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Development of Korean Frailty Index for Primary Care (KFI- PC) and Its Criterion Validity

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Background: The objective of this study was to develop and validate the Korean Frailty Index for Primary Care (KFI-PC) based on a comprehensive geriatric assessment. **Methods:** We developed a 54-item KFI-PC comprising 10 standard domains: cognitive status including delirium or dementia; mood; communication including vision, hearing, and speech; mobility; balance; bowel function; bladder function; ability to carry out activities of daily living; nutrition; and social resources. To test its validity, we applied KFI-PC to participants of the Korean Frailty Aging and Cohort Study (KFACS). We analyzed 1,242 participants (mean age, 77.9±3.9 years; 47.2% men) from the KFACS who visited 10 study centers in 2018, after excluding 32 participants with missing data required to assess Fried's physical frailty phenotype. **Results:** The mean KFI-PC score was 0.17±0.08, ranging from 0.02 to 0.52. The median KFI-PC score was higher in women than in men, and there was a trend toward higher values in older age groups. The prevalence of frailty when applying a generally used frailty index cutoff point of >0.25 was 17.5% in the whole study sample. As a construct validation of KFI-PC, the area under the receiver operating characteristic curve for Fried's physical frailty was 0.921, and the optimal cutoff value to predict frailty phenotype was 0.23. The KFI-PC score also correlated well with physical, cognitive, and psychological functions; nutritional status; disability in activities of daily living; and instrumental activities of daily living. The Cronbach's alpha coefficient of the 54 total items was 0.737. **Conclusion:** We developed KFI-PC with 53 deficits, including comprehensive geriatric assessment components, and demonstrated the acceptable construct validity and internal consistency of KFI-PC.

Key Words: Frailty, Validity, Comprehensive geriatric assessment

INTRODUCTION

Number of frail older people has been ever growing with the increase of global population aging. Frailty is defined as a status of vulnerability to identified stressors that exposes individuals to higher risks of negative health-related outcomes. The condition is usually caused by the interaction between progressive aging-related declines in multiple organ function and chronic diseases that often lead to a decreased level of functional reserve capacities.[1)]

Both phenotypic and deficit accumulation approaches are commonly used to define frailty. Representing the phenotypic approach, Fried's frailty phenotype defines frailty as the presence of three or more of five frailty items; namely, slow walking speed, impaired grip strength, declining physical activity levels, exhaustion,

and unintended weight loss.[2] The other approach to defining frailty is through the use of a frailty index that sums health deficits. In this context, health deficits can be any physical or mental disability, symptom and sign, disease, laboratory finding, etc.[3] Healthcare professionals have used comprehensive geriatric assessment (CGA) to develop a holistic overview of patients with complex needs, which is the essential step for the development of individualized, patient-centered care plans. CGA evaluates multiple aspects of older adults' health, including cognition, emotion, motivation, health attitude, vision, hearing, speech, sleep, pain, strength, balance, mobility, activities of daily living, social engagement, medication, control of life, etc. In primary care settings, frailty indices can be developed based on CGA.

A CGA-based frailty index (FI-CGA) was first developed using clinical examination data from the Canadian Study of Health and Aging.[4,5] The standardized CGA used to constitute the frailty index comprises assessments in 10 standard domains: (1) cognitive status including delirium or dementia; (2) mood and motivation; (3) communication including vision, hearing, and speech; (4) mobility; (5) balance; (6) bowel function; (7) bladder function; (8) instrumental activities of daily livings (IADLs) and activities of daily living (ADLs); (9) nutrition; and (10) social resources.[4] Based on this principle, Theou et al.[3] constructed FI-CGA containing 56 variables chosen from among a CGA adapted for use within the primary care setting.

The authors demonstrated that FI-CGA was feasible to assess frailty in primary care for a multidisciplinary primary care program for frailty. Additionally, FI-CGA was useful for the care of frail older persons in primary care as any specific problems out of 10 domains can be identified and managed effectively. Following these principles and the example of FI-CGA in Canada, we developed a Korean Frailty Index for Primary Care (KFI-PC) and investigated its validity and reliability.

MATERIALS AND METHODS

Development of KFI-PC

The deficits included in KFI-PC, along with their cutoff values, scoring measures, and related references, are described in Table 1.[2,6-18] The Korean version of the KFI-PC is provided in Supplementary Table S1. We adopted questionnaires or assessments validated in Korea for items of KFI-PC while referring to FI-CGA and the validated Korean frailty indices. We replaced or excluded items that were not appropriate for use in busy primary care settings in Korea; for example, "low mood" in FI-CGA was excluded because it is duplicated with the evaluation of "depression". We also excluded "motivation", "health attitude", and "control of life events" because they were not appropriate for Korean older adults. We excluded the timed up and go test because it requires a 3-m length of space to perform; it was replaced by a chair stand test (rising from a chair five times).[19] We also excluded IADLs of cooking and cleaning as those activities are not appropriate to assess older Korean men. We replaced these IADLs with "walking to distant destinations". FI-CGA also includes the Montreal Cognitive Assessment; however, as it takes more than 20 minutes to complete, we replaced it with the Mini-Cog test. The Mini-Cog test combines two simple cognitive tasks (a three-item word memory and clock drawing) with a scoring algorithm.[20] It can be completed in 2–4 minutes and has shown high diagnostic accuracy for dementia (sensitivity 76%, specificity 99%). We included factors related to hospital admission within 1 year and self-assessment of health as they are included in the Korean frailty index.[8] Contact frequency with friends,[17] living with family (a spouse), and frequency of going out of the home[7] were included as known social risk factors for frailty. Finally, we included data regarding appetite and number of full meals eaten per day from the Short Nutritional Assessment Questionnaire (SNAQ) as nutritional assessment.[18] Regarding comorbidities, FI-CGA allowed a maximum of 18 current conditions. The comorbidities included hypertension, diabetes, cancer, chronic obstructive pulmonary disease, myocardial infarction, heart failure, angina, asthma, arthritis, stroke, and kidney disease as they are embedded in the Fatigue, Resistance, Ambulation, Illnesses, and Loss of weight (FRAIL) questionnaire.[21] Spinal stenosis was included as the 12th disease to be questioned.[22] If the subjects had other diseases, each additional condition was recorded up to 18 diseases. We selected these items through article review and the consensus of three experts and authors (CWW, MK, and YL).

KFI-PC Scoring

In this study, similar to the FI-CGA scoring strategy, each deficit item was scored up to 1 point except for strength (item# 12-1) and climbing stairs (item# 12-2), which represented muscle strength of the upper and lower extremities, respectively. As suggested by Rockwood and Searle, each deficit variable was dichotomized or polychotomized and mapped to the interval 0–1 (e.g., for self-rating of health, "Excellent" was coded as 0, "very good" as 0.25, "good" as 0.5, "fair" as 0.75 and "poor" as 1) to represent the deficit frequency or severity.[23] Although KFI-PC includes a total of 54 items, the maximum deficit score is 53 as the questions on strength (item# 12-1) and climbing stairs (item# 12-2) had maximum scores of 0.5. The final scoring method was decided based on the consensus of the three experts. In general, missing variables can be imputed or removed from the denominator.[24] This study followed the latter approach of scoring KFI-PC. The KFI-PC score of each

Table 1. Overview of deficits included in the KFI-PC

No.	Deficit	Additional information	Cutoff values and KFI-PC score	References
1	Construct recall (drawing two interlocking pentagons)	CERAD-K, drawing two interlocking pentagons, assessed by trained clinical research coordinators	Abnormal = 1 Normal = 0	Lee et al. (2002) [6]
2	Three-item recall memory	CERAD-K, three-word recall, assessed by trained clinical research coordinators	Recall none = 1 Recall one or two words = 0.5 Recall all three words = 0	Lee et al. (2002) [6]
3	Recognition	Kihon Checklist for frailty, knowing current date (month and date), assessed by trained clinical research coordinators	Both wrong = 1 One correct = 0.5 Both correct = 0	Satake et al. (2016) [7]
4	Depressive mood	KFI, depressive mood over the past month, completed by trained clinical research coordinators	Yes = 1 No = 0	Hwang et al. (2010) [8]
5	Exhaustion	Fried's frailty phenotype, frequency of exhaustion per week, completed by trained clinical research coordinators	≥ 3 days = 1 0–2 days = 0	Fried et al (2001) [2]
6	Delirium or hallucination	Evaluated by professional medical practitioners	Yes = 1 No = 0	
7	Visual or auditory problem	KFI, completed by trained clinical research coordinators	Yes = 1 No = 0	Hwang et al. (2010) [8]
8	Sleeping pattern	Sleep latency (≥ 1 hour) or long sleep duration (≥ 8 hours), completed by trained clinical research coordinators	Yes to either one = 1 No = 0	Kang et al. (2019) [9]
9	Napping	Frequency of napping in the past week, information gathered by trained clinical research coordinators	More than once = 1 None = 0	
10	Inactivity	FPQ for use in screening community-dwelling older adults, moderate to vigorous physical activities of International Physical Activity Questionnaire (IPAQ) in the past week, completed by trained clinical research coordinators	Never = 1 More than once = 0	Oh et al. (2007) [10] & Kim et al. (2020) [11]
11	Chair rise test (chair stand test)	European Working Group on Sarcopenia in Older People (EWGSOP) definition, time (seconds) to rise five times from a chair, assessed by trained clinical research coordinators	≥ 12 sec = 1 10–12 sec = 0.5 < 10 sec = 0	Cruz-Jentoft et al. (2019) [12]
12-1	Strength	SARC-F, difficulty in lifting and moving 4.5 kg (a box of nine Korean pears), completed by trained clinical research coordinators	Yes = 0.5 No = 0	Kim et al. (2018) [13]
12-2	Climbing stairs	SARC-F, difficulty in climbing 10 stairs without pause, completed by trained clinical research coordinators	Yes = 0.5 No = 0	Kim et al. (2018) [13]
13	Balance confidence	Activities-specific Balance Confidence (ABC) scale, average total score, assessed by trained clinical research coordinators	≤ 58.13 = 1 > 58.13 = 0	Moiz et al. (2017) [14]
14	Fall	SARC-F, frequency of falls in the past year, completed by trained clinical research coordinators	≥ 2 = 1 1 = 0.5 None = 0	Kim et al. (2018) [13]
15	Assistance in walking	SARC-F, difficulty in walking from the room, completed by trained clinical research coordinators	A lot/have to use aids (A walking stick)/unable = 1 A little = 0.5 Not at all = 0	Kim et al. (2018) [13]
16	Ambulation	FPQ for use in screening community-dwelling older adults, able to walk one lap of a 400-m track, completed by trained clinical research coordinators	Little or very difficult = 1 Not difficult at all = 0	Kim et al. (2020) [11]
17	Transferring from a bed to a chair	SARC-F, difficulty in transferring from a chair (wheelchair) to a bed (mattress) or from a bed (mattress) to a chair (wheelchair), completed by trained clinical research coordinators	A lot/unable without help = 1 A little = 0.5 Not at all = 0	Kim et al. (2018) [13]

(Continued to next page)

Table 1. Continued

No.	Deficit	Additional information	Cutoff values and KFI-PC score	References
18	Mobility	Information gathered by trained clinical research coordinators	Wheelchair = 1 Use cane or walker = 0.5 Walks independently = 0	-
18	Fecal incontinence	KFI, fecal incontinent experience over the past month, completed by trained clinical research coordinators	Yes = 1 No = 0	Hwang et al. (2010) [8]
20	Bladder control	KFI, urinary incontinence experience in the past month, completed by trained clinical research coordinators	Yes = 1 No = 0	Hwang et al. (2010) [8]
21	Shopping	IADLs, difficulty in buying or shopping, completed by trained clinical research coordinators	Unable/require complete assistance = 1 Capable with partial assistance = 0.5 Capable by oneself = 0	Won et al. (2002) [15]
22	Managing medications	IADLs, difficulty in managing medication with correct dosages at the correct time, completed by trained clinical research coordinators	Unable/require complete assistance = 1 Capable with partial assistance = 0.5 Capable by oneself = 0	Won et al. (2002) [15]
23	Driving or using public transportation	IADLs, difficulty in driving or using public transportation, completed by trained clinical research coordinators	Unable/require complete assistance = 1 Capable with partial assistance = 0.5 Capable by oneself = 0	Won et al. (2002) [15]
24	Managing finances	IADLs, difficulty in managing own money or financial matters, completed by trained clinical research coordinators	Unable/require complete assistance = 1 Capable with partial assistance = 0.5 Capable by oneself = 0	Won et al. (2002) [15]
25	Polypharmacy	The number of prescribed medications taken regularly, assessed by trained clinical research coordinators	≥ 8 = 1 5–7 = 0.5 ≤ 4 = 0	Park et al. (2018) [16]
26	Hypertension	Current condition, information gathered by trained clinical research coordinators	Yes = 1 No = 0	-
27	Diabetes	Current condition, information gathered by trained clinical research coordinators	Yes = 1 No = 0	-
28	Cancer	Current condition, information gathered by trained clinical research coordinators	Yes = 1 No = 0	-
29	Chronic obstructive pulmonary disease (COPD)	Current condition, information gathered by trained clinical research coordinators	Yes = 1 No = 0	-
30	Myocardial infarction (MI)	Current condition, information gathered by trained clinical research coordinators	Yes = 1 No = 0	-
31	Heart failure	Current condition, information gathered by trained clinical research coordinators	Yes = 1 No = 0	-
32	Angina	Current condition, information gathered by trained clinical research coordinators	Yes = 1 No = 0	-
33	Asthma	Current condition, information gathered by trained clinical research coordinators	Yes = 1 No = 0	-
34	Arthritis	Current condition, information gathered by trained clinical research coordinators	Yes = 1 No = 0	-
35	Stroke	Current condition, information gathered by trained clinical research coordinators	Yes = 1 No = 0	-

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Table 1. Continued

No.	Deficit	Additional information	Cutoff values and KFI-PC score	References
36	Kidney disease	Current condition, information gathered by trained clinical research coordinators	Yes = 1 No = 0	-
37	Spinal stenosis	Current condition, information gathered by trained clinical research coordinators	Yes = 1 No = 0	-
38–43	Additional health conditions	Current condition: number of additional diseases other than 12 diseases above, information gathered by trained clinical research coordinators	1 = 1 2 = 2 3 = 3 4 = 4 5 = 5 6 = 6	-
44	Hospitalization	KFI, hospitalization experience over the past year, completed by trained clinical research coordinators	≥ 1 = 1 None = 0	Hwang et al. (2010) [8]
45	Self-assessment of health status	KFI, completed by trained clinical research coordinators	Bad = 1 Good = 0	Hwang et al. (2010) [8]
46	Social contact	Contact frequency with friends in the past week, completed by trained clinical research coordinators	Rarely = 1 Weekly/monthly = 0	Chon et al. (2018) [17]
47	Spouse	Currently living with spouse or someone else, information gathered by trained clinical research coordinators	Live alone = 1 With someone else, not spouse = 0.5 Spouse = 0	-
48	Meals	SNAQ, number of full meals per day, completed by trained clinical research coordinators	< 1 meal = 1 1 meal = 0.33 2 meals = 0.66 ≥ 3 meals = 0	Oh et al. (2019) [18]
49	Appetite	SNAQ, self-rated appetite, completed by trained clinical research coordinators	Very poor = 1 Poor = 0.66 Average = 0.33 Good/very good = 0	Oh et al. (2019) [18]
50	Walking to distant destinations	IADLs, difficulty in going out to a shop, neighborhood, hospital, or government offices within walking distance, completed by trained clinical research coordinators	Unable/require complete assistance = 1 Capable with partial assistance = 0.5 Capable by oneself = 0	Won et al. (2002) [15]
51	Frequency of going out	Kihon Checklist for frailty, going out frequency over the past week, completed by trained clinical research coordinators	None = 1 1 day = 0.75 2–3 days = 0.5 4–6 days = 0.25 Every day = 0	Satake et al. (2016) [7]
52	Weight loss	FPQ for use in screening community-dwelling older adults, unintended weight loss of 4.5 kg over the past year, completed by trained clinical research coordinators	Yes = 1 No = 0	Kim et al. (2020) [11]
53	Underweight	Medical examination, information gathered by trained clinical research coordinators	BMI < 18.5 kg/m^2 = 1 BMI ≥ 18.5 kg/m^2 = 0	

KFI-PC, Korean Frailty Index for Primary Care; CERAD-K, Korean version of the Consortium to Establish a Registry for Alzheimer's Disease; KFI, Korean Frailty Index; FPQ, Frailty Phenotype Questionnaire; SARC-F, Simple Sarcopenia Screening Tool, IADL, Instrumental Activities of Daily Living; SNAQ, Simplified Nutritional Appetite Questionnaire.

participant was calculated by dividing the number of deficits by the number of total variables that were recorded for that patient. For example, we divided the total score of deficits by 53 for patients with recorded data for all variables. If a patient was missing data on two variables, then the number of deficits for this patient was divided by 51. If data on one of the strength or climbing question was missing, the total KFI-PC score was calculated by dividing by 52.5. In this way, the KFI-PC score is continuous (0 to 1), with higher scores indicating an increased likelihood of frailty.

Study Sample and Study Design

To establish the feasibility and preliminary validity analysis of KFI-PC, we used cross-sectional data from the Korean Frailty Aging and Cohort Study (KFACS). KFACS is a multicenter longitudinal study whose participants were recruited from among community-dwelling residents in urban and rural areas nationwide in 10 study centers across different regions.[25] Each center recruited participants using quota sampling stratified by age and sex at local senior welfare centers, community health centers, apartments, housing complexes, and outpatient clinics. We used quota sampling based on age (70–74, 75– 79, and 80–84 years with a ratio of 6:5:4, respectively) and sex (male, female) with an aim of recruiting 1,500 men and 1,500 women. The inclusion criteria were age 70–84 years, living independently at home, having no plans to move out in the next 2 years, and no problems with communication due to serious cognitive impairment. The first wave of baseline data collection started in 2016–2017; of 3,014 participants who underwent baseline survey, 1,559 (51.7%) and 1,455 (48.3%) were enrolled in the study in 2016 and 2017, respectively. The follow-up rate in 2018 (baseline survey in 2016) was 92.5%, with 88.4% visiting the clinical sites, 11% completing telephone interviews, and approximately 0.5% involving home visits. This study included its sample from the second wave of a 2016 baseline survey, from among the 1,274 participants who visited the 10 study centers in 2018 as SNAQ was first included in the second wave in 2018. KFI-PC was assessed in on-site clinical examinations. The final analysis included 1,242 participants, after excluding 32 participants who did not have the data required to assess the Fried's physical frailty phenotype.

Ethics

The KFACS protocol was approved by the Institutional Review Board (IRB) of the Clinical Research Ethics Committee of Kyung Hee University Hospital, Seoul, Korea, and all subjects provided written informed consent (No. 2015-12-103). The present study was exempt from the requirement for IRB approval by the Clinical Research Ethics Committee of Kyung Hee University Hospital (No. 2020-04-033).

Assessment of Fried's Physical Frailty Phenotypes

This study defined physical frailty using a modified operational definition of Fried's physical frailty phenotypes from the Cardiovascular Health Study (CHS).[2] The five different components of frailty indicators were (1) weight loss: answering "yes" to "In the last year, have you lost more than 4.5 kg unintentionally?"; (2) weakness: maximal grip strength in the lowest 20% of the weighted KFACS population distribution, adjusted for sex and body mass index; (3) slowness: 4-m usual gait speed in the lowest 20% of the weighted KFACS population distribution, adjusted for sex and height; (4) exhaustion: answering "yes" to either one of the following statements from the Center for Epidemiological Studies-Depression scale "I felt that everything I did was an effort" or "I could not get going" for three or more days per week; and (5) low physical activity: kilocalorie per week (kcal/week) expenditures were calculated for each activity using its metabolic equivalent score using the International Physical Activity Questionnaire, with low physical activity defined as <494.65 kcal for men and <283.50 kcal for women, which was the lowest value for 20% of the sex-specific total energy consumed from a general Korea population-based survey of older adults.[26] Although the Physical Activity Scale for the Elderly (PASE) is one of the most commonly used methods, the Korean version takes up to 10 minutes to administer. A Korean study found moderate to high agreement between the CHS frailty phenotype definitions based on the K-PASE or International Physical Activity Questionnaire short form.[27] In this context, subjects with three or more components were considered to have physical frailty.

Statistical Analysis

Data are presented as mean ± standard deviation or as numbers (percentages). Continuous variables were compared using independent t-tests, and categorical variables were compared using chi-square or Fisher exact tests. We used Shapiro–Wilks tests to assess normality and Mann–Whitney U tests and Kruskal–Wallis tests to assess KFI-PC scores with respect to sex and age groups. Significant differences in KFI-PC scores between age groups were assessed using non-parametric post-hoc tests with Mann–Whitney U tests ($p<0.016$). The internal consistency of the 54 items was assessed based on Cronbach's alpha coefficients. For construct validation of KFI-PC-index, we used Spearman rank correlation coefficients (r_s) to explore the relationships between KFI-PC score and outcomes. Receiver operating characteristic (ROC) analysis was performed to explore the cutoff values of the KFI-PC score and to verify the criterion validity for frailty according to Fried's physical

frailty phenotype. The optimal cutoff values with the greatest sum of sensitivity and specificity for correctly identifying frail individuals were determined using Youden's index. The statistical analyses were performed using Stata (version 14.0; Stata Corp., College Station, TX, USA) and IBM SPSS Statistics for Windows, version 24.0 (IBM Corp., Armonk, NY, USA). Two-tailed $p < 0.05$ indicated statistical significance in this study.

RESULTS

Table 2 shows the characteristics of the study participants. Overall, the mean age was 77.9 and 28.9% of participants were living in rural areas. As the KFACS cohort study included participants who could visit 10 centers, ADL disability in any of five basic activities of daily living (i.e., dressing, bathing, toileting, transferring, and feeding) was rare (1.5%). Furthermore, the average overall KFI-PC score was 0.17. The KFI-PC score was higher in women and older groups in both sexes. The median and quartile KFI-PC scores for men and women and for age groups are shown in Supplementary Table S2. The KFI-PC scores showed a right-skewed distribution ranging from 0.02 to 0.52 (Fig. 1). Participants with KFI-PC score over 0.25, usually recognized the cutoff of frailty, represented 17.5% of the total population; however, the frailty prevalence by Fried's phenotype criteria was 9.2%. The KFI-PC score increased with age levels and the pattern was more exaggerated in women (Fig. 2). The deficit scores and missing data for each item of KFI-PC are presented in Table 3. The highest saturated deficit score was 60.2% with the current condition of hypertension. The highest rate of missing was 1.4% for the sleeping pattern item. The Cronbach's alpha coefficient of the 54 items total was 0.737, within the acceptable range (0.7 or above) for internal consistency (reliability).

Construct Validity of KFI-PC

To assess the construct validity (convergent validity) of KFI-PC, we compared it to Fried's physical frailty (Fig. 3, Table 4). ROC analysis performed to confirm the criterion-related validity of KFI-PC for Fried's physical frailty showed an area under the curve of

Table 2. Characteristics of the study sample

Variable	Overall (n = 1,242)	Men (n = 586)	Women (n = 656)	p-value
Age (y)	77.9 ± 3.9	78.2 ± 3.9	77.6 ± 3.9	0.014
Marriage status (n = 1,241)				
Married	800 (64.5)	523 (89.2)	277 (42.3)	0.000
Widowed/divorced	440 (35.5)	62 (10.6)	378 (57.7)	0.000
Single	1 (0.1)	1 (0.2)	0 (0)	0.000
Living in rural area	358 (28.9)	18 (31.0)	177 (27.0)	0.068
Education (n = 1,240)				
< Middle school	646 (52.1)	205 (35.0)	441 (67.3)	0.000
Middle and high school	402 (32.4)	232 (39.7)	170 (26.0)	0.000
College	192 (15.5)	148 (25.3)	44 (6.7)	0.000
ADL disability	19 (1.5)	7 (1.2)	12 (1.8)	0.250
KFI-PC score	0.17 ± 0.08	0.15 ± 0.07	0.20 ± 0.08	0.000
KFI-PC score by age group				
70–74 years	0.16 ± 0.07	0.13 ± 0.07	0.17 ± 0.07	0.000
75–79 years	0.17 ± 0.08	0.14 ± 0.07	0.20 ± 0.08	0.000
≥ 80 years	0.20 ± 0.09	0.16 ± 0.07	0.24 ± 0.09	0.000
KFI-PC score > 0.25 cutoff point	217 (17.5)	57 (9.7)	160 (24.4)	0.000
Fried's phenotype criteria				
Frail	114 (9.2)	44 (7.5)	70 (10.7)	0.001
Pre-frail	601 (48.4)	263 (44.9)	338 (51.5)	0.001
Robust	527 (42.4)	279 (47.6)	248 (37.8)	0.001

Values are presented as mean±standard deviation or number (%).
ADL, activities of daily living; KFI-PC, Korean Frailty Index for Primary Care.
ADL disability, dependent in any of five basic activities of daily living (i.e., dressing, bathing, toileting, transferring, and feeding).
p-values based on chi-square, Fisher exact, or independent t-test.

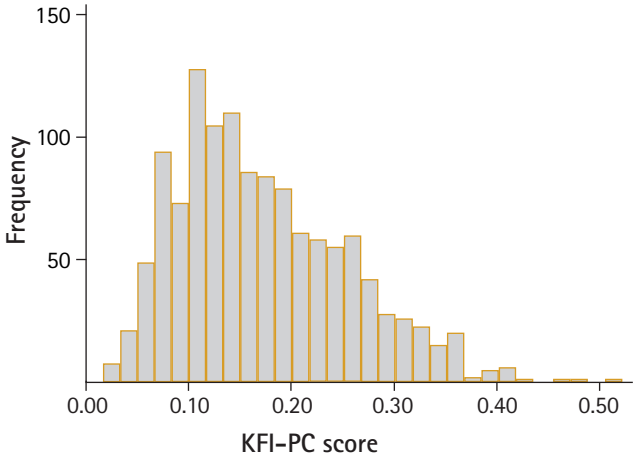

Fig. 1. The Korean Frailty Index for Primary Care (KFI-PC) score distribution in the study sample.

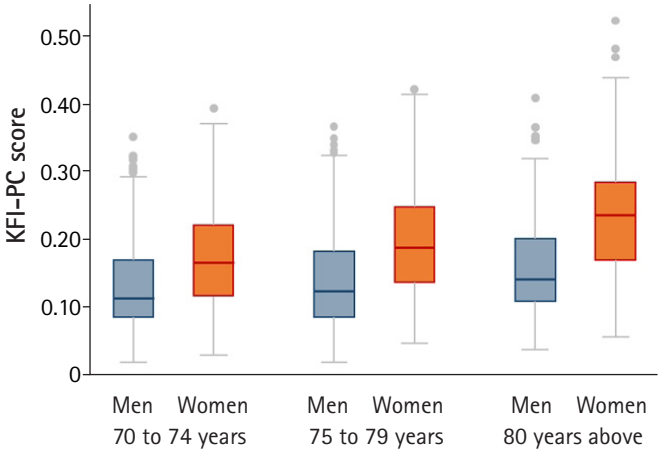

Fig. 2. Boxplot of the Korean Frailty Index for Primary Care (KFI-PC) scores for men and women and for three age groups. The median (horizontal line) is shown within each box. The KFI-PC score differed significantly between men and women in all age groups ($p<0.001$) and between the three age groups in men and women ($p<0.01$) except for 70–74 years vs. 75–79 years in men ($p=0.144$).

Table 3. The KFI-PC characteristics of the study sample

No	Deficit variable	Deficit score	Frequency (%)	Missing data
1	Construct recall (drawing two interlocking pentagons)	0	938 (75.5)	1 (0.1)
		1	303 (24.4)	
2	Three-item recall memory	0	514 (41.4)	1 (0.1)
		0.5	604 (48.6)	
		1	123 (9.9)	
3	Recognition	0	1,129 (90.9)	1 (0.1)
		0.5	95 (7.6)	
		1	17 (1.4)	
4	Depressive mood	0	821 (66.1)	0 (0)
		1	421 (33.9)	
5	Exhaustion	0	855 (68.8)	0 (0)
		1	421 (33.9)	
6	Delirium or hallucination	0	1,242 (100)	0 (0)
		1	0 (0)	
7	Visual or auditory problem	0	101 (81.6)	1 (0.1)
		1	227 (18.3)	
8	Sleeping pattern	0	908 (73.21)	18 (1.4)
		1	316 (25.4)	
9	Napping	0	683 (55.0)	0 (0)
		1	559 (45.0)	
10	Inactivity	0	761 (61.3)	0 (0)
		1	481 (38.7)	
11	Chair rise test	0	474 (38.2)	
		0.5	295 (23.8)	0 (0)
		1	473 (38.1)	
12-1	Strength	0	978 (78.7)	1 (0.1)
		0.5	263 (21.2)	
12-2	Climbing stairs	0	724 (58.3)	0 (0)
		0.5	518 (41.7)	

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Table 3. Continued

No	Deficit variable	Deficit score	Frequency (%)	Missing data
13	Balance confidence	0	988 (79.5)	1 (0.1)
		1	253 (20.4)	
14	Fall	0	972 (78.3)	6 (0.5)
		0.5	166 (13.4)	
		1	98 (7.9)	
15	Assistance in walking	0	1,192 (96.0)	0 (0)
		0.5	42 (3.4)	
		1	8 (0.6)	
16	Ambulation	0	886 (71.3)	1 (0.1)
		1	355 (28.6)	
17	Transferring from a bed to a chair	0	1,100 (88.6)	0 (0)
		0.5	128 (10.3)	
		1	14 (1.1)	
18	Mobility	0	1,198 (96.5)	0 (0)
		0.5	44 (3.5)	
		1	1 (0.1)	
19	Fecal incontinence	0	1,172 (94.4)	2 (0.2)
		1	68 (5.5)	
20	Bladder control	0	1,196 (96.3)	2 (0.2)
		1	4 (3.5)	
21	Shopping	0	1,211 (97.5)	0 (0)
		0.5	25 (2.0)	
		1	6 (0.5)	
22	Managing medications	0	1,233 (99.3)	0 (0)
		0.5	4 (0.3)	
		1	4 (0.3)	
23	Driving or using public transportation	0	1,218 (98.1)	0 (0)
		0.5	24 (1.9)	
		1	0 (0)	
24	Managing finances	0	1,118 (90.0)	0 (0)
		0.5	102 (8.2)	
		1	22 (1.8)	
25	Polypharmacy	0	770 (62.0)	3 (0.2)
		0.5	302 (24.3)	
		1	167 (13.4)	
26	Hypertension	0	494 (39.8)	0 (0)
		1	748 (60.2)	
27	Diabetes	0	959 (77.2)	0 (0)
		1	283 (22.8)	
28	Cancer	0	1,206 (97.1)	0 (0)
		1	36 (2.9)	
29	Chronic obstructive pulmonary disease	0	1,232 (99.2)	0 (0)
		1	10 (0.8)	
30	Myocardial infarction	0	1,214 (97.7)	0 (0)
		1	28 (2.3)	
31	Heart failure	0	1,228 (98.9)	0 (0)
		1	14 (1.1)	
32	Angina	0	1,141 (91.9)	0 (0)
		1	101 (8.1)	

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Table 3. Continued

No	Deficit variable	Deficit score	Frequency (%)	Missing data
33	Asthma	0	1,195 (96.2)	0 (0)
		1	47 (3.8)	
34	Arthritis	0	881 (70.9)	0 (0)
		1	361 (29.1)	
35	Stroke	0	1,239 (99.8)	0 (0)
		1	3 (0.2)	
36	Kidney disease	0	1,128 (98.9)	0 (0)
		1	3 (0.2)	
37	Spinal stenosis	0	1,196 (96.3)	0 (0)
		1	46 (3.7)	
38-43	Additional health conditions	0	525 (42.3)	0 (0)
		1	482 (38.8)	
		2	192 (15.5)	
		3	42 (3.4)	
		4	1(0.1)	
		5	0 (0)	
		6	0 (0)	
44	Hospitalization	0	1,055 (84.9)	0 (0)
		1	187 (15.1)	
45	Self-assessment of health status	0	853 (68.7)	1 (0.1)
		1	388 (31.2)	
46	Social contact	0	944 (76.0)	0 (0)
		1	298 (24.0)	
47	Spouse	0	779 (62.7)	0 (0)
		0.5	152 (12.2)	
		1	311 (25.0)	
48	Meals	0	1,135 (91.4)	0 (0)
		0.33	105 (8.5)	
		0.66	2 (0.2)	
		1	0 (0)	
49	Appetite	0	586 (47.2)	0 (0)
		0.33	476 (38.3)	
		0.66	155 (12.5)	
		1	25 (2.0)	
50	Walking to distant destinations	0	1,234 (99.4)	0 (0)
		0.5	8 (0.6)	
		1	0 (0)	
51	Going out	0	707 (56.9)	0 (0)
		0.25	238 (19.2)	
		0.5	158 (12.7)	
		0.75	28 (2.3)	
		1	111 (8.9)	
52	Weight loss	0	1,148 (92.4)	0 (0)
		1	94 (7.6)	
53	Underweight	0	1,215 (97.8)	0 (0)
		1	27 (2.2)	
Total score			9.2 ± 4.4	
Cronbach's alpha coefficient[a)]			0.737	

KFI-PC, Korean Frailty Index for Primary Care.
[a)]The internal consistency of the instrument items, assessed by Cronbach's alpha. The acceptable range of Cronbach's alpha is a value of 0.70 or above.

0.921 (95% confidence interval, 0.910–0.940). The ROC analysis revealed an optimal cutoff value, statistically defined as the best compromise between sensitivity and specificity, of 0.23 (sensitivity=89%, specificity=81%). The KFI-PC score showed correlations with physical, cognitive, and psychological functions, as well as nutritional status, disability in ADLs, and IADLs irrespective of age and sex (Table 4).

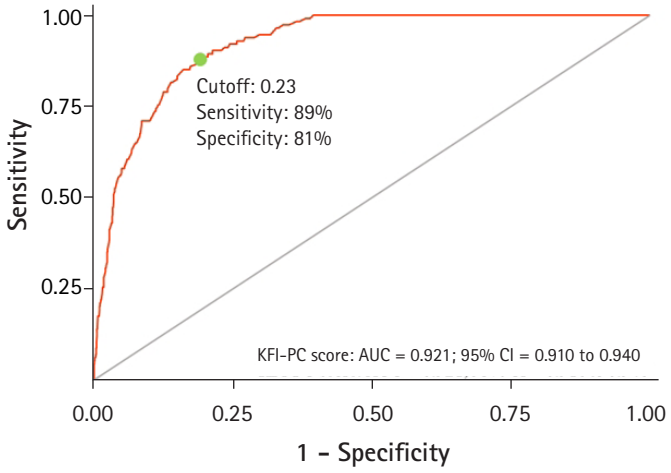

Fig. 3. Receiver operating characteristic (ROC) curve of the Korean Frailty Index for Primary Care (KFI-PC) score according to Fried's phenotype criteria. AUC, area under the ROC curve; CI, confidence interval.

DISCUSSION

We developed a KFI-PC containing 54 items with a maximum deficit score of 53 and demonstrated its acceptable internal consistency and construct validity. Broadly speaking, KFI-PC is a comprehensive assessment that covers health-related areas related to cognitive, mental, physical, social, and nutritional factors, as well as ADLs and medical illness.

Generally, frailty indices should contain at least 30 items and cover a range of health indicators including chronic conditions, physical/cognitive limitations, and general health. Another characteristic of frailty index is that each deficit should be health-related and increase with age.[24] Previous studies used 30–70 deficits to construct frailty indices. However, Searle et al.[23] recommended that frailty indices should include at least 30–40 total deficits. Another criterion is that the deficit should not saturate too early, i.e., it should not be present in all or most people. A reasonable criterion

Table 4. Construct validation of the KFI-PC

Variable	KFI-PC score		Age- and sex-adjusted KFI-PC score[a]	
	r_s	p-value	r_s	p-value
Fried's phenotype (score)	0.612	0.000	0.633	0.000
Physical function				
Handgrip strength (kg)	-0.478	0.000	-0.284	0.000
Usual gait speed (m/s)	-0.570	0.000	-0.512	0.000
Timed Up and Go test (s)	0.570	0.000	0.530	0.000
Short Physical Performance Battery (score)	-0.565	0.000	-0.532	0.000
SARC-F (score)	0.434	0.000	0.463	0.000
Cognitive function				
Mini-Mental State Examination (score)	-0.380	0.000	-0.335	0.000
Frontal Assessment Battery (score)	-0.413		0.330	0.000
Psychological status				
Geriatric Depression Scale (score)	0.534	0.000	0.510	0.000
Nutritional status				
Mini Nutritional Assessment Screening (score)	-0.473	0.000	-0.448	0.000
Total MNA (score)	-0.529	0.000	-0.513	0.000
Disability				
K-ADL (score)[b]	0.251	0.000	0.287	0.000
K-IADL (score)[c]	0.202	0.000	0.322	0.000

KFI-PC, Korean Frailty Index for Primary Care; SARC-F, simple 5-item questionnaire for sarcopenia screening; K-ADL, Korean activities of daily living; K-IADL, Korean instrumental activities of daily living.
p-values calculated using Spearman rank correlation coefficients (r_s).
[a]Age-and sex-adjusted Spearman partial correlation coefficients between KFI-PC score and outcomes.
[b]n=1,238.
[c]n=1,129.

for saturation appears to be about 80% or less as any deficits present in more than 80% of people do not make a significant difference in grading frailty.[28] KFI-PC satisfied all these requirements. Moreover, it covers a range of not only chronic conditions, physical/cognitive limitations, and general health but also the factors related to social and psychological health.

In this study, the ROC analysis demonstrated an optimal KFI-PC cutoff value of 0.23, consistent with the consensus cutoff point for frailty of 0.25 for the frailty index used to define frailty in other studies.[29] The original paper suggested a frailty cutoff of 0.25 based on a physical frailty index containing 70 deficits and data from participants aged 70 years and older in the Canadian Study of Health and Aging. However, another paper proposed a frailty cutoff of 0.21.[30] A study analyzing Canadian Health Survey data from participants aged 65 years and over reported that the risk of hospital-related events increased at a value of 0.21. The cutoff is the lowest point for predicting outcomes; it may be sensitive but not specific and, therefore, not the optimal threshold.

Regarding participants with missing variables, studies commonly exclude any item with more than 5% of missing data[31] and any participant with at least one missing item from more than 20% of the items.[30] In this study, 40 of 53 (75.5%) items had complete data. Of the 13 items with missing data, 10 items were missing only 1 or 2 value; the other three items had 3, 6, and 18 missing values. Thus, missing variables were not an issue in this study. KFI-PC is easily evaluated in primary care, as it is mainly made of self-responding questionnaires, with only the Mini-Cog and chair rise tests requiring healthcare provider evaluations. The Mini-Cog test can be completed in 2–4 minutes. The chair rise test takes approximately 1–2 minutes to administer after a simple demonstration. The chair rise test can be used as an alternative for gait speed or handgrip strength. It is particularly valuable and applicable to studies that do not or cannot include gait testing due to a lack of space or instrument to measure handgrip strength.

The KFI-PC score increased with age levels, a pattern that was more pronounced in women. Previous studies reported that deficits consistently accumulate exponentially with age at an average relative rate of approximately 3% per year on a log scale and that in general, at any given age, women on an average have more deficits than do men.[32] The reason for the sex difference may be mainly because of a higher incidence of comorbidities in women than in men, in addition to social, behavioral, and biological differences between men and women.[33]

We observed a frailty prevalence of 9.2% based on Fried's phenotype criteria and 17.5% based on KFI-PC, with a cutoff of 0.25. This result is compatible with that of previous reports of a 10% higher frailty prevalence using the frailty index compared with that using the phenotype criteria.[34] The frailty index is associated with adverse health outcomes even among people categorized as non-frail by frailty phenotype.[34] This finding suggests that the frailty index is a more sensitive measure for determining frailty owing to its ability to detect this condition at even the early stage of a frailty trajectory.[34] Furthermore, the continuous nature of the frailty index allows it to trace slight changes in frailty to intervene before an individual reaches a definite frail phenotype.[33] The prevalence of ADL disability in this study was only 1.5%. As the participants of the KFACS are comparatively healthy older adults who can visit the centers, the percentage of ADL disability may be lower than other home visit surveys. However, KFI-PC was developed for use in outpatient primary care and those patients must be ambulatory to visit clinics. In comparison, the reported prevalence of ADL disability was 2.6% in four outpatient clinics and two welfare centers.[35]

In conclusion, we developed KFI-PC containing 53 deficits including comprehensive geriatric assessment components. KFI-PC comprises mainly self-administered questionnaires; only the Mini-Cog and chair rise tests are assessed by medical personnel and require limited time to perform. We demonstrated the construct validity and internal consistency (reliability) of KFI-PC. KFI-PC is easily assessed, was not considered a burden on the medical personnel who practice in primary care, and was well validated. Further studies are needed to determine whether KFI-PC is a good indicator for the prevention of adverse health outcomes and if it is feasible in real-world primary care settings.

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CONFLICT OF INTEREST

The researchers claim no conflicts of interest.

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AUTHOR CONTRIBUTIONS

Conceptualization, CWW; Data curation, CWW, SL, MK; Funding acquisition, CWW; Investigation, CWW, SL, YL, MK; Methodology, CWW, SL, YL, MK; Project administration, CWW; Supervision, CWW; Writing-original draft, CWW, MK; Writing-review & editing, CWW, SL, YL, MK.

SUPPLEMENTARY MATERIALS

Supplementary materials can be found via https://doi.org/10.4235/agmr.20.0021

Table S1. KFI-PC in Korean version

Table S2. Median and quartiles (Q1, Q3) of the Korean Frailty Index for Primary Care scores for men and women and for three age groups

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