



Validation of a New Food Frequency Questionnaire for Protein Intake Assessment in Korean

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Background: Protein intake is a modifiable factor associated with sarcopenia prevention; however, no appropriate methods exist to assess dietary protein intake in Koreans. This study developed and validated a simple and convenient food frequency questionnaire (FFQ) to determine protein intake in Koreans. **Methods:** A total of 120 participants aged > 19 years were asked to complete both the FFQ used by the Korean National Health and Nutrition Examination Survey (KNHANES) and the newly developed Korean Protein Assessment Tool (KPAT). Protein intakes measured using the FFQ and the KPAT were compared using Pearson correlation coefficients, Bland-Altman plots, and intraclass correlation coefficients. **Results:** Protein intakes from the FFQ (62.06 ± 25.56 g/day) and KPAT (61.12 ± 24.26 g/day) did not differ significantly ($P=0.144$). Pearson's correlation coefficient values ranging from 0.92 to 0.96 indicated a positive correlation, while the intraclass correlation coefficient of 0.979 indicated excellent reliability in protein intake of the FFQ and the KPAT. The Bland-Altman plot also showed high agreement in the mean differences in protein intakes estimated by the FFQ and the KPAT. **Conclusions:** KPAT, a newly developed and simplified method, showed an acceptable correlation compared to previous FFQ tools. Thus, the KPAT may be useful to assess dietary protein intake in the Korean population.

Key Words: Diet surveys · Dietary proteins · Republic of Korea · Surveys and questionnaires

INTRODUCTION

Sarcopenia is a progressive skeletal muscle disease characterized by a gradual loss of muscle mass and function and related to a high risk for falls, frailty, hospitalization, and mortality.[1] Epidemiological studies showed that sufficient protein intake was positively associated with muscle protein synthesis in the elders. [2,3] The European Society for Clinical Nutrition and Metabolism Expert Group suggested protein intakes of 1.0 to 1.2 g/kg/day for healthy adults in the age of more than 65 years old, and 1.2 to 1.5 g/kg/day for older adults with the disease at risk of malnutrition.[4] Our previous double-blind randomized controlled trial reported that protein supplementation of 1.5 g/kg/day improved muscle mass and physical performance compared to protein supplementation of 0.8 g/kg/day or 1.2 g/kg/day in undernourished pre-frail and frail older Koreans.[5] However, the Korean National Health and Nutrition Examination Survey (KNHANES) showed

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that 48% of elderly men and 60% of elderly women consumed less than the amount of dietary reference intakes for Koreans (KDRI), the recommended amount of nutrients for Korean population, 0.91 g/kg/day.[6]

Identifying appropriate methods is important for evaluating protein intake. Protein intake cannot be measured using serum or urine samples, since serum level of protein is always maintained at a certain level, and protein is not appeared in urine unless patients have kidney disease.[7] Thus, protein intake can be evaluated by various dietary surveys including 24-hr recall, dietary records, and the food frequency questionnaire (FFQ), which measure all nutrients including protein.[8] Dietary records and 24-hr recall are not good for the measurement of habitual intake, while FFQ is reflect habitual intake but takes a long time to complete because of containing 112 food items to measure all nutrient intake.[9] There was a rapid self-management FFQ to evaluate dietary protein intake which included food items frequently consumed by the French population.[10] However, since the major protein foods for the Korean and French population are different according to the KNHANES, the French FFQ could not be used in the Korean population. [11] Thus, a new rapid questionnaire to measure only protein intake is needed to develop based on major protein foods consumed by Korean using the KNHANES data. To validate the newly developed questionnaire called Korean Protein Assessment Tool (KPAT), protein intake was measured by KPAT and FFQ using KNHANES was compared. Therefore, the purpose of the present study was to investigate the hypothesis that protein intakes measured by the newly developed simplified method called KPAT and FFQ using KNHANES were not significantly different.

METHODS

1. Participants

Adults aged 19 or older were recruited from inpatient and outpatient of Chung-Ang University Hospital Orthopedics. Participants who had changed their dietary patterns over the past year, had cognitive impairment, were pregnant, or were lactating women were excluded. This study was conducted in accordance with the Declaration of Helsinki, and all procedures were approved by the Institutional Review Board (IRB) of Chung-Ang University (IRB no. 2107-037-19376). Written informed consent was ob-

tained from all the patients before participation.

2. Assessment of dietary protein intake

Demographic information about age, sex, height, and weight was self-reported from all participants. The dietitian conducted face-to-face interviews to complete 2 questionnaires, the FFQ from the KNHANES and the developed separate questionnaire for protein intake called KPAT. The FFQ and the KPAT assessed average intake over the past year. Protein intake in FFQ was analyzed using CAN-Pro 5.0 (Korean Nutrition Society, Seoul, Korea), and protein intake in KPAT was analyzed by a KPAT self-calculated file.

The FFQ used by the KNHANES included 112 food items, and there were 9 intake frequency categories; once a day, twice a day, 3 times a day, once a week, 2 to 4 times a week, 5 to 6 times a week, once a month, 2 to 3 a month and never or seldom.[12] The serving size of food items was categorized by small, medium, large in FFQ. The KPAT was developed by adjusting the food list for estimating protein intake by integrating with the KNHANES 2013 to 2018.[13-17] The KPAT comprised 39 categories with 50 food items with high protein content and frequently consumed by Koreans in the existing FFQ order (Table 1). Food with similar protein content was arranged in one category and calculated on average. The frequency of food intake was written as the number per day, week, or month.

3. Statistical analyses

All data were analyzed using the SPSS statistics version 27.0 (SPSS Inc., Chicago, IL, USA). The significance level was set at a *P*-value of less than 0.05. Continuous variables were presented as the mean \pm standard deviation using the independent *t*-tests, and the proportions of nominal were presented by numbers (percentages) using the χ^2 test. The difference in the intake of protein between the FFQ and the KPAT was analyzed by a paired *t*-test. The correlation between protein intakes of the FFQ and the KPAT was investigated with the Pearson correlation coefficients. The Bland-Altman plot was used to compare the FFQ and the KPAT for quantifying the protein intakes. The distribution of protein intake was categorized into quartiles to test agreement at an individual level, and the Intraclass correlation coefficient was applied to assess reliability based on the 95% confident interval (CI) between the 2 dietary assessment methods, the FFQ and the KPAT.[18]

Table 1. List of the food items included in the Korean Protein Assessment Tool (KPAT)

Food group	Categories	Food item
Grains	Rice	Rice
	Mixed grains	Mixed grains
	Rice cakes	Rice cakes
	Noodles	Noodles
	Breads, Cakes	Breads, Cakes
	Root and tuber crops	Potato, Sweet potato
	Corns	Corns
Legumes	Nuts	Nuts
	Soybeans	Soybeans
	Bean curd	Bean curd
	Soy bean milk	Soy bean milk
	Fermented soybean paste	Fermented soy bean paste
Meats & Fishes	Meats	Meats
	Meat soups	Meat soups
	Meat processed products	Ham, Sausage, Bacon
	Egg	Egg
	Fishes	Chub mackerel, Cutlassfish, Corvina, Pacific saury
	Squid, Shrimp	Squid, Shrimp
	Long arm octopus, Webfoot octopus	Long arm octopus, Webfoot octopus
	Anchovy	Anchovy
	Shellfish	Shellfish
	Fish cake	Fish cake
	Fish soups	Fish soups
Vegetables	Vegetables	Vegetables
	Kimchi	Kimchi
	Sea weed	Sea weed
	Mushrooms	Mushrooms
Dairy products	Milk	Milk
	Liquid yogurt	Liquid yogurt
	Yogurt	Yogurt
	Cheddar cheese	Cheddar cheese
Fruits	Fruits	Fruits (Banana, Apple, Grape, Strawberry)
	Melon, Watermelon	Melon, Watermelon
Instant foods	Ramen	Ramen
	Hamburger, Sandwich	Hamburger, Sandwich
	Pizza	Pizza
	Dumpling	Dumpling
	Snacks	Snacks
	Makgeolli (Rice wine)	Makgeolli (Rice wine)

RESULTS

One hundred twenty participants completed both the FFQ and the KPAT (Table 2). There were 33% males and 67% females in total participants, 31 (54.4%) of participants aged <65 years, and 49 (77.8%) of participants aged ≥ 65 years were women. Participants were classified based on the age of 65 due to the difference in daily protein intake in accordance with KDRI.[11] Participants aged <65 years were significantly taller and heavier and consumed higher energy, carbohydrate, fat, and protein compared to participants aged ≥ 65 years. There was no significant difference in body mass index between the participants aged <65 years and aged ≥ 65 years.

Protein intakes investigated by the FFQ and the KPAT were not significantly different in both participants aged <65 years and aged ≥ 65 years (Table 3). The intraclass correlation coefficient of 0.979 (95% CI, 0.970-0.986) indicated excellent reliability in protein intakes (g/day) estimated by both the FFQ and the KPAT (Table 4). Regarding protein intake as g/kg/day, the intraclass correlation coefficient of 0.972 (95% CI, 0.960-0.980) also indicated excellent reliability in protein intakes assessed by FFQ and KPAT (Supplementary Appendix 1). Pearson's correlation coefficient showed a significant positive correlation between the FFQ and the KPAT in total participants and participants aged <65 years and aged ≥ 65 years (Fig. 1). With the Bland-Altman plot, there were no significant mean differences of estimated protein intake measured by 2 methods within 95% limits of agreement (Fig. 2).

DISCUSSION

The present study showed that protein intake estimated by both the FFQ and the KPAT were not significantly different, and the measurement values of protein intake between the FFQ and the KPAT were positively correlated.

According to 2013 to 2017 the KNHANES, the average protein intake was 83 to 88 g/day for men aged <65 years, 58 to 64 g/day for women aged <65 years.[13-17] In this study, the average protein intake estimated by FFQ and KPAT was 83 and 81 g/day for men aged <65 years, 64 and 63 g/day for women aged <65 years, respectively. Protein intake of participants aged <65 years in this study showed similar results to the KNHANES data. In addition, according

Table 2. General characteristics of participants aged < 65 years and aged ≥ 65 years

	Total (N = 120)	Age		P-value
		< 65 years (N = 57)	≥ 65 years (N = 63)	
Age (yr)	58.85 ± 20.07	40.23 ± 12.00	75.70 ± 5.99	<0.001
Female	80 (66.7)	31 (54.4)	49 (77.8)	0.011
Weight (kg)	59.88 ± 12.96	64.45 ± 15.34	55.74 ± 8.56	<0.001
Height (cm)	160.41 ± 10.17	165.44 ± 9.57	155.87 ± 8.45	<0.001
BMI (kg/m ²)	23.13 ± 3.63	23.27 ± 3.77	23.00 ± 3.60	0.676
Dietary intake				
Energy intake (kcal/day)	1,808.49 ± 731.41	2,145.17 ± 743.67	1,503.88 ± 573.37	<0.001
Carbohydrate (g/day)	291.01 ± 115.89	326.15 ± 116.19	259.21 ± 106.87	0.001
Fat (g/day)	39.57 ± 24.25	52.41 ± 26.27	27.95 ± 14.72	<0.001
Protein (g/day)	62.06 ± 25.56	72.66 ± 27.19	52.47 ± 19.74	<0.001
Protein (g/kg/day)	1.04 ± 0.38	1.14 ± 0.40	0.95 ± 0.34	0.006

The data is presented as N (%) of participants for categorical variables or mean ± standard deviation for continuous variables. BMI, body mass index.

Table 3. Comparison of protein intakes assessed by a food frequency questionnaire used by KNHANES and KPAT

	Protein intake by KNHANES (g/day)	Protein intake by KPAT (g/day)	P-value ^{a)}	Protein intake by KNHANES (g/kg/day)	Protein intake by KPAT (g/kg/day)	P-value ^{b)}
Total (N = 120)	62.06 ± 25.56	61.12 ± 24.26	0.144	1.04 ± 0.38	1.03 ± 0.37	0.250
Age < 65 yr (N = 57)	72.66 ± 27.19	71.17 ± 25.97	0.105	1.14 ± 0.40	1.12 ± 0.39	0.189
Age ≥ 65 yr (N = 63)	52.47 ± 19.74	52.02 ± 18.54	0.621	0.95 ± 0.34	0.94 ± 0.32	0.708

The data is presented as mean ± standard deviation for continuous variables.

^{a)}Statistical difference on protein intakes between KNHANES and KPAT using the paired *t*-test.

^{b)}Statistical difference on protein intakes per body weight between KNHANES and KPAT using the paired *t*-test.

KNHANES, the Korean National Health and Nutrition Examination Survey; KPAT, the Korean Protein Assessment Tool.

Table 4. Intraclass correlation coefficient for protein intake assessed by the food frequency questionnaires used by KNHANES and KPAT

Protein intake by KNHANES (g/day)	Protein intake by KPAT (g/day)				Intraclass correlation coefficient
	≤ 45.46	45.46 < to ≤ 59.30	59.30 < to ≤ 72.17	> 72.17	
≤ 43.47	25 ^{a)}	4	1	0	0.979
43.47 < to ≤ 59.58	5	20	5	0	
59.58 < to ≤ 75.50	0	6	19	5	
> 75.50	0	0	5	25	

^{a)}Each value expressed the number of participants matching each quartile in the food frequency questionnaire and KPAT and each quartile had 30 participants.

KNHANES, the Korean National Health and Nutrition Examination Survey; KPAT, the Korean Protein Assessment Tool.

to the 2013 to 2017 KNHANES, the average protein intake was 58 to 69 g/day for men aged ≥ 65 years, 38 to 50 g/day for women aged ≥ 65 years.[13-17] In this study, the average protein intake estimated by FFQ and KPAT was 62 and 60 g/day for men aged ≥ 65 years, 50 and 50 g/day for women aged ≥ 65 years, respectively. Thus, the protein intake of participants aged ≥ 65 years in this study showed similar results to the KNHANES data. Previous studies reported that Korean elders over 65 years old consumed about 20 g

less protein per day than adults aged 30 to 64 years old, which showed similar to the results of the present study. [6,19] The KDRI recommends a daily protein intake of 60 to 65 g/day for men aged < 65 years and 50 to 55 g/day for women aged < 65 years, and 60 g/day for men aged ≥ 65 years and 50 g/day for women aged ≥ 65 years.[11] The study showed that 21% of the Koreans consumed less than the recommended amount of intake based on the KDRI for protein. Our result was similar to 23%, which was re-

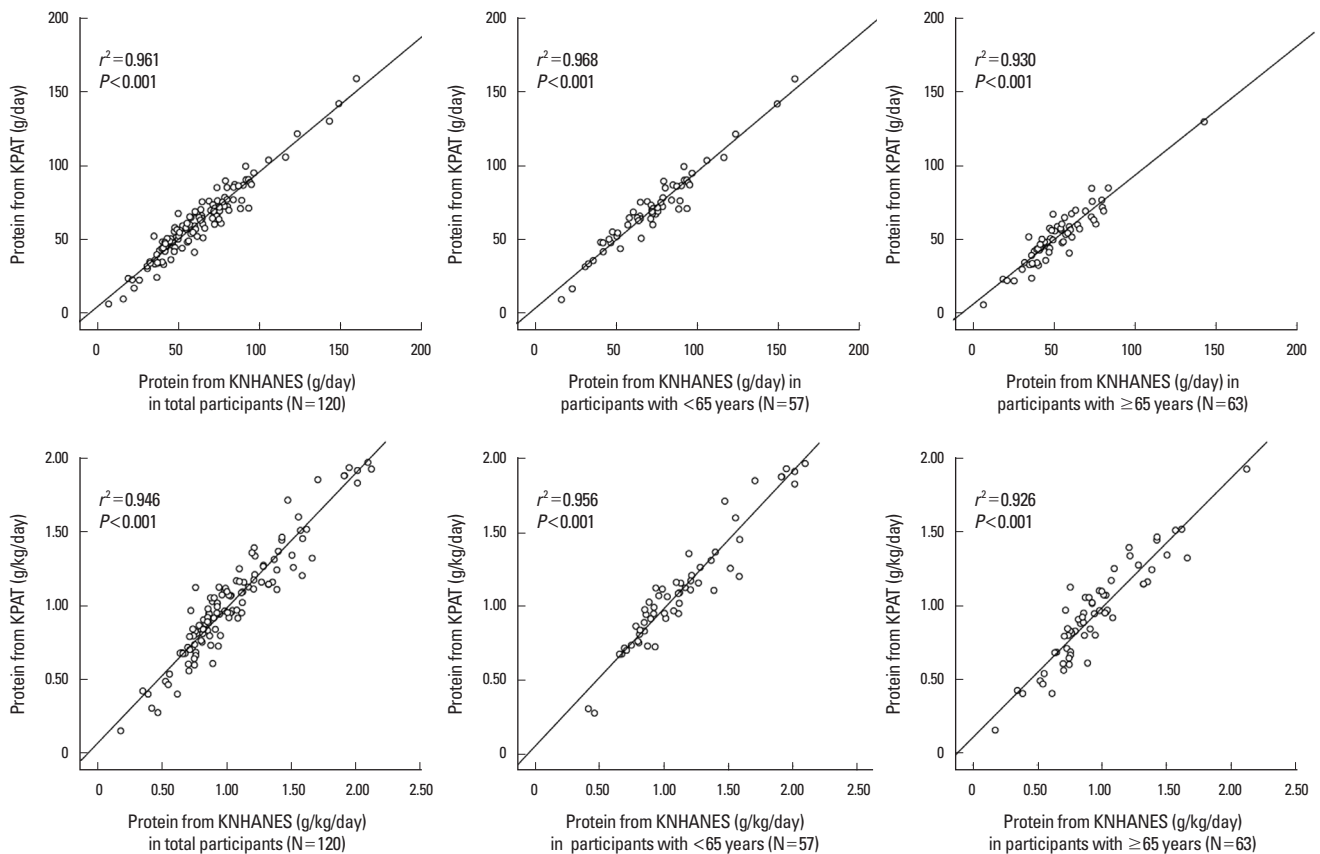


Fig. 1. Pearson correlation of protein intake assessed the food frequency questionnaires used by the Korean National Health and Nutrition Examination Survey (KNHANES) and the Korean Protein Assessment Tool (KPAT) for all participants, participants aged <65 years, and participants aged ≥65 years.

ported by the KNHANES.[20]

Morin et al. [10] previously developed a rapid the FFQ for protein intake of the French population and showed that protein intakes were not significantly different using paired t-test between their new FFQ and dietary record ($P=0.075$), and between the new FFQ and 24-hr recall ($P=0.520$), which were consistent with our study ($P=0.144$). The French study showed that protein intakes measured by the new FFQ, dietary record, and 24-hr recall had no difference in variability using the Bland-Altman plot.[10] In the present study, protein intakes measured by the FFQ and KPAT had no difference in variability using the Bland-Altman plot with the narrow range compared to the previous French study.

The French FFQ comprised 20 food items, frequently consumed by the French population, such as meat and dairy products.[10] However, KPAT included not only meat and dairy products but also grains which were major pro-

tein foods in Korea. According to the KNHANES, grains were the top protein source, followed by meat, fish and shellfish, vegetables, beans, and legumes.[11] In this study, grains were also the top protein source, followed by meat, egg, vegetables, pizza. The ranking of protein-based foods in our study was similar to that of protein-based foods in the KNHANES. Animal-based proteins with a high protein content of a higher quality contained all the essential amino acids required by the human body and were more digestible.[21] However, the main sources of dietary protein in the Korean population were rice and other grains. The Korean diet is a plant-based protein, contributing to nearly 2-thirds of total protein intake and the amount of protein in these foods could not be ignored.[22]

In the present study, the Pearson correlation coefficient of protein intake estimated by the FFQ and the KPAT was 0.92 to 0.96, suggesting a very high correlation as compared with other nutrient validation. Previous studies showed

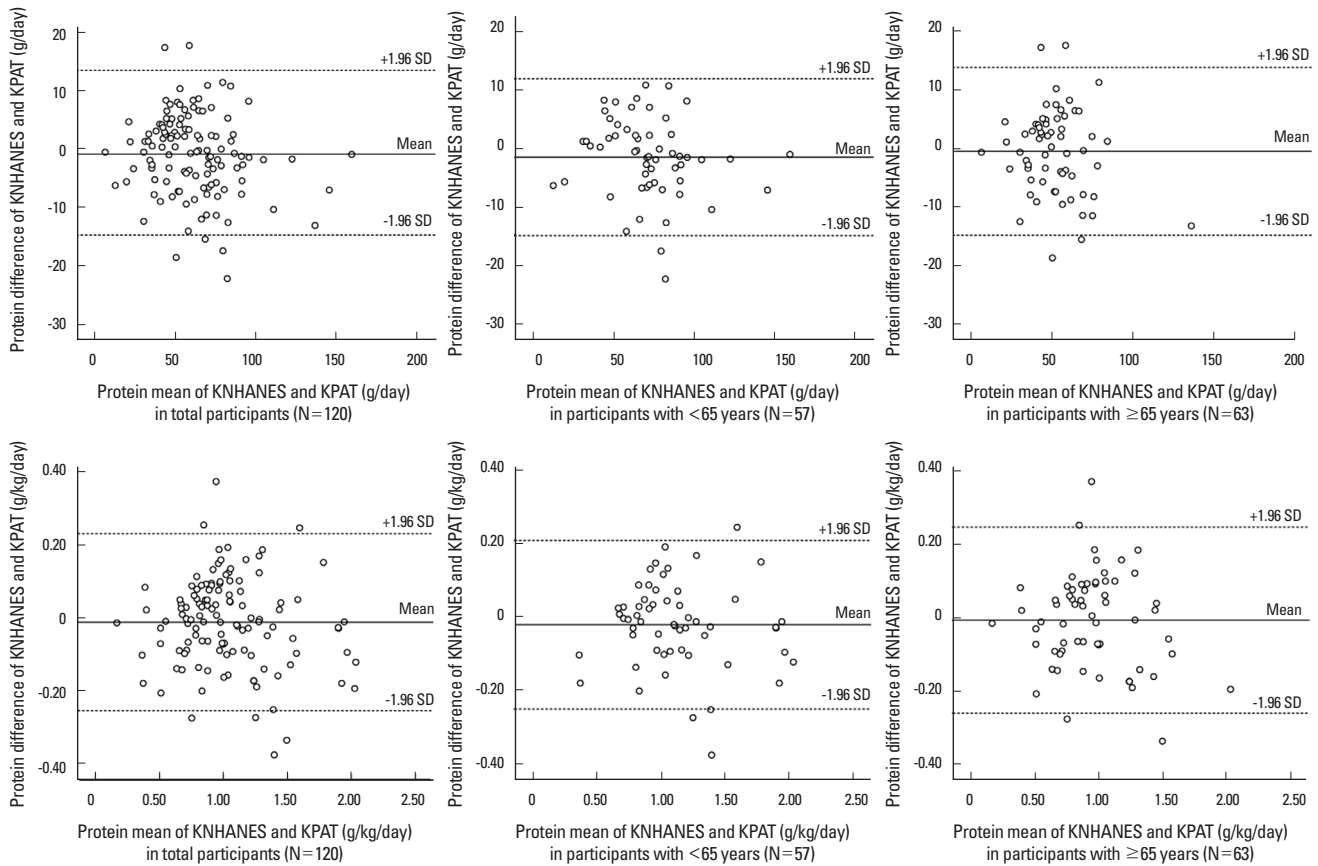


Fig. 2. Bland-Altman plot of difference in protein intake assessed the food frequency questionnaires used by the Korean National Health and Nutrition Examination Survey (KNHANES) and the Korean Protein Assessment Tool (KPAT) for all participants, participants aged <65 years, and participants aged ≥ 65 years.

that Pearson correlation coefficients obtained from calcium intakes to validate questionnaires were in the range of 0.56 to 0.84 in Asian,[23,24] and 0.64 to 0.90 in westerners.[25,26] The correlation coefficients of calcium questionnaires were narrower ranges in studies done in Americans and Europeans than in studies done in Asian. The sources of calcium intake for Americans and Europeans were simple due to their high large dependence on milk and milk products, which were rich in calcium content and had high availability and good absorption in the intestine.[27] The sources of calcium in the Asian diet were more diverse than the American and European diet, and their source of calcium included dark green, beans, seaweed, and seafood.[28]

Gross classification according to the quartiles of intake indicated that 74% of participants were classified into the same or adjacent quartile. Intraclass correlation coefficient showed excellent reliability of 0.979, a 97.9% agreement, between the FFQ and the KPAT. This result was better than

0.79 to 0.86 of the intraclass correlation coefficient obtained from calcium intake in a previous study.[29] In addition, the Bland-Altman plot showed good agreement between the FFQ and the KPAT.

The present study had a few limitations. First, basic dietary survey methods might have some reporting bias using self-reported dietary intake and recall bias using intake memories over the past year. Second, the intake of protein could be affected by seasonal variation, and the developed KPAT was not validated in all 4 seasons. Third, Participants were recruited only in a hospital, not the entire population, and selection bias might have existed.

The KPAT has a few strengths. First, the newly developed KPAT is a simple questionnaire tool to assess protein intake. Second, the KPAT is convenient and simple to estimate protein intake, since KPAT consists of only 39 questions but FFQ has 112 questions. Third, the dietary protein intake can be assessed by good validity and reproducibility. The

present study suggests that the developed KPAT can be a useful and simple evaluation tool to assess dietary protein intake for the Korean population. The KPAT can be useful for the rapid evaluation of protein intake at the clinical setting, and for prescribing appropriated amount of protein for patients whose protein intake is low. The KPAT will be released as an online version to use at the clinical setting.

DECLARATIONS

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Ethics approval and consent to participate

This study was conducted in accordance with the Declaration of Helsinki, and all procedures were approved by the Institutional Review Board (IRB) of Chung-Ang University (IRB no. 2107-037-19376).

Conflict of interest

No potential conflict of interest relevant to this article was reported.

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Supplementary Appendix 1. Intraclass correlation coefficient for quartiles of protein intake per weight assessed by the food frequency questionnaires used by KNHANES and KPAT

Protein intake by KNHANES (g/kg/day)	Protein intake by KPAT (g/kg/day)				Intraclass correlation coefficient
	≤0.80	0.80 < to ≤ 0.97	0.97 < to ≤ 1.18	>1.18	
≤0.77	25 ^{a)}	4	1	0	0.972
0.77 < to ≤ 0.95	5	17	8	0	
0.95 < to ≤ 1.22	0	9	16	5	
>1.22	0	0	5	25	

^{a)}Each value expressed the number of participants matching each quartile in the food frequency questionnaire and KPAT and each quartile had 30 participants.

KNHANES, the Korean National Health and Nutrition Examination Survey; KPAT, the Korean Protein Assessment Tool.