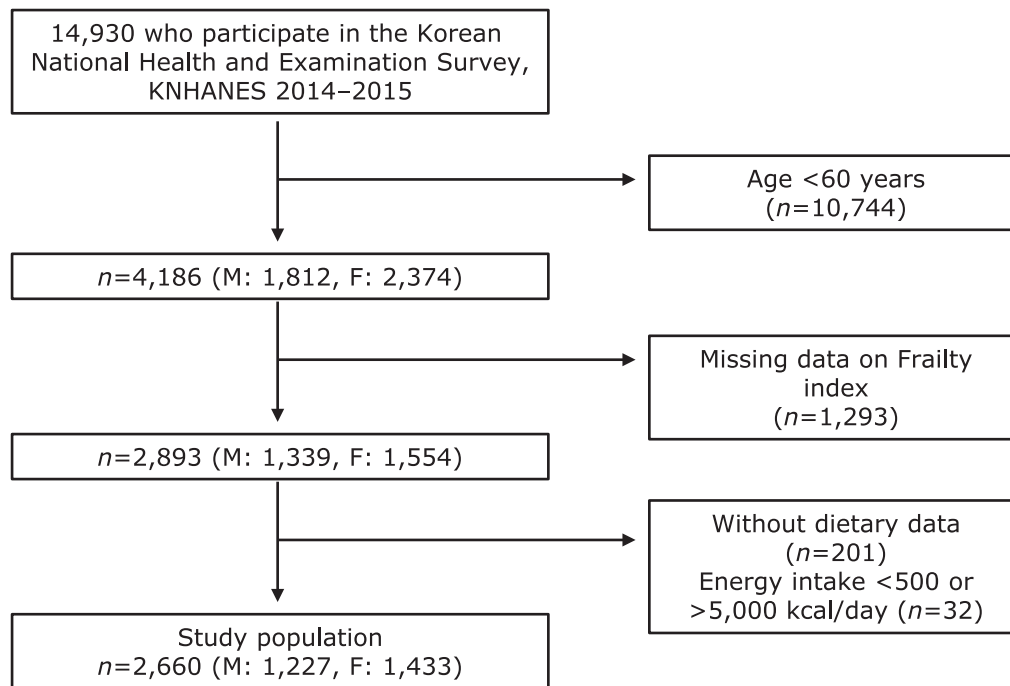


Fig. 1. Flow diagram of subject selection.

Materials and Methods

Study designs and participants. The analysis in this study used raw data from the 6th 2-Year KNHANES (2014–2015). A total of 14,930 individuals participated in the KNHANES (2014–2015), including 4,186 aged ≥ 60 years (excluding 10,744 participants). Among them, individuals with no missing data regarding the main variables in this study (frailty index) (excluding 1,293 individuals), KHEI, and nutrient intake analysis (excluding 201 individuals), were included as subjects in this study, while those whose energy intake <500 or $>5,000$ kcal/day (32 individuals) were also excluded. Thus, a total of 2,660 individuals (males: 1,227, females: 1,433) satisfied these criteria (Fig. 1). The present study was approved by the Clinical Test Deliberation Commission of Institutional Review Board (IRB), Wonkwang University (WKIRB-202008-SB-040).

Frailty assessment. This study used the Fried phenotype index⁽²⁴⁾ with five main indicators; unintended weight loss, emotional exhaustion, low physical activity, slow walking speed, and weak grip strength, to categorize the frailty status as frail, (positive results for ≥ 3 indicators), pre-frail (positive results for 1–2 indicators) and normal (no indicators). Among the 2,660 subjects, 829 (32.9%) were diagnosed as normal, 1,470 (55.3%) as pre-frail, and 314 (11.8%) as frail. Regarding the KNHANES raw data, the diagnostic criterion for unintended weight loss was a weight loss of ≥ 3 kg in the past year. For emotional exhaustion, the diagnosis was based on the level of stress awareness to include individuals who responded, ‘I feel considerably exhausted.’ For low physical activity, the diagnosis was based on the number of walking days per week, the walking time in hours, and the walking time in minutes, to include individuals with walking per week <120 min. For slow walking speed, the EuroQol-5 Dimension (EQ-5D), a motor ability indicator, was used for diagnosis, to include individuals who responded, ‘I have slight difficulty walking’ or ‘I have to stay in bed all day.’ For weak grip strength, a digital grip strength dynamometer (T.K.K. 5401, Takei Scientific Instruments Co., Ltd., Niigata, Japan) was used to measure grip strength six times in total (three times for each hand); the

diagnosis was based on the second and third mean grip strength values, to include individuals with grip strength <28 kg for males and <18 kg for females.⁽²⁵⁾

KHEI. The KHEI was calculated using data obtained using 24-h dietary recall. The KHEI was developed with an aim to evaluate the overall diet quality as well as the adherence to the dietary guidelines and essential diet from the 2015 Dietary Reference Intakes for Koreans, based on data from the 5th KNHANES.^(21,26) The KHEI comprises 14 items in total; 8 items in the Adequacy domain (Total fruit intake, Fresh fruit intake, Total vegetable intake, Vegetable intake excluding Kimchi and pickled vegetable intake, Milk and milk products intake, Total proteins intake, Mixed grains intake, and Frequency of eating breakfast), 3 items in the Moderation domain (Sodium intake, Saturated fatty acid intake, and Sweets and beverages intake), and 3 items in the Balance of energy domain (Energy intake, Energy intake from carbohydrates, and Energy intake from fat). Each item was assigned a score of 5 or 10 so that the total score summed to 100, with higher total scores indicating increased diet quality. In assigning the score, those between the maximum and minimum levels were assigned in proportion to the intake amount or percentage; however, for certain items in the Moderation domain, the method used in the American HEI was followed for exceptional cases.⁽²⁰⁾

Covariance.

General characteristics and physical examination. This study analyzed the following parameters the health survey data of the subjects: level of education, average monthly household income, smoking status, alcohol drinking status, and current illness. The level of education was categorized as \leq elementary, middle school graduation, high school graduation, and \geq university. The average monthly household income was divided into four levels: lowest, lower-middle, upper-middle, and highest. The smoking status was categorized into current smoker, past smoker, and non-smoker. The alcohol drinking status was categorized into current drinker, past drinker, and non-drinker. For the physical examination variables, the height and weight were used, while the body mass index (BMI) was obtained by dividing the weight (kg) by the

square of the height (m).

Comorbidities. This study analyzed 11 types of comorbidities: hypertension, dyslipidemia, diabetes, stroke, myocardial infarction, angina, osteoarthritis, rheumatoid arthritis, pulmonary tuberculosis, and depression. Hypertension was diagnosed based on current illness, systolic blood pressure >140 mmHg, and drug administration. Dyslipidemia was diagnosed based on current illness, drug administration, low-density lipoprotein (LDL) cholesterol (≥ 160 mg/dl), total cholesterol (≥ 240 mg/dl), high-density lipoprotein cholesterol (<40 mg/dl), and triglycerides (≥ 200 mg/dl). while LDL cholesterol was calculated using the Friedewald equation. Diabetes was diagnosed based on current illness, insulin use, drug administration, fasting blood glucose level, and plasma hemoglobin level. For other diseases, the current illness was used as the diagnostic criterion.

Statistical analysis. Statistical analyses were performed using IBM Corp. Released 2016. IBM SPSS Statistics for Windows, ver. 24.0. Armonk, NY: IBM Corp. All analyses involved complex sampling analyses with stratification variables, clustering variables, and weighted values. The continuous variables including age, height, weight, BMI, comorbidities, nutrient intake, and KHEI, were expressed as means and SD using the general linear model. The nominal variables including sex, education level, marital status, alcohol drinking status, and smoking status, were expressed as numbers and percentages

through crossover analysis. To determine the association between frailty status and KHEI, the total KHEI score and the three KHEI classes (Adequacy, Moderation, and Balance) were used in the analysis. Based on the highest values of the KHEI and the three KHEI classes, the odds ratios (ORs) were estimated using logistic regression analysis, where the control variables were sex, age, average monthly household income, education level, comorbidity, and single-household status. The ORs and 95% confidence intervals (95% CIs) were calculated and the level of significance was $p < 0.05$ for all analyses.

Results

General characteristics of the subjects according to frailty status. The results of the analysis of the general characteristics of the subjects according to frailty status are presented in Table 1. Based on the frailty criteria, 876 (34.1%) subjects were normal, 1,470 (55.3%) were pre-frail, and 314 (11.8%) were frail. According to frailty status, age was significantly higher in the order of normal, pre-frail, and frail ($p < 0.001$) with significantly decreasing physical activity ($p < 0.001$). All other variables, including monthly household income, education level, alcohol drinking status, smoking status, single-household status, and comorbidities, showed significant differences according to frailty status ($p < 0.001$).

Table 1. General characteristics of the subjects according to frailty status

Variables	Normal (n = 876)	Pre-frail (n = 1,470)	Frail (n = 314)	p
Sex [n (%)]				<0.001
Men (n = 1,227)	473 (53.9) ¹⁾	656 (45.3)	98 (33.9)	
Women (n = 1,433)	403 (46.1)	814 (54.7)	216 (66.1)	
Age (years)	67.3 \pm 0.2 ²⁾	69.7 \pm 0.2	73.7 \pm 0.4	<0.001
BMI (kg/m ²)	24.2 \pm 0.1	24.2 \pm 0.1	23.9 \pm 0.2	0.363
Income				<0.001
Lowest	301 (34.9)	856 (58.3)	247 (76.0)	
Lower middle	169 (18.5)	211 (13.8)	35 (11.9)	
Upper middle	228 (26.9)	274 (19.1)	22 (8.3)	
Highest	177 (19.7)	127 (8.8)	10 (3.8)	
Education				<0.001
\leq Elementary	311 (34.8)	860 (58.7)	233 (78.0)	
Middle school	174 (18.4)	213 (14.0)	28 (10.4)	
High school	239 (27.0)	266 (18.8)	19 (7.7)	
\geq University	183 (19.7)	122 (8.5)	9 (3.8)	
Alcohol drinking				<0.001
Current drinking	568 (62.0)	813 (57.1)	100 (35.8)	
Past drinking	177 (19.9)	312 (21.2)	77 (28.3)	
Non drinking	163 (18.1)	338 (21.7)	112 (35.9)	
Smoking				0.006
Current smoking	96 (11.7)	171 (12.1)	31 (10.3)	
Past smoking	298 (34.2)	398 (27.4)	67 (23.7)	
Non smoking	481 (54.2)	900 (60.5)	216 (66.1)	
Living status				<0.001
Living alone	96 (9.0)	284 (16.2)	83 (22.9)	
Not living alone	780 (91.0)	1,186 (83.8)	231 (77.1)	
Physical activity				<0.001
None	588 (65.5)	1,158 (79.5)	269 (86.5)	
≥ 1 day/week	288 (34.5)	312 (20.5)	45 (13.5)	
Comorbidities				<0.001
0	158 (18.7)	204 (13.3)	30 (10.8)	
1	310 (34.9)	426 (28.5)	80 (25.0)	
2	275 (31.8)	456 (32.0)	89 (28.0)	
≥ 3	133 (14.6)	384 (26.2)	115 (36.2)	

¹⁾n (%), ²⁾mean \pm SE. BMI, body mass index. Physical activity: leisure moderate-intensity exercise. Comorbidities: hypertension, dyslipidemia, diabetes, stroke, myocardial infarction, angina, osteoarthritis, rheumatoid arthritis, pulmonary tuberculosis, depression.

Energy and nutrient intake analysis according to frailty status. The results of the analysis of energy and nutrient intake according to frailty status are presented in Table 2. The energy intake and the intake of all nutrients were lowest for frail status and second-lowest for pre-frail ($p < 0.001$). The intakes of fat and protein per weight (kg) were significantly low ($p < 0.001$) while the percentage of carbohydrate intake was high compared to the low intake of fat and protein ($p < 0.001$).

KHEI total score and score per variable according to frailty status. The results of the analysis of KHEI total score and scores per variable according to frailty status are presented in Table 3. The KHEI total score decreased significantly from normal to frail, at 70.6 ± 0.5 for normal, 66.7 ± 0.4 for pre-frail,

and 64.3 ± 0.8 for frail ($p < 0.001$). Analysis of the scores per domain, showed significantly lower scores towards frail status with respect to Adequacy and Balance ($p < 0.001$, but significantly higher with respect to Moderation ($p < 0.001$). For 12 of the 14 items of the KHEI variables, including 'Mixed grains intake' ($p < 0.001$), 'Total fruits intake' ($p < 0.001$), 'Fresh fruits intake' ($p < 0.001$), 'Total vegetables intake' ($p < 0.001$), 'Vegetable intake excluding Kimchi and pickled vegetables intake' ($p < 0.001$), 'Meat, fish, eggs and beans intake' ($p < 0.001$), 'Milk and milk products intake' ($p = 0.029$), 'Percentages of energy from carbohydrates' ($p < 0.001$), 'Percentages of energy from fat' ($p < 0.001$), and 'Energy intake' ($p = 0.039$), the scores decreased significantly towards frail status.

Table 2. Energy and nutrient intake analysis

Variables	Normal (n = 876)	Pre-frail (n = 1,470)	Frail (n = 314)	p
Energy (kcal)	1,922.1 ± 28.9 ¹⁾	1,787.2 ± 22.7	1,542.7 ± 45.2	<0.001
Carbohydrate (g)	319.6 ± 4.8	310.4 ± 4.0	282.0 ± 8.0	<0.001
Protein (g)	65.9 ± 1.3	57.7 ± 1.0	47.7 ± 1.9	<0.001
Fat (g)	33.5 ± 1.1	28.2 ± 0.8	20.8 ± 1.3	<0.001
SFA (g)	8.8 ± 0.3	7.8 ± 0.2	5.6 ± 0.3	<0.001
MUFA (g)	10.1 ± 0.4	8.2 ± 0.3	6.0 ± 0.4	<0.001
PUFA (g)	9.4 ± 0.3	7.6 ± 0.2	5.8 ± 0.4	<0.001
Fiber (g)	29.0 ± 0.6	25.3 ± 0.5	20.2 ± 0.9	<0.001
Calcium (mg)	497.3 ± 11.8	452.6 ± 10.7	346.7 ± 16.7	<0.001
Sodium (g)	3,540.8 ± 82.0	3,395.2 ± 74.4	2,766.5 ± 123.0	<0.001
Potassium (g)	3,274.2 ± 61.6	2,919.9 ± 52.2	2,296.7 ± 90.4	<0.001
Vitamin A (mg)	833.9 ± 42.0	727.9 ± 40.9	487.7 ± 39.6	<0.001
Thiamin (mg)	2.0 ± 0.0	1.8 ± 0.0	1.5 ± 0.1	<0.001
Riboflavin (mg)	1.3 ± 0.0	1.1 ± 0.0	0.9 ± 0.0	<0.001
Niacin (mg)	15.9 ± 0.4	13.7 ± 0.3	11.1 ± 0.5	<0.001
Vitamin C (mg)	129.4 ± 5.2	113.8 ± 5.1	88.1 ± 7.1	<0.001
Carbohydrate/weight (kg)	5.2 ± 0.1	5.2 ± 0.1	5.1 ± 0.2	0.637
Fat/weight (kg)	0.5 ± 0.0	0.5 ± 0.0	0.4 ± 0.0	<0.001
Protein/weight (kg)	1.1 ± 0.0	1.0 ± 0.0	0.9 ± 0.0	<0.001
CHO:PRO:FAT	67.9:15.1:13.7	70.7:13.6:12.8	74.1:11.5:12.3	<0.001

¹⁾mean ± SE.

Table 3. Associations between KHEI and frailty status

Variables	Maximum score	Normal (n = 876)	Pre-frail (n = 1,470)	Frail (n = 314)	p
KHEI total score	100	70.6 ± 0.5 ¹⁾	66.7 ± 0.4	64.3 ± 0.8	<0.001
[Adequacy] score	55	36.9 ± 0.4	34.1 ± 0.3	31.2 ± 0.6	<0.001
Have breakfast	10	9.5 ± 0.1	9.3 ± 0.1	9.4 ± 0.2	0.608
Mixed grains intake	5	3.2 ± 0.1	2.8 ± 0.1	2.5 ± 0.2	<0.001
Total fruits intake	5	3.1 ± 0.1	2.8 ± 0.1	2.5 ± 0.1	<0.001
Fresh fruits intake	5	3.3 ± 0.1	2.9 ± 0.1	2.6 ± 0.2	<0.001
Total vegetables intake	5	4.0 ± 0.1	3.8 ± 0.0	3.4 ± 0.1	<0.001
Vegetable intake excluding Kimchi and pickled vegetables intake	5	3.8 ± 0.1	3.5 ± 0.1	3.0 ± 0.1	<0.001
Meat, fish, eggs, and beans intake	10	7.1 ± 0.1	6.4 ± 0.1	5.7 ± 0.2	<0.001
Milk and milk products intake	10	3.0 ± 0.2	2.6 ± 0.1	2.1 ± 0.3	0.029
[Moderation] score	30	25.5 ± 0.2	25.7 ± 0.1	27.1 ± 0.2	<0.001
Percentage of energy from saturated fatty acid	10	9.3 ± 0.1	9.3 ± 0.1	9.6 ± 0.1	0.016
Sodium intake	10	6.6 ± 0.1	7.0 ± 0.1	7.8 ± 0.2	<0.001
Percentages of energy from sweets and beverages	10	9.6 ± 0.1	9.5 ± 0.1	9.6 ± 0.1	0.073
[Balance of energy intake] score	15	8.2 ± 0.2	6.9 ± 0.1	6.1 ± 0.3	<0.001
Percentages of energy from carbohydrates	5	2.0 ± 0.1	1.5 ± 0.1	1.2 ± 0.1	<0.001
Percentages of energy from fat	5	2.9 ± 0.1	2.3 ± 0.1	1.9 ± 0.1	<0.001
Energy intake	5	3.3 ± 0.1	3.1 ± 0.1	3.0 ± 0.2	0.039

¹⁾mean ± SE. KHEI, Korean Healthy Eating Index.

Table 4. Frailty Odds ratio based on KHEI

Variables	Pre-frail		p	Frail		p
	OR	95% CI		OR	95% CI	
KHEI total score						
Crude	2.16	(1.72–2.73)	<0.001	3.61	(2.49–5.24)	<0.001
Adjusted	1.71	(1.31–2.22)	<0.001	1.87	(1.21–2.91)	0.009
KHEI classification						
[Adequacy] score						
Crude	2	(1.56–2.56)	<0.001	4.68	(3.12–7.04)	<0.001
Adjusted	1.51	(1.16–1.96)	0.01	2.39	(1.48–3.86)	0.002
[Moderation] score						
Crude	0.84	(0.68–1.04)	0.265	0.4	(0.28–0.59)	<0.001
Adjusted	1.15	(0.89–1.48)	0.538	0.99	(0.58–1.68)	0.935
[Balance of energy intake]						
Crude	1.86	(1.49–2.31)	<0.001	2.74	(1.93–3.89)	<0.001
Adjusted	1.36	(1.07–1.74)	0.021	1.35	(0.85–2.14)	0.292

Adjusted: sex, age, income, education, comorbidities, living alone, physical activity. OR, odds ratio; CI, confidence interval; KHEI, Korean Healthy Eating Index.

Frailty ORs analysis based on the KHEI. The results of the analysis of the ORs of frailty based on the KHEI of all subjects are presented in Table 4. Analysis of the ORs of pre-frail and frail according to normal KHEI status showed that compared to the group with the highest KHEI, the group with low KHEI had a 1.71-fold higher pre-frail OR (95% CI 1.31–2.22, $p < 0.001$) and 1.87-fold higher frail OR (95% CI 1.21–2.91, $p = 0.009$). Analysis of the pre-frail and frail ORs for each KHEI domain showed significant results for the Adequacy domain. Compared to the group with the highest Adequacy score, the group with low scores showed a 1.51-fold higher pre-frail OR (95% CI 1.16–1.96, $p = 0.010$) and 2.39-fold higher frail OR (95% CI 1.48–3.86, $p = 0.002$).

Discussion

This study investigated the association between frailty ORs and diet quality using KHEI data from individuals aged ≥ 60 years who had participated in the 6th KNHANES (2014–2015). The result of the analysis showed that a high-quality diet, as assessed by KHEI, was negatively associated with the OR of frailty.

This study analyzed the KNHANES data of 2,660 individuals aged ≥ 60 years based on the frailty diagnosis developed by Fried *et al.*⁽²⁴⁾ among these individuals, 32.9% were normal group, 55.3% were pre-frail, and 11.8% were frail. The same diagnostic criteria used to analyze data from the 2008 National Survey of Senior Citizens⁽²⁷⁾ showed that 42.4% of participants were normal, 49.3% were pre-frail, and 8.3% were frail. In the study of Jung *et al.*,⁽²⁸⁾ the frailty prevalence in the Korean elderly was 13.2%. Despite the slight differences in prevalence for individual frailty status, the level in the present study was approximately 10%, consistent with the results of the previous studies. The differences in the distributions of frailty diagnoses are presumed to be due to the fact that the previous studies targeted subjects aged ≥ 65 years, while the subjects in this study were males and females aged ≥ 60 years; i.e., the subjects in this study were younger, and that the parameters of frailty diagnosis varied between this and the previous studies.

The subjects in this study were divided into three groups; normal, pre-frail, and frail, to analyze the KHEI total scores and scores per variable according to frailty status. The result showed a mean KHEI total score of the subjects in the frail group of 64.3 ± 0.8 , which was lower than that (67.8) of subjects aged ≥ 60 years in 2013–2015.⁽²¹⁾ In addition, analysis of the correlations between the three KHEI domains and frailty showed that compared to the group with the highest KHEI score, the group

with low scores exhibited a high ORs of frail. A number of studies have also identified the association between diet quality and frailty. In Struijk *et al.*⁽²⁹⁾ analyzed the correlation with frailty risk using three diet evaluation tools [Alternate Mediterranean Diet (AMED), DASH score, and Alternate Healthy Eating Index (AHEI)-2010], reporting decreasing risks of frailty from the group with the lowest HEI to the group with the highest HEI, consistent with the results of the present study. The finding so far is significant in two aspects: first, for elderly adults in Korea as well, the frailty status may be influenced by the overall diet quality rather than the intake of a single nutrient or food group. Second, a diet evaluation tool that reflects the Korean dietary lifestyle was used to analyze the association with frailty. The most well-known diet evaluation methods at present, including the HEI, DQI, DASH score, and MED score, were developed based on the dietary guidelines or healthy diet patterns in the US or Europe. As these indicators are known to be associated with frailty, the fact that the present study analyzed the association with frailty in Korean elderly using a diet evaluation tool that reflects the Korean dietary lifestyle is significant.

This study analyzed the ORs of pre-frail and frail for the three KHEI domains based on HEI classes. The results showed that compared to the group with the highest score, the group with low scores exhibited significantly higher pre-frail and frail ORs for the Adequacy domain. The Adequacy domain of the KHEI evaluates whether the subjects eat breakfast and whether they have adequate intakes of various food groups. Several studies reported a high dietary variety score (DVS) or a diet comprising a variety of food types to be correlated with a low level of frailty or better health status, consistent with the results of the present study based on the KHEI.^(30,31) The Moderation domain, on the other hand, showed a significant increase in the KHEI scores with increased level of frailty. The Moderation score increases with decreased intake of saturated fatty acids, sodium, sweets, and beverages against the energy intake and all three groups showed a higher score for Moderation items than others. This result is likely to be correlated to the decreased dietary intake in the elderly⁽³²⁾ likely because, for the elderly in particular, the intake of nutrients and foods related to diseases are more restricted in the diet of those who are less healthy. For the elderly, therefore, the Adequacy items should be more carefully managed, while plans for improvement should be considered based on the individual circumstances of the elderly.

The analysis of KHEI items according to frailty status showed significant differences for all items except for 'Have breakfast' and 'Percentages of energy from sweets and beverages'. Previous

studies that analyzed the correlation of each HEI item and frailty showed a decreased risk of frailty with increased intake of ‘mixed grains’,⁽³³⁾ ‘fruits and vegetables’,^(14,34–36) ‘dairy products’,⁽¹⁵⁾ ‘protein’,^(13,37) and ‘energy’.⁽¹³⁾ Thus, efforts are needed to improve the overall diet quality for frailty prevention and management. Notably, among the elderly in Korea, ‘Milk and milk products intake’ among the KHEI items showed a score of 2.1 out of 10, indicating a substantially low intake of dairy products, which may be due to physical changes such as reduced lactase production, reduced digestive function, and altered appetite causing low preference for dairy products; therefore, education alone may not be sufficient to improve the dietary lifestyle in these individuals. Thus, in addition to the education and promotion of appropriate dietary lifestyle for frailty prevention and management, new recipes using dairy products and customized products for the elderly should be developed, as well as an environment to ensure their intake by the elderly in daily life.

The analysis of energy and nutrient intakes according to frailty status revealed significant differences for all nutrients as well as energy. Compared to the subjects in the normal group, those in the frail group showed approximately ≥ 400 kcal lower energy consumption with low intakes of all nutrients. Without adequate energy intake, individuals may experience nutrient imbalance; moreover, a prolonged state of imbalance in the elderly may worsen the frailty status, such as reduced quality of life, higher medical costs, and increased mortality. Protein intake, in particular, is a critical factor in frailty prevention in the elderly and related studies have been actively pursued; however, the intake of proteins was lower in frail subjects in the present study. Inadequate protein intake is related to reduced protein synthesis in skeletal muscles and myosin formation.⁽³⁸⁾ In the elderly, the utility of essential amino acids in protein synthesis is low.⁽³⁹⁾ In a study that monitored protein synthesis in skeletal muscles, however, protein synthesis did not differ significantly between the elderly and younger adult groups following adequate protein intake.⁽⁴⁰⁾ Moreover, analysis of the percentage of calorie nutrient intake in this study showed a 74.3% carbohydrate intake in the subjects in the frail group, a level higher than that in the normal or pre-frail group. This may increase the secretion of insulin and, in the case of the elderly, the high incidence of impaired glucose tolerance and the increased insulin resistance due to aging may prevent the normal use of glucose to facilitate protein catabolism in the liver and muscles. Adequate calorie nutrient intake in the elderly is, thus, crucial and, as the findings in this study suggest, inappropriate diets in frail elderly should be improved.

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As a cross-sectional study analyzing the diet quality of the elderly according to the frailty status based on the KNHANES data, this study is limited in analyzing the precise cause-and-effect relationship on the influence of overall dietary habits and lifestyle on frailty status. In addition, the diet study relied on a 24 h recall questionnaire to examine the intake of a single day; thus, the average dietary patterns of the subjects could not be analyzed. Also, the frailty status was diagnosed using the conventional parameters in the KNHANES data, which may vary from the parameters used in previous studies. Nevertheless, the significance of this study includes its use of large-scale data that represent the national population, along with the KHEI developed to reflect the Korean dietary lifestyle, to analyze the correlation with frailty status. Furthermore, as the KHEI used in this study is the dietary lifestyle index of the entire national population, the findings in this study regarding each detailed item of the KHEI according to frailty status may be useful basic data for future analysis of dietary patterns based on the life cycle or chronic diseases.

Author Contributions

Study concept and design: CS, WN; analysis and interpretation of data: HK; drafting of the manuscript: WN, HK; study supervision: CS.

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Abbreviations

BMI	body mass index
DASH	Dietary Approach to Stop Hypertension
DQI	Diet Quality Index
DVS	dietary variety score
HEI	Healthy Eating Index
KHEI	Korean Healthy Eating Index
KNHANES	Korea National Health and Examination Survey
MDS	Mediterranean Diet Score
OR	odds ratio

Conflict of Interest

No potential conflicts of interest were disclosed.

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