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Cohort Profile: Korean Frailty and Aging Cohort Study (KFACS)

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Table 1. General characteristics of participants in the Korean Frailty and Aging Cohort Study (KFACS) baseline survey, 2016 – 2017. Participants were sorted into three age groups (70 –74, 75 – 79, and 80 – 84 years).

Table 2. Summary of key variables collected from the Korean Frailty and Aging Cohort Study (KFACS) at baseline (2016-2017) and the first follow-up period (2019-2020)

Table 3. List of laboratory test variables collected during the Korean Frailty and Aging Cohort Study (KFACS) baseline survey (2016 – 2017)

Table 4. Characteristics of participants of the KFACS baseline survey, 2016 – 2017 according to Fried's frailty phenotype (n = 2907). Participants were sorted into three age groups (70 –74, 75 – 79, and 80 – 84 years).

Figure 1. Locations of the 10 centers involved in the Korean Frailty and Aging Cohort Study (KFACS)

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Abstract

Purpose The purpose of KFACS is to initiate a nationwide, population-based prospective cohort study of older adults living in the community to assess their frailty status and explore transitions between frailty states over time.

Participants The KFACS is a multicenter longitudinal study with the baseline survey conducted from May 2016 to November 2017. Each center recruited participants using quota sampling stratified by age and sex. The number of participants recruited through 2 years of baseline study from 10 centers was 3014, with each site accounting for approximately 300 participants.

Findings to date The key variables of KFACS are as follows: Demographics, Lifestyle and health-related behaviors, Health status, Social function, Cognitive function, Anthropometric measurements, Physical function, Health assessments (blood pressure, heart rate, visual acuity assessment, hearing (pure tone audiometry) assessment, electrocardiogram test, chest X-ray), Body composition (dual energy X-ray absorptiometry (DEXA) in 8 centers and bioelectrical impedance analysis (BIA) at 2 centers, Panoramic radiography), and laboratory tests. In the baseline study of 2016–2017, 2907 of 3014 individuals fulfilled all five components of Fried's frailty phenotype. The results indicated that 7.8% of the participants (n=228) were frail, 47.0% (n=1366) were pre-frail, and 45.2% (n=1313) were robust. The prevalence of frailty increased with age in both sexes; in the group aged 70–74 years, 1.8% of men and 3.7% of women were frail, whereas in the 80–84 years age group, 14.9% of men and 16.7% of women were frail. Women tended to exhibit a higher prevalence of frailty than men in all age groups.

Future plans Frailty is increasingly recognized as a major threat to healthy aging, and the KFACS is expected to be a valuable resource hub in identifying risk factors and building an evidence base for the prevention and management of frailty in community-dwelling older adults in Korea.

Key words: Frailty, cohort studies, aging, older adults, Republic of Korea

Strengths and limitations of this study

- The main strengths of the KFACS are the inclusion of a nationwide population of community-dwelling Korean older adults
- The KFACS has a comprehensive scope of assessments, with the inclusion of physical examinations, health assessments, a neuropsychological battery for cognitive function, in-depth social function surveys, dental radiography, blood tests and banking, and most importantly, a diverse range of frailty and sarcopenia assessments.
- The KFACS includes two sub-cohort studies i.e., a survey of social frailty involving bimonthly interviews and a nutrition survey involving home visits.
- One weakness of the study is that the participants had to be ambulatory to visit the 10 centers in the baseline survey, and home-bound disabled or institutionalized persons could not participate. In addition, dementia patients with problems in communication were excluded.
- The participants were not selected through probability sampling due to the strengthened data privacy laws that prevented researchers from acquiring the personal information of people living in the communities around the 10 centers. However, the distribution of sample characteristics (age, sex, education, place of residence) of KFACS participants was similar to the estimates of the older (70 – 84 years) population drawn from the national census.

Introduction

The population of Korea is aging rapidly, with more than 14% of the total population in Korea consisting of people older than 65 years according to the 2018 Aged Population Report created by the Korean Statistical Information Service. The proportion of the aged in the population is projected to increase to 24.5% by 2030 and 41.0% by 2060 [1]. The percentage of the population older than 75 years is estimated to reach 10.0% by 2030 and 25.9% by 2060, with the percentage of the population aged 85 years and older predicted to increase to 2.8% and 11.2% by these dates, respectively [1,2]. Aging of the population is accompanied by increased rates of multimorbidity along with increased need for social support, as well as increased burden on families and public health medical expenditure [3,4]. An increasing proportion of community-dwelling older adults present frailty, a status of extreme vulnerability to endogenous and exogenous stressors exposing the individual to increased risk of negative health-related outcomes [5]. Therefore, it is becoming increasingly important to develop means of identifying frailty, which represents a transition phase between healthy aging and disability, as well as develop interventions to prevent adverse outcomes [5].

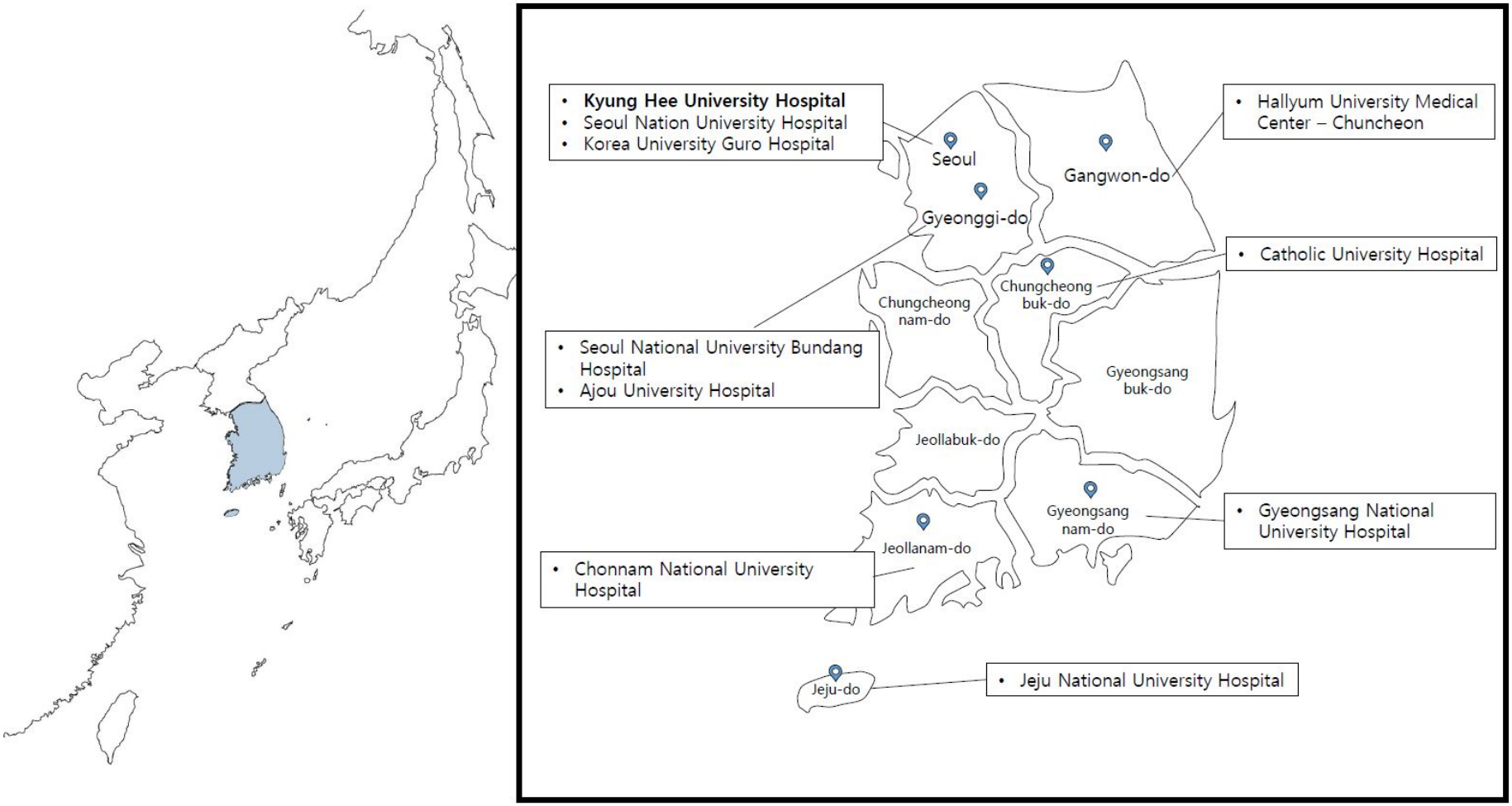
Although many Korean cohort studies on age-related health conditions for older adults have been reported, such as the Korean Longitudinal Study on Health and Aging (KLoSHA) [6], Korean Urban and Rural Elderly (KURE) cohort study [7], and Aging Study of Pyeongchang Rural Area (ASPRA) [8], none focused on frailty in older adults on a nationwide scale. With a focus on evidence-based diagnosis and management methods of frailty in community-dwelling older adults, the Korean Frailty and Aging Cohort Study (KFACS) was instigated with funding from the Ministry of Health and Welfare in December 2015 [9]. The purpose of KFACS is to initiate a nationwide, population-based prospective cohort study of older adults living in the community to assess their frailty status and explore

transitions between frailty states over time. The specific aims of the study were to 1) identify risk factors involved in the transition between states of frailty and the development of adverse outcomes, such as disability, institutionalization, and mortality; 2) develop models for predicting the onset and progression of frailty; and 3) create an evidence base for developing clinical practice guidelines for the prevention and management of frailty in older adults [9].

Cohort description

The KFACS is a multicenter longitudinal study with the baseline survey conducted from May 2016 to November 2017. The participants were recruited from among community-dwelling residents in urban and rural areas nationwide in 10 study centers across different regions—three from Seoul Metropolitan Area, two from Gyeonggi Province, and one from each of Gangwon Province, Chungcheong-buk Province, Jeolla-nam Province, Gyeongsang-nam Province, and Jeju Island in South Korea (Figure 1).

Figure 1. Locations of the 10 centers involved in the Korean Frailty and Aging Cohort Study (KFACS)



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 the aim of recruiting 1500 men and 1500 women.

The inclusion criteria were an age of 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 number of participants recruited through 2 years of baseline study from 10 centers was 3014, with each site accounting for approximately 300 participants.

Of the 3014 participants, 1559 (51.7%) joined the study in 2016 and 1455 (48.3%) joined in 2017. The mean age was 76.0 years, and 1582 participants (52.5%) were female. Overall, 39.4% were aged 70–74 years, 37.4% were aged 75 – 79 years, and 23.2% were in their 80s. The baseline survey indicated that 28% of the subjects were urban residents, 42% were suburban residents, and 30% were residents of rural areas (Table 1). Other general characteristics of the KFACS participants are shown in Table 1.

Table 1. General characteristics of participants in the Korean Frailty and Aging Cohort Study (KFACS) baseline survey, 2016 – 2017. Participants were sorted into three age groups (70 –74, 75 – 79, and 80 – 84 years).

Variable	Total	Male (n=1,432)			p-value	Female (n=1,582)			p-value
		70-74	75-79	80-84		70-74	75-79	80-84	
Total baseline study participants, *n* (%)	3014 (100)	521 (17.3)	552 (18.3)	359 (11.9)		668 (22.2)	574 (19)	340 (11.3)	
2016, *n* (%)	1559 (51.7)	267 (8.9)	280 (9.3)	187 (6.2)		338 (11.2)	297 (9.9)	190 (6.3)	
2017, *n* (%)	1455 (48.3)	254 (8.4)	272 (9)	172 (5.7)		330 (10.9)	277 (9.2)	150 (5)	
Demographics, *n* (%)									
Marital Status									
Single	4 (0.1)	2 (0.4)	0 (0.0)	1 (0.3)		1 (0.1)	0 (0.0)	0 (0.0)	
Married	2929 (97.3)	505 (97.1)	536 (97.3)	350 (97.5)	0.697	645 (96.6)	561 (97.7)	332 (97.9)	.520
Divorced/widowed	78 (2.6)	13 (2.5)	15 (2.7)	8 (2.2)		22 (3.3)	13 (2.3)	7 (2.1)	
Residence area									
Urban	827 (27.6)	137 (26.5)	146 (26.6)	106 (29.5)		186 (28)	160 (28.1)	92 (27.1)	
Suburban	1262 (42.1)	211 (40.8)	223 (40.6)	140 (39)	0.877	291 (43.8)	262 (46.0)	135 (39.8)	.224
Rural	909 (30.3)	169 (32.7)	180 (32.8)	113 (31.5)		187 (28.2)	148 (26.0)	112 (33.0)	
Education									
< Middle school	1452 (48.2)	150 (28.8)	169 (30.6)	127 (35.5)		383 (57.3)	365 (63.7)	258 (75.9)	
Middle and high school	1048 (34.8)	235 (21.1)	226 (17.6)	140 (12.3)	0.024	218 (16.2)	155 (11.9)	74 (10.9)	< 0.001
≥ College	512 (17.0)	136 (50.1)	157 (51.8)	91 (52.2)		67 (26.5)	53 (24.4)	8 (13.2)	
Receiving allowance, yes, *n* (%)	166 (5.5)	31 (6.0)	20 (3.6)	22 (6.1)	0.132	30 (4.5)	26 (4.5)	37 (10.9)	< 0.001
Receiving medical aid, yes, *n* (%)	45 (1.5)	4 (0.8)	6 (1.1)	4 (1.1)	0.829	9 (1.3)	11 (1.9)	11 (3.2)	0.124
Lifestyle characteristics									
Current drinker, *n* (%)	890 (41.2)	269 (56.8)	273 (54.7)	169 (52.6)	0.517	80 (19.7)	61 (21.4)	38 (21.6)	0.812
Current smoker, *n* (%)	174 (15.1)	61 (14.8)	56 (13.3)	41 (15.0)	0.775	2 (11.8)	4 (40.0)	10 (52.6)	0.034
Sleeping (h/day), mean (SD)	6.24 (1.47)	6.43 (1.39)	6.54 (1.31)	6.54 (1.50)	0.354	6.06 (1.47)	5.87 (1.50)	6.08 (1.54)	0.056
Physical activity (METS/week), mean (SD)	52.45 (63.58)	71.52 (85.37)	66.08 (68.75)	46.52 (54.89)	< 0.001	51.01 (59.48)	39.5 (43.72)	32.6 (46.61)	< 0.001
Body composition, mean (SD)									
Calf circumference (cm)	33.8 (2.7)	33.8 (2.7)	33.8 (2.7)	33.8 (2.7)	< 0.001	33.7 (2.4)	33.7 (2.4)	33.7 (2.4)	< 0.001
Waist circumference (cm)	87.7 (8.6)	87.7 (8.6)	87.7 (8.6)	87.7 (8.6)	0.530	86.4 (8.0)	86.4 (8.0)	86.4 (8.0)	0.116
BMI (kg/m^2)	24.4 (3.0)	24.4 (3.0)	24.4 (3.0)	24.4 (3.0)	0.008	24.9 (2.9)	24.9 (2.9)	24.9 (2.9)	0.687
Physical function									
Timed up-and-go (s), mean (SD)	10.5 (2.9)	9.5 (2.7)	10.4 (2.5)	11.1 (2.7)	< 0.001	9.9 (2.2)	10.8 (3.2)	12.5 (3.5)	< 0.001
ADL disability, *n* (%)	337 (11.2)	32 (6.1)	42 (7.6)	41 (11.4)	0.016	64 (9.6)	86 (15.0)	72 (21.2)	< 0.001
IADL disability, *n* (%)	1148 (38.1)	311 (59.7)	303 (54.9)	219 (61.0)	0.128	101 (15.1)	107 (18.6)	107 (31.5)	< 0.001
Fall experience, yes, *n* (%)	612 (20.3)	67 (12.9)	96 (17.4)	65 (18.1)	0.055	136 (20.4)	160 (27.9)	88 (25.9)	0.006
SPPB, mean (SD)	3.74 (1.28)	3.32 (0.83)	3.58 (1.43)	3.92 (1.14)	< 0.001	3.54 (0.87)	3.88 (1.28)	4.58 (1.84)	< 0.001
Grip strength (kg), mean (SD)	26.2 (7.6)	34.2 (5.6)	32.2 (5.8)	28.8 (5.4)	< 0.001	22 (4.0)	20.7 (4.1)	18.9 (3.9)	< 0.001

Gait speed (m/s), mean (SD)	1.1 (0.26)	1.21 (0.25)	1.16 (0.27)	1.04 (0.24)	< 0.001	1.14 (0.23)	1.05 (0.22)	0.92 (0.22)	< 0.001
Psychological function, mean (SD)									
Self-rated health (range: 0 – 100)	73.9(17.4)	77.7(14.5)	76.2(15.3)	72.4(16.4)	< 0.001	74.7(17.8)	71.8(18.6)	67.8(20.7)	< 0.001
GDS (range: 0 – 15)	3.3 (3.7)	2 (3.0)	2.5 (3.4)	3.1 (3.3)	< 0.001	3.4 (3.7)	4.1 (4.1)	4.9 (4.3)	< 0.001
EQ-5D (range: 0 – 1)	0.9 (0.1)	0.(0.1)	0.9 (0.1)	0.9 (0.1)	< 0.001	0.9 (0.1)	0.8 (0.1)	0.8 (0.2)	< 0.001
Cognitive function, mean (SD)									
MMSE-KC (range: 0 – 30)	25.5 (3.4)	26.8 (2.4)	26.1 (3.1)	25.3 (3.6)	< 0.001	25.9 (3.2)	24.8 (3.4)	23.3 (3.8)	< 0.001
Word list: memory (range: 0 – 30)	16.6 (4.4)	17.8 (3.7)	16.2 (4.0)	14.4 (4.2)	< 0.001	18.1 (4.1)	16.6 (4.5)	14.6 (4.7)	< 0.001
Word list: recall (range: 0 – 10)	5.5 (2.1)	6.1 (1.9)	5.3 (2.0)	4.6 (2.1)	< 0.001	6.1 (2.0)	5.3 (2.1)	4.5 (2.2)	< 0.001
Word list: recognition (range: 0 – 10)	8.5 (1.9)	8.9 (1.4)	8.5 (1.9)	8.2 (2.2)	< 0.001	8.9 (1.6)	8.4 (1.9)	8 (2.4)	< 0.001
FAB (range: 0 – 18)	13.4 (3.1)	14.6 (2.4)	14 (2.7)	13.3 (3.2)	< 0.001	13.4 (2.9)	12.7 (3.1)	11.4 (3.3)	< 0.001
Nutritional status, *n* (%)									
Normal	2519 (83.8)	450 (86.5)	457 (82.9)	297 (82.7)		576 (86.2)	464 (81.3)	275 (81.4)	
At risk of malnutrition	457 (15.2)	68 (13.1)	88 (16.0)	53 (14.8)	0.037	89 (13.3)	103 (18.0)	56 (16.6)	0.013
Malnutrition, yes, *n* (%)	31 (1.0)	2 (0.4)	6 (1.1)	9 (2.5)		3 (0.4)	4 (0.7)	7 (2.1)	
Social function, *n* (%)									
Social network type									
Contact with others more than once a week	2502 (83.0)	420 (80.6)	449 (81.3)	287 (79.9)	0.870	574 (85.9)	486 (84.7)	286 (84.1)	0.704
Attending religious gatherings at least once a month regularly	1272 (42.2)	161 (30.9)	177 (32.1)	126 (35.1)	0.513	355 (53.1)	289 (50.3)	164 (48.2)	0.521
Social capital									
Participating in more than two social gatherings	1632 (54.1)	273 (52.4)	265 (48.0)	172 (47.9)	0.272	423 (63.3)	327 (57.0)	172 (50.6)	< 0.001
Social support									
Receiving instrumental support	2212 (73.4)	380 (72.9)	408 (73.9)	261 (72.7)	0.903	496 (74.3)	424 (73.9)	243 (71.5)	0.621
Receiving informational support	2345 (77.8)	392 (75.2)	424 (76.8)	273 (76)	0.834	542 (81.1)	452 (78.7)	262 (77.1)	0.283
Receiving appraisal support	2351 (78.0)	392 (75.2)	433 (78.4)	271 (75.5)	0.402	540 (80.8)	455 (79.3)	260 (76.5)	0.269
Medical conditions, *n* (%)									
Hypertension	1746 (57.9)	263 (50.5)	302 (54.7)	211 (58.8)	0.108	369 (55.2)	354 (61.7)	247 (72.6)	< 0.001
Diabetes mellitus	663 (22)	117 (22.5)	136 (24.6)	86 (24.0)	0.722	126 (18.9)	116 (20.2)	82 (24.1)	0.136
Arthritis	761 (25.2)	62 (11.9)	77 (13.9)	56 (15.6)	0.439	205 (30.7)	220 (38.3)	141 (41.5)	0.007
Osteoporosis	483 (16.0)	8 (1.5)	22 (4.0)	19 (5.3)	0.004	158 (23.7)	172 (30.0)	104 (30.6)	0.001
Depression	87 (2.9)	5 (1.0)	15 (2.7)	8 (2.2)	0.112	21 (3.1)	26 (4.5)	12 (3.5)	0.427
Heart disease	251 (8.5)	53 (10.2)	61 (11.2)	38 (10.8)	0.874	31 (4.8)	36 (6.4)	32 (9.8)	0.010
Polypharmacy	891 (32.8)	174 (28.2)	148 (37.6)	86 (44.4)	< 0.001	231 (24.2)	175 (30.0)	77 (42.0)	< 0.001

Abbreviations: BMI = body mass index; ADL = Activities of Daily Living; IADL = Instrumental Activities of Daily Living; SPPB = Short Physical Performance Battery; GDS = Geriatric Depression Scale; EQ-5D = EuroQol five-dimension scale; MMSE = Mini-Mental State Examination; FAB = Frontal Assessment Battery. Nutritional status was rated using the Mini-Nutritional Assessment screening score (12 – 14 points, normal; 8 – 11 points, at risk of malnutrition; 0 – 7 points, malnutrition); polypharmacy indicates the use of five or more prescribed drugs.

There were no statistically significant differences between sexes except for the following variables: marriage status, whether the subject received instrumental support, whether the subject received an allowance, whether the subject received appraisal support, self-rated health, performance in word recall, performance in word recognition, weight loss status, low activity status, grip strength, and gait speed.

The prospective cohort design of the KFACS included data collection every 2 years. The first wave of baseline data collection started in 2016 – 2017, and the follow-up (2018 – 2109) is currently in process. Follow-up surveys are conducted on a 2-year basis with 4 months of allowance limitations. Follow-up for the baseline cohort in 2016 (total number, 1559) was conducted in 2018. The follow-up rate was 92.5%, with 88.4% visiting the clinical sites, 11% involving telephone interviews, and approximately 0.5% involving home visits. The follow-up rate was 93.9% if we included findings such as entering nursing homes (four participants) or death (18 participants). The mean follow-up time range was 682.6 ± 34.4 days.

Field work methods

All participants visited their corresponding study centers to conduct face-to-face interviews, health examinations, and laboratory tests for the baseline survey. At follow-up, participants primarily visited their center, but we also conducted home visits, telephone interviews, and proxy interviews (in this order) if visiting the center was not possible.

Data collection and key variables

Table 2. Summary of key variables collected from the Korean Frailty and Aging Cohort Study (KFACS) at baseline (2016-2017) and the first follow-up period (2019-2020)

Variable	Baseline	Follow-up	Proxy interviews

Demographics			
Age, sex, education	✓	✓	
Marital status, family structure	✓	✓	✓
Work/employment	✓	✓	
Household income	✓	✓	✓
Living environment (rural, suburban, urban)	✓	✓	
Health behavior			
Smoking, alcohol drinking	✓	✓	✓
Sleep, physical activity (IPAQ)	✓	✓	✓
IPAQ environmental module	✓		
Oral hygiene, dental checkup	✓	✓	
Health checkup	✓	✓	
Nutritional risk (MNA)	✓	✓	✓
Eating behavior	✓	✓	
Food security	✓		
Short Nutritional Assessment Questionnaire (SNAQ)		✓	
Health Status			
Self-rated health (SF-12), comorbidity, polypharmacy	✓	✓	
Constipation		✓	
Quality of life (EQ-5D)	✓	✓	
EuroQol Visual Analogue Scale (EQ-VAS)	✓	✓	
Depressive symptoms (GDS-SF)	✓	✓	
K-ADL	✓	✓	
K-IADL	✓	✓	✓
Physical resilience		✓	
Experience of falls, recent injury, fear of falling	✓	✓	✓
Activities-specific Balance, Confidence scale (ABC)	✓	✓	
Oral health: mastication, pronunciation difficulties	✓	✓	
Women's health	✓		
Healthcare			
Outpatient visits, hospitalization, unmet needs	✓	✓	
Healthcare costs, long-term care services	✓	✓	
Health literacy	✓	✓	
Social function			
Social network: PANT	✓	✓	
Social capital: Participation in social activities	✓	✓	✓
Social support: ENRICHD	✓	✓	
Cognitive function (CERAD-K, FAB)			
Global cognition: MMSE	✓	✓	
Executive function: FAB	✓	✓	
Processing speed: Trail Making Test A	✓	✓	
Memory: word list memory, recall, recognition	✓	✓	
Attention: digit span forward/digit span backward	✓	✓	
Korean version of the Alzheimer's disease survey			✓
Anthropometry			

Body weight, height	✓	✓	✓
Body weight last year	✓	✓	✓
Head circumference, waist circumference	✓	✓	
Leg length	✓	✓	
Upper arm circumference, calf circumference	✓	✓	
Physical function			
Hand-grip strength	✓	✓	
4-m usual gait speed	✓	✓	
SPPB – item 3: standing balance, item 5: chair-stand time, usual gait speed, timed up-and-go test	✓	✓	
Health Assessments			
Vital signs: blood pressure, heart rate	✓	✓	
Visual acuity: Snellen chart (corrected vision)	✓	✓	
Hearing: pure tone audiometry (500, 1000, 2000, 3000, and 4000 Hz)	✓	✓	
Electrocardiogram	✓	✓	
Chest X-ray	✓	✓	
Body composition			
Dual Energy X-ray Absorptiometry (DEXA): KFCAS at eight medical centers (2016 – 2017)	✓	✓	
Ultrasound: muscle quality (Kyung Hee University only)	✓	✓	
Bioelectric Impedance Analysis (BIA): KFCAS at two medical centers	✓	✓	
Joint replacement (identifiable from DEXA images)		✓	
Panoramic radiography			
Periodontitis, upper and lower jaw bones (bone mineral density)	✓	✓	
Supernumerary, missing, and impacted teeth, etc.	✓	✓	
Frailty & Sarcopenia Assessment			
CHS (Fried phenotype): unintentional weight loss, hand grip strength, self-reported exhaustion, physical activity, gait speed	✓	✓	
KLoSHA frailty index: SPPB, K-IADL, K-ADL, MMSE, albumin	✓	✓	
FRAIL questionnaire: fatigue, resistance, ambulation, illness, loss of weight	✓	✓	✓
Korean Frailty Index: eight items (hospitalization, self-rated health, polypharmacy, weight loss, depressed mood, incontinence, TUG, hearing/vision impairment)	✓	✓	
Frailty scale: weakness, exhaustion, isolation	✓	✓	
SOF index: chair-stand, energy (GDS), loss of weight	✓	✓	
SARC-F: five items (strength, assistance with walking,	✓	✓	

rising from a chair, climbing stairs, falls)

Abbreviations: IPAQ = International Physical Activity Questionnaire; MNA = Mini-Nutritional Assessment; K-ADL = Korean Activities of Daily Living; K-IADL = Korean Instrumental Activities of Daily Living; SF-12 = 12-item Short Form Survey; EQ-VAS = EuroQol Visual Analogue Scale; ABC = Activities-specific Balance, Confidence scale; PANT = Practitioner Assessment of Network Type; ENRICHD = Enhancing Recovery in Coronary Artery Disease; MMSE = Mini-Mental State Examination; FAB = Frontal Assessment Battery; SPPB = Short Physical Performance Battery; CHS = Cardiovascular Health Study; KLoSHA = Korean Longitudinal Study on Health and Aging; TUG = timed up-and-go; SOF = Study of Osteoporotic Fracture; GDS = Geriatric Depression Scale. Health literacy was assessed based on the capacity to obtain, process, understand, and use health information.

The key variables of the KFACS questionnaires are listed in Table 2 and consisted of demographics, including socioeconomic status, living environment, lifestyle and health-related behaviors, the International Physical Activity Questionnaire (IPAQ) [10], the IPAQ environmental module (IPAQ-E) [11], dental checkup status, and nutritional status using the Korean version of the Mini-Nutritional Assessment (MNA) [12]. Health status was determined according to self-rated health conditions (SF-12) [13], self-reported and physician-diagnosed chronic diseases, medications, quality of life (EQ-5D) [14], and EuroQol Visual Analogue Scale (EQ-VAS) [15]. A 15-item Korean version of the Short Form Geriatric Depression Scale (SGDS-K) [16], activities of daily living (ADL), instrumental activities of daily living (IADL) [17], falls and fear of falling, Activities-specific Balance, Confidence scale (ABC) [18], oral health, and women's health of the participants were scored, and the number of outpatient services, hospitalization rate, number of long-term care services, and health literacy were determined to measure health status. Social assessment included Practitioner Assessment of Network Type (PANT) [19], social participation and activities, and the Enhancing Recovery in Coronary Artery Disease (ENRICHD) Social Support Instrument [20, 21]. For cognitive function, assessments were made using the Mini-Mental State Examination (MMSE); Trail Making Test A; word list memory, recall, and recognition; digit span [22] in the Consortium to

Establish a Registry for Alzheimer's disease (CERAD) [23]; and Frontal Assessment Battery (FAB) [24]. We included anthropometric measurements of body weight, height, head circumference, waist circumference, leg length, and upper arm circumference. Physical function was assessed based on grip strength, gait speed, the Short Physical Performance Battery (SPPB), and timed up-and-go test. Health assessments, such as those for blood pressure, heart rate, visual acuity, and hearing (pure tone audiometry), as well as electrocardiograms and chest X-rays were carried out. To determine body composition, dual energy X-ray absorptiometry (DEXA) was performed at eight centers and bioelectrical impedance analysis (BIA) was performed at two centers. Panoramic radiography was carried out to assess dental status. Blood samples after an 8-h fast were taken at around 08:00 to ensure the reliability of hormone tests (Table 3). All blood and urine samples from the participants at 10 centers were brought to a commercial laboratory and used for the tests. An extra 10 ml of blood was collected from each participant and sent to Kyung Hee University Medical Center for storage in deep freezers.

Table 3. List of laboratory test variables collected during the Korean Frailty and Aging Cohort Study (KFACS) baseline survey (2016 – 2017)

2016 – 2017
Laboratory Tests (Taken at 08:00 after 8 h of fasting) • Hematology: CBC (WBC, RBC, Hb, HCT, MCV, MCHC, platelet) • Biochemistry: AST, ALT, GGT, total protein, albumin, total bilirubin, alkaline phosphatase, creatine kinase, BUN, creatinine, sodium, potassium, chloride, cystatin C, HBs Ag • Metabolic parameters: glucose (FBS), calcium, phosphorus (Pi), magnesium, HbA1c, total cholesterol, LDL-C, HDL-C, triglyceride, 25 (OH) vitamin D, vitamin B12 • Hormone and tumor markers: free T4, TSH, insulin, cortisol (S), free testosterone, **DHEA, IGF-1** • Inflammation markers: hs-CRP, **GDF-15**

- Genetic and muscle: **myostatin,** AMPK (phenotype)
- Urine test: urine 10 (stick), urine microscopic

※ Variables in bold text were added in 2017

Abbreviations: BUN = blood urea nitrogen; AST = aspartate aminotransferase test; ALT = alanine aminotransferase test; GGT = gamma-glutamyl transferase; HDL = high-density lipoprotein; LDL = low-density lipoprotein; Hb A1c = hemoglobin A1c; WBC = white blood cell; RBC = red blood cell; Hb = hemoglobin, HCT = hematocrit test; MCV = mean corpuscular volume; MCH = mean corpuscular hemoglobin; MCHC = mean corpuscular hemoglobin concentration; HBs Ag = hepatitis B virus surface antigen; TSH = thyroid-stimulating hormone; Hs-CRP = high-sensitivity C-reactive protein; IGF-1 = insulin-like growth factor 1; DHEA = dehydroepiandrosterone; GDF-15 = growth/differentiation factor 15.

Frailty assessment

To define physical frailty, the KFACS used a modified version of the Fried Frailty Phenotype (FFP) consisting of five components of frailty: unintended weight loss, weakness, self-reported exhaustion, slowness, and low physical activity [25].

- Unintentional weight loss: defined as a "yes" response to the question: "In the last year, have you lost more than 4.5 kg unintentionally?"
- Weakness: defined as the lower 20th percentile of grip strength (maximal grip strength in kg after measuring twice for each hand using a hand grip dynamometer [T.K.K.5401; Takei Scientific Instruments Co, Ltd., Tokyo, Japan]) stratified by sex and BMI

Men	Women
BMI ≤22…≤25.0 kg	BMI ≤23…≤16.8 kg
BMI 22.1–24…≤27.0 kg	BMI 23.1–25…≤17.7 kg
BMI 24.1–26…≤27.8 kg	BMI 25.1–27…≤17.8 kg
BMI >26…≤28.5 kg	BMI >27…≤17.7 kg

quartiles based on the KFACS baseline survey.

- Self-reported exhaustion: defined as a "yes" response to either of the following statements from the Center for Epidemiological Studies-Depression scale on 3 or more days per week: "I felt that everything I did was an effort" and "I could not get going."
- Slowness: Walking speed over 4 m was measured using an automatic timer (Gaitspeedometer; Dynamicphysiology, Daejeon, Korea), with acceleration and deceleration phases of 1.5 m. The mean values were selected after measuring twice. The lowest 20% of gait speed stratified by sex and height based on KFACS data was suggested as a cut-off.

Men	Women
Height ≤165 cm...≤ 0.93 m/s	Height ≤152 cm...≤ 0.85 m/s
Height >165 cm...≤ 0.98 m/s	Height >152 cm...≤ 0.93 m/s

- Low physical activity: energy expenditure estimates (kcal/week) were calculated using the IPAQ and metabolic equivalent scores were derived from vigorous, moderate, and mild activities in the questionnaire. Low physical activity level was defined as < 494.65 kcal for men and < 283.50 kcal for women, corresponding to the lowest 20% of the total energy consumed in a population-based Korean survey of older adults from among the general population [4].

Total frailty scores (range: 0–5) were calculated by assigning a score of 1 to positive responses on each of the above five components. Participants with a score of 0 were classified as “robust”, a score of 1–2 as “prefrail”, and a score of 3–5 as “frail”.

Data quality assurance

The study procedures were carried out by two clinical research investigators at each of the 10 participating centers. The research investigators had been trained at Kyung Hee University Medical Center by KFACS staff members every year and had taken tests to ensure standardized quality. In addition, KFACS staff members visit the centers annually and monitor the investigators’ performance based on the protocol, manual, and examination guidebook created by the KFACS group.

All data obtained from the questionnaires were sent to Kyung Hee University Medical Center and managed by one medical record administrator.

Findings to date

Sub-cohorts

The KFACS is unique not only because it is a cohort study of community-dwelling older adults but also because it includes two sub-cohort studies a survey of social frailty and a nutrition survey.

The social frailty survey is a bimonthly telephone survey of a subgroup of the KFACS cohort who participated in the second round of the KFACS baseline survey in 2017. From September 2017 to February 2019, a total of 582 older adults provided additional informed consent to participate in the bimonthly telephone interviews. Among the 582 participants, 433

completed the seventh survey (74.4% follow-up). The variables in this survey included health-related events (i.e., restricted activity), healthcare utilization (i.e., hospitalization, emergency department visits, and medical expenses), disability (i.e., physical functioning and IADL activity), and frailty (Tilburg Frailty Indicator), and social relationships (social network and social participation).

To establish the nutritional sub-cohort, 1002 participants who gave informed consent were selected from among the KFACS participants in the first round considering the sampling criteria, i.e., the ratios of age and sex. The 24-h dietary recall method was used to assess dietary factors by home-visit personal interviews. In the nutritional survey, 1002 subjects from the first-round baseline (2016) KFACS cohort participated in 2016 – 2017, with 522 completing the 2-year follow-up survey conducted in 2018 – 2019.

Publications

Among the social factors, the risk of frailty increased significantly when the frequency of contact with friends decreased [26]. Nutritional status (especially anorexia) was shown to increase the risk of frailty [27], the average daily intake of nutrients (adjusted for sex and age) was shown to decrease significantly with increasing severity of frailty, and frail subjects had significantly lower levels of protein, vitamin E, vitamin C, and calcium intake than robust subjects and subjects in the pre-frail stage [28]. Frailty was associated with long sleep latency in elderly male subjects and with sleeping for more than 8 h in elderly female subjects [29]. Moreover, our previous study showed that moderate hearing loss was strongly associated with social frailty [30]. The prevalence of frailty was reported to increase with a daily sodium intake of > 3575 mg [31]. The self-administered health assessment tool, the EQ-VAS, was deemed appropriate as a frailty screening tool [32], and low calf circumference (< 32 cm) was shown to

be strongly related to cognitive frailty in men [33].

In the baseline study of 2016 – 2017, 2907 of 3014 individuals fulfilled all five components of Fried's frailty phenotype. The results indicated that 7.8% of the participants (n = 228) were frail, 47.0% (n = 1366) were pre-frail, and 45.2% (n = 1313) were robust (Table 4). The prevalence of frailty increased with age in both sexes; in the group aged 70 – 74 years, 1.8% of men and 3.7% of women were frail, whereas in the 80 – 84 years age group, 14.9% of men and 16.7% of women were frail. Women tended to exhibit a higher prevalence of frailty than men in all age groups (Table 4).

Table 4. Characteristics of participants of the KFACS baseline survey, 2016 – 2017 according to Fried's frailty phenotype (n = 2907). Participants were sorted into three age groups (70 –74, 75 – 79, and 80 – 84 years).

Variable	Total (n=2,907)	Male (n=1,383)	Female (n=1,524)	Male			*p*	Female			*p*
				70-74 (n=506)	75-79 (n=529)	80-84 (n=348)		70-74 (n=649)	75-79 (n=551)	80-84 (n=324)	
Frailty status according to Fried's phenotype, *n* (%)											
Robust	1313 (45.2)	695 (50.3)	618 (40.6)	308 (60.9)	278 (52.6)	109 (31.3)	< 0.001	318 (49.0)	223 (40.5)	77 (23.8)	< 0.001
Pre-frail	1366 (47.0)	590 (42.7)	776 (50.9)	189 (37.4)	214 (40.5)	187 (53.7)		307 (47.3)	276 (50.1)	193 (59.6)	
Frail	228 (7.8)	98 (7.1)	130 (8.5)	9 (1.8)	37 (7.0)	52 (14.9)		24 (3.7)	52 (9.4)	54 (16.7)	
Frailty phenotype, *n* (%)											
Unintentional weight loss (> 4.5 kg)	142 (4.9)	75 (5.4)	67 (4.4)	18 (3.6)	34 (6.4)	23 (6.6)	0.062	22 (3.4)	26 (4.7)	19 (5.9)	0.181
Low grip strength	602 (20.7)	283 (20.5)	319 (20.9)	53 (10.5)	92 (17.4)	138 (39.7)	< 0.001	85 (13.1)	119 (21.6)	115 (35.5)	< 0.001
Self-reported exhaustion	971 (33.4)	323 (23.4)	648 (42.5)	95 (18.8)	128 (24.2)	100 (28.7)	0.004	239 (36.8)	229 (41.6)	180 (55.6)	< 0.001
Slowness	625 (21.5)	297 (21.5)	328 (21.5)	67 (13.2)	101 (19.1)	129 (37.1)	< 0.001	75 (11.6)	124 (22.5)	129 (39.8)	< 0.001
Low physical activity	325 (11.2)	155 (11.2)	170 (11.2)	37 (7.3)	53 (10.0)	65 (18.7)	< 0.001	46 (7.1)	59 (10.7)	65 (20.1)	< 0.001

Strengths and limitations

The main strengths of the KFACS are 1) the inclusion of a nationwide population of community-dwelling Korean older adults; 2) a comprehensive scope of assessments, with the inclusion of physical examinations, health assessments, a neuropsychological battery for cognitive function, in-depth social function surveys, dental radiography, blood tests and banking, and most importantly, a diverse range of frailty and sarcopenia assessments; and 3) the inclusion of two sub-cohort studies i.e., a survey of social frailty involving bimonthly interviews and a nutrition survey involving home visits.

One weakness of the study is that the participants had to be ambulatory to visit the 10 centers in the baseline survey, and home-bound disabled or institutionalized persons could not participate. In addition, dementia patients with problems in communication were excluded. Second, the participants were not selected through probability sampling due to the strengthened data privacy laws that prevented researchers from acquiring the personal information of people living in the communities around the 10 centers. However, the distribution of sample characteristics (age, sex, education, place of residence) of KFACS participants was similar to the estimates of the older (70 – 84 years) population drawn from the national census.

Frailty is increasingly recognized as a major threat to healthy aging, and the KFACS is expected to be a valuable resource hub in identifying risk factors and building an evidence base for the prevention and management of frailty in community-dwelling older adults in Korea.

Collaboration

KFACS questionnaires, manuals, and guidelines used in the study are provided for

the purposes of policy and academic research upon request. All published articles and news articles using the KFACS database, data provision manuals, and contact information are available at the KFACS website (http://www.kfacs.kr). The KFACS cohort database and blood samples are available to researchers, and the authors anticipate collaboration even with foreign researchers, although approval from the Kyung Hee University Hospital IRB is required to share the dataset or banked blood samples for all the researchers.

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Contributors

The study protocol was designed by CWW, YL and JK, DC, SK, COK, MKK, BC, KMC, ER, HCJ, SJS, JHL, YSP, SGL, BJK, HJK, and MK contributed on conceptual design and obtained data. CWW, SL, YL, and MK drafted the manuscript and SL and KJL analyzed the data. All authors participated in revision of the manuscript, and approved the final version.

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Ethics Statement

The KFACS protocol was approved by the institutional review boards (IRBs) of the clinical research ethics committees of all 10 participating centers, including the coordinating center, Kyung Hee University Hospital, Seoul, Korea (IRB number: 2015-12-103). All

participants provided written informed consent. This report was exempted from approval by the IRB of the Clinical Research Ethics Committee of Kyung Hee University Hospital (IRB number: 2019-08-072).

Competing interests

None declared.

Data sharing statement

All published articles and news articles using the KFACS database, data provision manuals, and contact information are available at the KFACS website (http://www.kfacs.kr). The KFACS cohort database and blood samples are available to researchers, and the authors anticipate collaboration even with international researchers, although approval from the Kyung Hee University Hospital IRB is required to share the dataset or banked blood samples for all the researchers.

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Cohort Profile: Korean Frailty and Aging Cohort Study (KFACS)

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Title Page: Cohort Profile

Title: Cohort Profile: Korean Frailty and Aging Cohort Study (KFACS)

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Table 1. General characteristics of participants in the Korean Frailty and Aging Cohort Study (KFACS) baseline survey, 2016 – 2017. Participants were sorted into three age groups (70 –74, 75 – 79, and 80 – 84 years).

Table 2. Summary of variables collected from the Korean Frailty and Aging Cohort Study (KFACS) at baseline (2016-2017) and the first follow-up period (2019-2020)

Table 3. List of laboratory test variables collected during the Korean Frailty and Aging Cohort Study (KFACS) baseline survey (2016 – 2017)

Table 4. Characteristics of participants of the KFACS baseline survey, 2016 – 2017 according to Fried's frailty phenotype (n = 2907). Participants were sorted into three age groups (70 –74, 75 – 79, and 80 – 84 years).

Figure 1. Locations of the 10 centers involved in the Korean Frailty and Aging Cohort Study (KFACS) - (File type: PDF) is uploaded separately.

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Abstract

Purpose The purpose of the Korean Frailty and Aging Cohort Study (KFACS) is to initiate a nationwide, population-based prospective cohort study of older adults living in the community to assess their frailty status and explore transitions between frailty states over time in Korea.

Participants The KFACS is a multicenter longitudinal study with the baseline survey conducted from May 2016 to November 2017. Each center recruited participants using quota sampling stratified by age and sex. The number of participants recruited through 2 years of baseline study from 10 centers was 3014, with each site accounting for approximately 300 participants. The inclusion criteria were: having an age of 70 – 84 years, currently living in the community, having no plans to move out in the next 2 years, having no problems with communication, and no prior dementia diagnosis.

Findings to date To define physical frailty, the KFACS used a modified version of the Fried Frailty Phenotype (FFP) consisting of five components of frailty: unintended weight loss, weakness, self-reported exhaustion, slowness, and low physical activity. In the baseline study of 2016–2017, 2907 of 3014 individuals fulfilled all five components of Fried's frailty phenotype. The results indicated that 7.8% of the participants (n=228) were frail, 47.0% (n=1366) were pre-frail, and 45.2% (n=1313) were robust. The prevalence of frailty increased with age in both sexes; in the group aged 70–74 years, 1.8% of men and 3.7% of women were frail, whereas in the 80–84 years age group, 14.9% of men and 16.7% of women were frail. Women tended to exhibit a higher prevalence of frailty than men in all age groups.

Future plans The KFACS plans to identify outcomes and risk factors associated with frailty by conducting a 10-year cohort study, with a follow-up every 2 years, using 3014 baseline participants.

Key words: Frailty, cohort studies, aging, older adults, Republic of Korea

Strengths and limitations of this study

- The main strengths of the KFACS are the inclusion of a nationwide population of community-dwelling Korean older adults.
- The KFACS has a comprehensive scope of assessments, with the inclusion of physical examinations, health assessments, a neuropsychological battery for cognitive function, in-depth social function surveys, dental radiography, blood tests and banking, and most importantly, a diverse range of frailty and sarcopenia assessments.
- All the data are available and open to all researchers.
- The KFACS includes two sub-cohort studies i.e., a survey of social frailty involving bimonthly interviews and a nutrition survey involving home visits.
- One weakness of the study is that the participants had to be ambulatory to visit the 10 centers in the baseline survey, and home-bound disabled or institutionalized persons could not participate.

Introduction

The population of Korea is aging rapidly, with more than 14% of the total population in Korea consisting of people older than 65 years according to the 2018 Aged Population Report created by the Korean Statistical Information Service. The proportion of the aged in the population is projected to increase to 24.5% by 2030 and 41.0% by 2060 [1]. The percentage of

the population older than 75 years is estimated to reach 10.0% by 2030 and 25.9% by 2060, with the percentage of the population aged 85 years and older predicted to increase to 2.8% and 11.2% by these dates, respectively [1,2]. Aging of the population is accompanied by increased rates of multimorbidity along with increased need for social support, as well as increased burden on families and public health medical expenditure [3,4]. Many recent studies increasingly identify frailty as a major threat to healthy aging, as frailty prevalence increases with age [5-7]. An increasing proportion of community-dwelling older adults present frailty, a status of extreme vulnerability to endogenous and exogenous stressors exposing the individual to increased risk of negative health-related outcomes [5]. Therefore, it is becoming increasingly important to develop means of identifying frailty, which represents a transition phase between healthy aging and disability, as well as develop interventions to prevent adverse outcomes [7].

Although many Korean cohort studies on age-related health conditions for older adults have been reported, such as the Korean Longitudinal Study on Health and Aging (KLoSHA) [8], Korean Urban and Rural Elderly (KURE) cohort study [9], and Aging Study of Pyeongchang Rural Area (ASPRA) [10], none focused on frailty in older adults on a nationwide scale. With a focus on evidence-based diagnosis and management methods of frailty in community-dwelling older adults, the Korean Frailty and Aging Cohort Study (KFACS) was instigated with funding from the Ministry of Health and Welfare in December 2015 [6]. Because the KFACS will be the first study to examine frailty specifically in a cohort of Korean subjects, it has several important implications for older Korean adults. Firstly, the KFACS will provide the natural history of frailty in Korea, which has never been studied. Secondly, the KFACS was constructed with in-depth considerations of the demographic characteristics of Korean adults – one of the fastest growing aging populations in the world. The KFACS specifically takes into account the rapid

trend of increasing life expectancy and the corresponding increase in supportive care expenditures [11]. Moreover, several potential risk factors for frailty are also considered including: nutrition (older Korean adults have relatively poor nutritional statuses, specifically consuming lower levels of protein and calcium, and having higher sodium intakes) [12], physical function (sedentary lifestyle) [11], and social aspects (high poverty and depression rates, and low social activity and participation rates) [11, 13-14]. The purpose of KFACS is to initiate a nationwide, population-based prospective cohort study of older adults living in the community to assess their frailty status and explore transitions between frailty states over time. The specific aims of the study were to 1) identify risk factors involved in the transition between states of frailty and the development of adverse outcomes, such as disability, institutionalization, and mortality; 2) develop models for predicting the onset and progression of frailty; and 3) create an evidence base for developing clinical practice guidelines for the prevention and management of frailty in older adults [6].

Cohort description

The KFACS is a multicenter longitudinal study with the baseline survey conducted from May 2016 to November 2017. The participants were recruited from among community-dwelling residents in urban and rural areas nationwide in 10 study centers across different regions covering different residential locations (urban, suburban, and rural) —three from Seoul Metropolitan Area, two from Gyeonggi Province, and one from each of Gangwon Province, Chungcheong-buk Province, Jeolla-nam Province, Gyeongsang-nam Province, and Jeju Island in South Korea (Figure 1).

Each center recruited participants using quota sampling stratified by age (70 – 74, 75 –

79, and 80 – 84 years with a ratio of 6:5:4, respectively) and sex (male and female), with the aim of recruiting 1500 men and 1500 women. Participants were recruited from diverse settings (local senior welfare centers, community health centers, apartments, housing complexes, and outpatient clinics) to minimize selection bias. By reference, the prevalence of frailty among adults between 65 and 70 was 3.7% based on living profiles of older people survey in 2008 in Korea. The prevalence was 7.4%, 11.6%, and 15.4% on 70-74, 75-79, and 80-84, respectively [4]. Due to its relatively small number, and the suggestion from the frailty consensus, which states that all persons older than 70 years should be screened for frailty, we have set the starting age from 70 to 84 for this study [7]. Persons over 85 years of age were excluded for having relatively higher difficulty in their center visit and follow-up surveys. Additionally, the advanced age of participants over 85 has a higher probability of affecting the frailty statuses of these individuals, possibly hindering the identification of physical frailty-associated risk factors. We intentionally recruited relatively healthy community-dwelling older adults living in the community in this study by mostly recruiting participants who were able to visit the clinical sites. The inclusion criteria of KFACS participants were therefore: aged 70 – 84 years, currently living in the community, having no plans to move out in the next 2 years, and having no problems with communication and no prior dementia diagnosis. In this case, "move out" refers to relocating to areas outside the three neighboring towns above.

Of the 3014 participants, 1559 (51.7%) joined the study in 2016 and 1455 (48.3%) joined in 2017. The mean age was 76.0 years, and 1582 participants (52.5%) were female. Overall, 39.4% were aged 70–74 years, 37.4% were aged 75 – 79 years, and 23.2% were in their 80s. The baseline survey indicated that 28% of the subjects were urban residents, 42% were suburban residents, and 30% were residents of rural areas (Table 1). Other general characteristics

of the KFACS participants are shown in Table 1.

Patient and Public Involvement

This study was completed without participant involvement. The participants were not invited to contribute the development of the design, recruitment, questionnaires of the KFACS nor to have commitment to the results of this study. All participants were informed of the use of the data for research in this study. We have informed the participants of the main results of their blood, urine, Chest X-ray, DEXA, Electrocardiography, and cognitive function tests. We have plans to disseminate the results of the study: (a) develop the guidelines for the prevention and management of physical frailty based on the results from the KFACS data and disclose to the public, and (b) provide printed materials on the main results of the KFACS to the participants.

Table 1. General characteristics of participants in the Korean Frailty and Aging Cohort Study (KFACS) baseline survey, 2016 – 2017. Participants were sorted into three age groups (70 –74, 75 – 79, and 80 – 84 years).

Variable	Total	Male (n=1,432)			p-value	Female (n=1,582)			p-value
		70-74	75-79	80-84		70-74	75-79	80-84	
Total baseline study participants, *n* (%)	3014 (100)	521 (17.3)	552 (18.3)	359 (11.9)		668 (22.2)	574 (19)	340 (11.3)	
2016, *n* (%)	1559 (51.7)	267 (8.9)	280 (9.3)	187 (6.2)		338 (11.2)	297 (9.9)	190 (6.3)	
2017, *n* (%)	1455 (48.3)	254 (8.4)	272 (9)	172 (5.7)		330 (10.9)	277 (9.2)	150 (5)	
Demographics, *n* (%)									
Marital Status									
Single	4 (0.1)	2 (0.4)	0 (0.0)	1 (0.3)		1 (0.1)	0 (0.0)	0 (0.0)	
Married	2929 (97.3)	505 (97.1)	536 (97.3)	350 (97.5)	0.697	645 (96.6)	561 (97.7)	332 (97.9)	.520
Divorced/widowed	78 (2.6)	13 (2.5)	15 (2.7)	8 (2.2)		22 (3.3)	13 (2.3)	7 (2.1)	
Residence area									
Urban	827 (27.6)	137 (26.5)	146 (26.6)	106 (29.5)		186 (28)	160 (28.1)	92 (27.1)	
Suburban	1262 (42.1)	211 (40.8)	223 (40.6)	140 (39)	0.877	291 (43.8)	262 (46.0)	135 (39.8)	.224
Rural	909 (30.3)	169 (32.7)	180 (32.8)	113 (31.5)		187 (28.2)	148 (26.0)	112 (33.0)	
Education									
< Middle school	1452 (48.2)	150 (28.8)	169 (30.6)	127 (35.5)		383 (57.3)	365 (63.7)	258 (75.9)	
Middle and high school	1048 (34.8)	235 (21.1)	226 (17.6)	140 (12.3)	0.024	218 (16.2)	155 (11.9)	74 (10.9)	< 0.001
≥ College	512 (17.0)	136 (50.1)	157 (51.8)	91 (52.2)		67 (26.5)	53 (24.4)	8 (13.2)	
Receiving basic living subsidy, yes, *n* (%)	166 (5.5)	31 (6.0)	20 (3.6)	22 (6.1)	0.132	30 (4.5)	26 (4.5)	37 (10.9)	< 0.001
Receiving medical aid, yes, *n* (%)	45 (1.5)	4 (0.8)	6 (1.1)	4 (1.1)	0.829	9 (1.3)	11 (1.9)	11 (3.2)	0.124
Lifestyle characteristics									
Current drinker, *n* (%)	890 (41.2)	269 (56.8)	273 (54.7)	169 (52.6)	0.517	80 (19.7)	61 (21.4)	38 (21.6)	0.812
Current smoker, *n* (%)	174 (15.1)	61 (14.8)	56 (13.3)	41 (15.0)	0.775	2 (11.8)	4 (40.0)	10 (52.6)	0.034
Sleeping (h/day), mean (SD)	6.24 (1.47)	6.43 (1.39)	6.54 (1.31)	6.54 (1.50)	0.354	6.06 (1.47)	5.87 (1.50)	6.08 (1.54)	0.056
Physical activity (METS/week), mean (SD)	52.45 (63.58)	71.52 (85.37)	66.08 (68.75)	46.52 (54.89)	< 0.001	51.01 (59.48)	39.5 (43.72)	32.6 (46.61)	< 0.001
Body composition, mean (SD)									
Calf circumference (cm)	33.8(2.7)	35.2(2.2)	34.7(2.6)	33.7(2.7)	< 0.001	33.7(2.4)	32.6(2.5)	32.3(2.6)	< 0.001
Waist circumference (cm)	87.7(8.6)	88.9(8.1)	88.3 (8.7)	88.5(9.1)	0.530	86.4(8.0)	87.1(8.4)	87.4(9.4)	0.116
BMI (kg/m^2)	24.4(3.0)	24.2(2.8)	23.8(3.0)	23.7(3.0)	0.008	24.9(2.9)	24.9(3.1)	24.7(3.4)	0.687
Physical function									
Timed up-and-go (s), mean (SD)	10.5 (2.9)	9.5 (2.7)	10.4 (2.5)	11.1 (2.7)	< 0.001	9.9 (2.2)	10.8 (3.2)	12.5 (3.5)	< 0.001
ADL disability, *n* (%)	337 (11.2)	32 (6.1)	42 (7.6)	41 (11.4)	0.016	64 (9.6)	86 (15.0)	72 (21.2)	< 0.001
IADL disability, *n* (%)	1148 (38.1)	311 (59.7)	303 (54.9)	219 (61.0)	0.128	101 (15.1)	107 (18.6)	107 (31.5)	< 0.001
Fall experience, yes, *n* (%)	612 (20.3)	67 (12.9)	96 (17.4)	65 (18.1)	0.055	136 (20.4)	160 (27.9)	88 (25.9)	0.006
SPPB, mean (SD)	3.74 (1.28)	3.32 (0.83)	3.58 (1.43)	3.92 (1.14)	< 0.001	3.54 (0.87)	3.88 (1.28)	4.58 (1.84)	< 0.001
Grip strength (kg), mean (SD)	26.2 (7.6)	34.2 (5.6)	32.2 (5.8)	28.8 (5.4)	< 0.001	22 (4.0)	20.7 (4.1)	18.9 (3.9)	< 0.001

Gait speed (m/s), mean (SD)	1.1 (0.26)	1.21 (0.25)	1.16 (0.27)	1.04 (0.24)	< 0.001	1.14 (0.23)	1.05 (0.22)	0.92 (0.22)	< 0.001
Psychological function, mean (SD)									
Self-rated health (range: 0 – 100)	73.9(17.4)	77.7(14.5)	76.2(15.3)	72.4(16.4)	< 0.001	74.7(17.8)	71.8(18.6)	67.8(20.7)	< 0.001
GDS (range: 0 – 15)	3.3 (3.7)	2 (3.0)	2.5 (3.4)	3.1 (3.3)	< 0.001	3.4 (3.7)	4.1 (4.1)	4.9 (4.3)	< 0.001
EQ-5D (range: 0 – 1)	0.9 (0.1)	0.(0.1)	0.9 (0.1)	0.9 (0.1)	< 0.001	0.9 (0.1)	0.8 (0.1)	0.8 (0.2)	< 0.001
Cognitive function, mean (SD)									
MMSE-KC (range: 0 – 30)	25.5 (3.4)	26.8 (2.4)	26.1 (3.1)	25.3 (3.6)	< 0.001	25.9 (3.2)	24.8 (3.4)	23.3 (3.8)	< 0.001
Word list: memory (range: 0 – 30)	16.6 (4.4)	17.8 (3.7)	16.2 (4.0)	14.4 (4.2)	< 0.001	18.1 (4.1)	16.6 (4.5)	14.6 (4.7)	< 0.001
Word list: recall (range: 0 – 10)	5.5 (2.1)	6.1 (1.9)	5.3 (2.0)	4.6 (2.1)	< 0.001	6.1 (2.0)	5.3 (2.1)	4.5 (2.2)	< 0.001
Word list: recognition (range: 0 – 10)	8.5 (1.9)	8.9 (1.4)	8.5 (1.9)	8.2 (2.2)	< 0.001	8.9 (1.6)	8.4 (1.9)	8 (2.4)	< 0.001
FAB (range: 0 – 18)	13.4 (3.1)	14.6 (2.4)	14 (2.7)	13.3 (3.2)	< 0.001	13.4 (2.9)	12.7 (3.1)	11.4 (3.3)	< 0.001
Nutritional status, *n* (%)									
Normal	2519 (83.8)	450 (86.5)	457 (82.9)	297 (82.7)		576 (86.2)	464 (81.3)	275 (81.4)	
At risk of malnutrition	457 (15.2)	68 (13.1)	88 (16.0)	53 (14.8)	0.037	89 (13.3)	103 (18.0)	56 (16.6)	0.013
Malnutrition, yes, *n* (%)	31 (1.0)	2 (0.4)	6 (1.1)	9 (2.5)		3 (0.4)	4 (0.7)	7 (2.1)	
Social function, *n* (%)									
Social network type									
Contact with others more than once a week	2502 (83.0)	420 (80.6)	449 (81.3)	287 (79.9)	0.870	574 (85.9)	486 (84.7)	286 (84.1)	0.704
Attending religious gatherings at least once a month regularly	1272 (42.2)	161 (30.9)	177 (32.1)	126 (35.1)	0.513	355 (53.1)	289 (50.3)	164 (48.2)	0.521
Social capital									
Participating in more than two social gatherings	1632 (54.1)	273 (52.4)	265 (48.0)	172 (47.9)	0.272	423 (63.3)	327 (57.0)	172 (50.6)	< 0.001
Social support									
Receiving instrumental support	2212 (73.4)	380 (72.9)	408 (73.9)	261 (72.7)	0.903	496 (74.3)	424 (73.9)	243 (71.5)	0.621
Receiving informational support	2345 (77.8)	392 (75.2)	424 (76.8)	273 (76)	0.834	542 (81.1)	452 (78.7)	262 (77.1)	0.283
Receiving appraisal support	2351 (78.0)	392 (75.2)	433 (78.4)	271 (75.5)	0.402	540 (80.8)	455 (79.3)	260 (76.5)	0.269
Medical conditions, *n* (%)									
Hypertension	1746 (57.9)	263 (50.5)	302 (54.7)	211 (58.8)	0.108	369 (55.2)	354 (61.7)	247 (72.6)	< 0.001
Diabetes mellitus	663 (22)	117 (22.5)	136 (24.6)	86 (24.0)	0.722	126 (18.9)	116 (20.2)	82 (24.1)	0.136
Arthritis	761 (25.2)	62 (11.9)	77 (13.9)	56 (15.6)	0.439	205 (30.7)	220 (38.3)	141 (41.5)	0.007
Osteoporosis	483 (16.0)	8 (1.5)	22 (4.0)	19 (5.3)	0.004	158 (23.7)	172 (30.0)	104 (30.6)	0.001
Depression	87 (2.9)	5 (1.0)	15 (2.7)	8 (2.2)	0.112	21 (3.1)	26 (4.5)	12 (3.5)	0.427
Heart disease	251 (8.5)	53 (10.2)	61 (11.2)	38 (10.8)	0.874	31 (4.8)	36 (6.4)	32 (9.8)	0.010
Polypharmacy	891 (32.8)	174 (28.2)	148 (37.6)	86 (44.4)	< 0.001	231 (24.2)	175 (30.0)	77 (42.0)	< 0.001

Abbreviations: BMI = body mass index; ADL = Activities of Daily Living; IADL = Instrumental Activities of Daily Living; SPPB = Short Physical Performance Battery; GDS = Geriatric Depression Scale; EQ-5D = EuroQol five-dimension scale; MMSE = Mini-Mental State Examination; FAB = Frontal Assessment Battery. Nutritional status was rated using the Mini-Nutritional Assessment screening score (12 – 14 points, normal; 8 – 11 points, at risk of malnutrition; 0 – 7 points, malnutrition); polypharmacy indicates the use of five or more prescribed drugs.

There were no statistically significant differences between sexes except for the following variables: marriage status, whether the subject received instrumental support, whether the subject received a basic living subsidy, whether the subject received appraisal support, self-rated health, performance in word recall, performance in word recognition, weight loss status, low activity status, grip strength, and gait speed.

The prospective cohort design of the KFACS included data collection every 2 years. The first wave of baseline data collection started in 2016 – 2017, and the follow-up (2018 – 2019) has been currently finished. Follow-up surveys were conducted on a 2-year basis with 4 months of allowance limitations. The follow-up rate in 2018 was 92.5%, with 88.4% visiting the clinical sites, 11% involving telephone interviews, and approximately 0.5% involving home visits. The follow-up rate was 93.9% if we included findings such as entering nursing homes (four participants) or death (18 participants). The mean follow-up time range was 682.6 ± 34.4 days. Moreover, the follow-up rate in 2019 was 94.8%, with 91.1% visiting the clinical site, 8.5% participating telephone interview, and 0.2% comprising home visits. If we include findings on nursing home (one participant) or death (19 participants), the follow-up rate would be 96.2% in 2019. The mean follow-up time range was 705.1 ± 38.0 days. Strategies promoting recruitment and retainment included enlisting caregiver assistance, providing transportation for center visit, explaining key test results, informing participants of identified health issues, maintaining regular communication (phone calls, greeting cards for holidays, and birthday), and involving proxy respondents' answer.

Field work methods

All participants visited their corresponding study centers to conduct face-to-face interviews,

health examinations, and laboratory tests for the baseline survey. At follow-up, participants primarily visited their center, but we also conducted home visits, telephone interviews, and proxy interviews (in this order) if visiting the center was not possible.

Data collection and variables

Table 2. Summary of variables collected from the Korean Frailty and Aging Cohort Study (KFACS) at baseline (2016-2017) and the first follow-up period (2019-2020)

Variable	Baseline	Follow-up	Proxy interviews
Demographics			
Age, sex, education	✓	✓	
Marital status, family structure	✓	✓	✓
Work/employment	✓	✓	
Household income	✓	✓	✓
Living environment (rural, suburban, urban)	✓	✓	
Health behavior			
Smoking, alcohol drinking	✓	✓	✓
Sleep, physical activity (IPAQ)	✓	✓	✓
IPAQ environmental module	✓		
Oral hygiene, dental checkup	✓	✓	
Health checkup	✓	✓	
Nutritional risk (MNA)	✓	✓	✓
Eating behavior	✓	✓	
Food security	✓		
Short Nutritional Assessment Questionnaire (SNAQ)		✓	
Health Status			
Self-rated health (SF-12), comorbidity, polypharmacy	✓	✓	
Constipation		✓	
Quality of life (EQ-5D)	✓	✓	
EuroQol Visual Analogue Scale (EQ-VAS)	✓	✓	
Depressive symptoms (GDS-SF)	✓	✓	
K-ADL	✓	✓	
K-IADL	✓	✓	✓
Physical resilience		✓	
Experience of falls, recent injury, fear of falling	✓	✓	✓
Activities-specific Balance, Confidence scale (ABC)	✓	✓	
Oral health: mastication, pronunciation difficulties	✓	✓	
Women's health	✓		
Healthcare			
Outpatient visits, hospitalization, unmet needs	✓	✓	
Healthcare costs, long-term care services	✓	✓	

Health literacy	✓	✓	
Social function			
Social network: PANT	✓	✓	
Social capital: Participation in social activities	✓	✓	✓
Social support: ENRICHD	✓	✓	
Cognitive function (CERAD-K, FAB)			
Global cognition: MMSE	✓	✓	
Executive function: FAB	✓	✓	
Processing speed: Trail Making Test A	✓	✓	
Memory: word list memory, recall, recognition	✓	✓	
Attention: digit span forward/digit span backward	✓	✓	
Korean version of the Alzheimer's disease survey			✓
Anthropometry			
Body weight, height	✓	✓	✓
Body weight last year	✓	✓	✓
Head circumference, waist circumference	✓	✓	
Leg length	✓	✓	
Upper arm circumference, calf circumference	✓	✓	
Physical function			
Hand-grip strength	✓	✓	
4-m usual gait speed	✓	✓	
SPPB – item 3: standing balance, item 5: chair-stand time, usual gait speed, timed up-and-go test	✓	✓	
Health Assessments			
Vital signs: blood pressure, heart rate	✓	✓	
Visual acuity: Snellen chart (corrected vision)	✓	✓	
Hearing: pure tone audiometry (500, 1000, 2000, 3000, and 4000 Hz)	✓	✓	
Electrocardiogram	✓	✓	
Chest X-ray	✓	✓	
Body composition			
Dual Energy X-ray Absorptiometry (DEXA): KFCAS at eight medical centers (2016 – 2017)	✓	✓	
Ultrasound: muscle quality (Kyung Hee University only)	✓	✓	
Bioelectric Impedance Analysis (BIA): KFCAS at two medical centers	✓	✓	
Joint replacement (identifiable from DEXA images)		✓	
Panoramic radiography			
Periodontitis, upper and lower jaw bones (bone mineral density)	✓	✓	
Supernumerary, missing, and impacted teeth, etc.	✓	✓	
Frailty & Sarcopenia Assessment			

CHS (Fried phenotype): unintentional weight loss, hand grip strength, self-reported exhaustion, physical activity, gait speed	✓	✓	
KLoSHA frailty index: SPPB, K-IADL, K-ADL, MMSE, albumin	✓	✓	
FRAIL questionnaire: fatigue, resistance, ambulation, illness, loss of weight	✓	✓	✓
Korean Frailty Index: eight items (hospitalization, self-rated health, polypharmacy, weight loss, depressed mood, incontinence, TUG, hearing/vision impairment)	✓	✓	
Frailty scale: weakness, exhaustion, isolation	✓	✓	
SOF index: chair-stand, energy (GDS), loss of weight	✓	✓	
SARC-F: five items (strength, assistance with walking, rising from a chair, climbing stairs, falls)	✓	✓	

Abbreviations: IPAQ = International Physical Activity Questionnaire; MNA = Mini-Nutritional Assessment; K-ADL = Korean Activities of Daily Living; K-IADL = Korean Instrumental Activities of Daily Living; SF-12 = 12-item Short Form Survey; EQ-VAS = EuroQol Visual Analogue Scale; ABC = Activities-specific Balance, Confidence scale; PANT = Practitioner Assessment of Network Type; ENRICHD = Enhancing Recovery in Coronary Artery Disease; MMSE = Mini-Mental State Examination; FAB = Frontal Assessment Battery; SPPB = Short Physical Performance Battery; CHS = Cardiovascular Health Study; KLoSHA = Korean Longitudinal Study on Health and Aging; TUG = timed up-and-go; SOF = Study of Osteoporotic Fracture; GDS = Geriatric Depression Scale. Health literacy was assessed based on the capacity to obtain, process, understand, and use health information.

The variables of the KFACS questionnaires are listed in Table 2 and consisted of demographics, including socioeconomic status, living environment, lifestyle and health-related behaviors, the International Physical Activity Questionnaire (IPAQ) [15], the IPAQ environmental module (IPAQ-E) [16], dental checkup status, and nutritional status using the Korean version of the Mini-Nutritional Assessment (MNA) [17]. Health status was determined according to self-rated health conditions (SF-12) [18]. We used a pre-defined list of chronic health conditions, which are based on comorbidities according to Charlson's classification to collect self-reported and physician-diagnosed chronic diseases [19], medications, quality of life (EQ-5D) [20], and EuroQol Visual Analogue Scale (EQ-VAS) [21]. A 15-item Korean version

of the Short Form Geriatric Depression Scale (SGDS-K) [22], activities of daily living (ADL), instrumental activities of daily living (IADL) [23], falls and fear of falling, Activities-specific Balance, Confidence scale (ABC) [24], oral health, and women's health of the participants were scored, and the number of outpatient services, hospitalization rate, number of long-term care services, and health literacy were determined to measure health status. Social assessment included Practitioner Assessment of Network Type (PANT) [25], social participation and activities, and the Enhancing Recovery in Coronary Artery Disease (ENRICHD) Social Support Instrument [26-27]. For cognitive function, assessments were made using the Mini-Mental State Examination (MMSE); Trail Making Test A; word list memory, recall, and recognition; digit span [28] in the Consortium to Establish a Registry for Alzheimer's disease (CERAD) [29]; and Frontal Assessment Battery (FAB) [30]. We included anthropometric measurements of body weight, height, head circumference, waist circumference, leg length, and upper arm circumference. Physical function was assessed based on grip strength, gait speed, the Short Physical Performance Battery (SPPB), and timed up-and-go test. Health assessments, such as those for blood pressure, heart rate, visual acuity, and hearing (pure tone audiometry), as well as electrocardiograms and chest X-rays were carried out. To determine body composition, dual energy X-ray absorptiometry (DEXA) was performed at eight centers and bioelectrical impedance analysis (BIA) was performed at two centers. Panoramic radiography was carried out to assess dental status. Blood samples after an 8-h fast were taken at around 08:00 to ensure the reliability of hormone tests (Table 3). All blood and urine samples from the participants at 10 centers were brought to a commercial laboratory and used for the tests. An extra 10 ml of blood was collected from each participant and sent to Kyung Hee University Medical Center for storage in deep freezers.

Table 3. List of laboratory test variables collected during the Korean Frailty and Aging Cohort Study (KFACS) baseline survey (2016 – 2017)

2016 – 2017
Laboratory Tests (Taken at 08:00 after 8 h of fasting) • Hematology: CBC (WBC, RBC, Hb, HCT, MCV, MCHC, platelet) • Biochemistry: AST, ALT, GGT, total protein, albumin, total bilirubin, alkaline phosphatase, creatine kinase, BUN, creatinine, sodium, potassium, chloride, cystatin C, HBs Ag • Metabolic parameters: glucose (FBS), calcium, phosphorus (Pi), magnesium, HbA1c, total cholesterol, LDL-C, HDL-C, triglyceride, 25 (OH) vitamin D, vitamin B12 • Hormone and tumor markers: free T4, TSH, insulin, cortisol (S), free testosterone, **DHEA, IGF-1** • Inflammation markers: hs-CRP, **GDF-15** • Genetic and muscle: **myostatin,** AMPK (phenotype) • Urine test: urine 10 (stick), urine microscopic ※ Variables in bold text were added in 2017

Abbreviations: BUN = blood urea nitrogen; AST = aspartate aminotransferase test; ALT = alanine aminotransferase test; GGT = gamma-glutamyl transferase; HDL = high-density lipoprotein; LDL = low-density lipoprotein; Hb A1c = hemoglobin A1c; WBC = white blood cell; RBC = red blood cell; Hb = hemoglobin, HCT = hematocrit test; MCV = mean corpuscular volume; MCH = mean corpuscular hemoglobin; MCHC = mean corpuscular hemoglobin concentration; HBs Ag = hepatitis B virus surface antigen; TSH = thyroid-stimulating hormone; Hs-CRP = high-sensitivity C-reactive protein; IGF-1 = insulin-like growth factor 1; DHEA = dehydroepiandrosterone; GDF-15 = growth/differentiation factor 15.

Frailty assessment

To define physical frailty, the KFACS used a modified version of the Fried Frailty Phenotype (FFP) consisting of five components of frailty: unintended weight loss, weakness, self-reported exhaustion, slowness, and low physical activity [31].

- Unintentional weight loss: defined as a "yes" response to the question: "In the last year, have you lost more than 4.5 kg unintentionally?"

- Weakness: defined as the lower 20th percentile of grip strength (maximal grip strength

in kg after measuring twice for each hand using a hand grip dynamometer [T.K.K.5401; Takei Scientific Instruments Co, Ltd., Tokyo, Japan]) stratified by sex and BMI quartiles based on the KFACS baseline survey.

Men	Women
BMI ≤22…≤25.0 kg	BMI ≤23…≤16.8 kg
BMI 22.1–24…≤27.0 kg	BMI 23.1–25…≤17.7 kg
BMI 24.1–26…≤27.8 kg	BMI 25.1–27…≤17.8 kg
BMI >26…≤28.5 kg	BMI >27…≤17.7 kg

- Self-reported exhaustion: defined as a "yes" response to either of the following statements from the Center for Epidemiological Studies-Depression scale on 3 or more days per week: "I felt that everything I did was an effort" and "I could not get going."

- Slowness: Walking speed over 4 m was measured using an automatic timer (Gaitspeedometer; Dynamicphysiology, Daejeon, Korea), with acceleration and deceleration phases of 1.5 m. The mean values were selected after measuring twice. The lowest 20% of gait speed stratified by sex and height based on KFACS data was suggested as a cut-off.

Men	Women
Height ≤165 cm...≤ 0.93 m/s	Height ≤152 cm...≤ 0.85 m/s
Height >165 cm...≤ 0.98 m/s	Height >152 cm...≤ 0.93 m/s

- Low physical activity: energy expenditure estimates (kcal/week) were calculated using the IPAQ and metabolic equivalent scores were derived from vigorous, moderate, and mild activities in the questionnaire. Low physical activity level was defined as < 494.65 kcal for men and < 283.50 kcal for women, corresponding to the lowest 20% of

the total energy consumed in a population-based Korean survey of older adults from among the general population [4].

Total frailty scores (range: 0–5) were calculated by assigning a score of 1 to positive responses on each of the above five components. Participants with a score of 0 were classified as "robust", a score of 1–2 as "prefrail", and a score of 3–5 as "frail".

Sub-cohorts

The KFACS is unique because it is a cohort study of community-dwelling older adults, and it includes two sub-cohort studies: a survey of social frailty and a nutrition survey.

The social frailty survey is a bimonthly telephone survey of a subgroup within the KFACS cohort who participated in the second round of the 2017 KFACS baseline survey. From September 2017 to February 2019, 582 older adults provided additional informed consent to participate in the bimonthly telephone interviews. Among the 582 participants, 433 completed the seventh survey (74.4% follow-up). The variables in this survey included: health-related events (i.e., restricted activity), healthcare utilization (i.e., hospitalization, emergency room visits, and medical expenses), disability (i.e., physical functioning and IADL activity), and frailty (Tilburg Frailty Indicator), and social relationships (social network size and social activity participation). Through the KFACS social sub-cohort, we expect to identify social factors that determine and contribute to the physical frailty of older adults, and also to help more accurately define social frailty.

To establish the nutritional sub-cohort, 1002 participants who gave informed consent were selected from among the first round KFACS participants according to sampling criteria (i.e. the ratios of age and sex). The 24-h dietary recall method was used to assess dietary factors

during home-visit personal interviews. Of the 1002 subjects from the first-round baseline (2016) KFACS cohort who participated in 2016 – 2017, 522 participants completed the 2-year follow-up survey conducted in 2018 – 2019. Numerous studies have reported the effects of proper nutrition in older adults, which lowers the prevalence of frailty [32-33]. Including the nutrition sub-cohort will enable us to develop protein intake guidelines and nutritional intervention programs to prevent frailty, as one of the significant risk factors.

Data quality assurance

The study procedures were carried out by two clinical research investigators from each of the 10 centers, for a total of 20 clinical investigators who carried the study procedures. The research investigators had been trained at Kyung Hee University Medical Center by KFACS staff members every year and had taken tests to ensure standardized quality. In addition, KFACS staff members visit the centers annually and monitor the investigators' performance based on the protocol, manual, and examination guidebook created by the KFACS group.

All data obtained from the questionnaires were sent to Kyung Hee University Medical Center and managed by one medical record administrator.

Findings to date

In the baseline study (2016 – 2017) a total of 2907 out of 3014 individuals fulfilled all five components of Fried's frailty phenotype. The results indicated that 7.8% of the participants (n = 228) were frail, 47.0% (n = 1366) were pre-frail, and 45.2% (n = 1313) were robust (Table 4). The prevalence of frailty increased with age in both sexes; in the group aged 70 – 74 years, 1.8% of men and 3.7% of women were frail, whereas in the 80 – 84 years age group, 14.9% of men and 16.7% of women were frail. Women tended to exhibit a higher prevalence of frailty

than men in all age groups (Table 4).

Publications and findings using KFACS data

Among the social factors, the risk of frailty increased significantly when the frequency of contact with friends decreased [34]. Nutritional status (especially anorexia) was shown to increase the risk of frailty [35], the average daily intake of nutrients (adjusted for sex and age) was shown to decrease significantly with increasing severity of frailty, and frail subjects had significantly lower levels of protein, vitamin E, vitamin C, and calcium intake than robust subjects and subjects in the pre-frail stage [36]. Frailty was associated with long sleep latency in elderly male subjects and with sleeping for more than 8 h in elderly female subjects [37]. Moreover, our previous study showed that moderate hearing loss was strongly associated with social frailty [38]. The prevalence of frailty was reported to increase with a daily sodium intake of > 3575 mg [39]. The self-administered health assessment tool, the EQ-VAS, was deemed appropriate as a frailty screening tool [40], and low calf circumference (< 32 cm) was shown to be strongly related to cognitive frailty in men [41].

Brief analysis plans

Utilizing longitudinal KFACS data, both cross-sectional and longitudinal relationships between demographic characteristics, health behaviors, health statuses, and physical frailty will be characterized in a specifically Korean sample. In addition to identifying the risk factors and predictors of frailty by examining cohorts of community-dwelling older Korean adults on the national scale, we will provide the basis for developing future evaluation guidelines and screening tools for the prevention and management of physical frailty.

Table 4. Characteristics of participants of the KFACS baseline survey, 2016 – 2017 according to Fried's frailty phenotype (n = 2907). Participants were sorted into three age groups (70 –74, 75 – 79, and 80 – 84 years).

Variable	Total (n=2,907)	Male (n=1,383)	Female (n=1,524)	Male			*p*	Female			*p*
				70-74 (n=506)	75-79 (n=529)	80-84 (n=348)		70-74 (n=649)	75-79 (n=551)	80-84 (n=324)	
Frailty status according to Fried's phenotype, *n* (%)											
Robust	1313 (45.2)	695 (50.3)	618 (40.6)	308 (60.9)	278 (52.6)	109 (31.3)	< 0.001	318 (49.0)	223 (40.5)	77 (23.8)	< 0.001
Pre-frail	1366 (47.0)	590 (42.7)	776 (50.9)	189 (37.4)	214 (40.5)	187 (53.7)		307 (47.3)	276 (50.1)	193 (59.6)	
Frail	228 (7.8)	98 (7.1)	130 (8.5)	9 (1.8)	37 (7.0)	52 (14.9)		24 (3.7)	52 (9.4)	54 (16.7)	
Frailty phenotype, *n* (%)											
Unintentional weight loss (> 4.5 kg)	142 (4.9)	75 (5.4)	67 (4.4)	18 (3.6)	34 (6.4)	23 (6.6)	0.062	22 (3.4)	26 (4.7)	19 (5.9)	0.181
Low grip strength	602 (20.7)	283 (20.5)	319 (20.9)	53 (10.5)	92 (17.4)	138 (39.7)	< 0.001	85 (13.1)	119 (21.6)	115 (35.5)	< 0.001
Self-reported exhaustion	971 (33.4)	323 (23.4)	648 (42.5)	95 (18.8)	128 (24.2)	100 (28.7)	0.004	239 (36.8)	229 (41.6)	180 (55.6)	< 0.001
Slowness	625 (21.5)	297 (21.5)	328 (21.5)	67 (13.2)	101 (19.1)	129 (37.1)	< 0.001	75 (11.6)	124 (22.5)	129 (39.8)	< 0.001
Low physical activity	325 (11.2)	155 (11.2)	170 (11.2)	37 (7.3)	53 (10.0)	65 (18.7)	< 0.001	46 (7.1)	59 (10.7)	65 (20.1)	< 0.001

Strengths and limitations

The main strengths of the KFACS are 1) the inclusion of a nationwide population of community-dwelling Korean older adults; 2) the attainment of over 90% of follow-up rate both in 2018 (92.4%) and in 2019 (94.8%) of the baseline data collected in 2016-2017; 3) a comprehensive scope of assessments, with the inclusion of physical examinations, health assessments, a neuropsychological battery for cognitive function, in-depth social function surveys, dental radiography, blood tests and banking, and most importantly, a diverse range of frailty and sarcopenia assessments; and most importantly all the data are available and open to all researchers; and 4) the inclusion of two sub-cohort studies i.e., a survey of social frailty involving bimonthly interviews and a nutrition survey involving home visits.

One weakness of the study is that the participants had to be ambulatory to visit the 10 centers in the baseline survey, and home-bound disabled or institutionalized persons could not participate. In addition, dementia patients with problems in communication were excluded. Second, the participants were not selected through probability sampling due to the strengthened data privacy laws that prevented researchers from acquiring the personal information of people living in the communities around the 10 centers. However, the distribution of sample characteristics (age, sex, education, place of residence) of KFACS participants was similar to the estimates of the older (70 – 84 years) population drawn from the national census.

Collaboration

KFACS questionnaires, manuals, and guidelines used in the study are provided for the purposes of policy and academic research upon request. All published articles and news articles using the KFACS database, data provision manuals, and contact information are available at the KFACS website (http://www.kfacs.kr). The KFACS cohort database and blood samples are available to researchers, and the authors anticipate collaboration even with foreign researchers, although approval from the Kyung Hee University Hospital IRB is required to share the dataset or banked blood samples for all the researchers.

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Contributors

The study protocol was designed by CWW, YL and JK, DC, SK, COK, MKK, BC, KMC, ER, HCJ, SJS, JHL, YSP, SGL, BJK, HJK, JC, HG, and MK contributed on conceptual design and obtained data. CWW, SL, YL, and MK drafted the manuscript and SL and KJL analyzed the data. All authors participated in the revision of the manuscript, and approved the final version.

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Ethics Statement

The KFACS protocol was approved by the institutional review boards (IRBs) of the clinical research ethics committees of all 10 participating centers (Kyung Hee University, Seoul National University Hospital, Korea University Guro Hospital, Hallym University Medical Center – Chuncheon, Seoul National University Bundang Hospital, Ajou University Hospital, Gyeongsang National University Hospital, Chonnam National University Hospital, and Jeju National University Hospital), including the coordinating center, Kyung Hee University Hospital, Seoul, Korea (IRB number: 2015-12-103). All participants provided written informed consent. This report was exempted from approval by the IRB of the Clinical Research Ethics Committee of Kyung Hee University Hospital (IRB number: 2019-08-072).

Competing interests

None declared.

Data sharing statement

All published articles and news articles using the KFACS database, data provision manuals, and contact information are available at the KFACS website (http://www.kfacs.kr). The KFACS cohort database and blood samples are available to researchers, and the authors anticipate collaboration even with international researchers, although approval from the Kyung Hee University Hospital IRB is required to share the dataset or banked blood samples for all the researchers.

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