



TITLE:

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## Original Article

# Efficient and rapid assessment of multiple aspects of frailty using the Kyoto Frailty Scale, developed from the Edmonton Frail Scale

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**Abstract.** [Purpose] Global aging has led to a dramatic increase in the number of frail people, who are likely to become bedridden. Since frailty can be partially reversed, early intervention would be beneficial for patients, family members, and clinicians. This study was designed to develop a screening tool for an accurate and comprehensive assessment of frailty by modulating the Edmonton Frail Scale (EFS). [Participants and Methods] The EFS, covering multiple domains, is one of the major diagnostic tools for frailty. Frail and non-frail participants (n=67) were evaluated for each diagnostic item of the EFS to identify the most efficient combination of questions by evaluating its sensitivity and specificity. [Results] The Kyoto Frailty Scale (KFS) was developed as a rapid frailty scale, based on the EFS. The KFS comprises nine questions about health status, polypharmacy, hospitalization, living with a reliable caregiver, shopping, transportation, housework, money management, and forgetting to take medicine. The KFS has an excellent negative predictive value (100%) for screening frailty and a positive predictive value (97%) for screening prefrailty and frailty if we regard KFS  $\geq 4$  as a test positive. [Conclusion] The KFS permits clinician to rapidly and accurately screen for frailty and prefrailty, or exclude frailty.

**Key words:** Cognitive frailty, Edmonton Frail Scale, Self-reporting questionnaire

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## INTRODUCTION

Global aging reflects an increase in life expectancy; however, this has been accompanied by a dramatic increase in the number of frail people, most of whom are likely to become bedridden and to require nursing care<sup>1)</sup>. Frail elderly people are estimated to account for 17% of the world's population over 65 years of age, or about 120 million people worldwide<sup>2)</sup>. Frailty compromises their ability to cope with acute stressors due to decreasing physiological reserves and diminished organ system function<sup>3)</sup>, although frailty may be at least partially reversible<sup>4)</sup>. Early intervention for managing frailty can improve outcomes in terms of activities of daily living (ADL) and morbidity<sup>5, 6)</sup>.

At present, there are three major assessments to define frailty: 1) the Fried Cardiovascular Health Study (CHS) Index<sup>7)</sup> for physical frail phenotype, 2) the Rockwood Frailty Index (FI)<sup>8)</sup> to evaluate multimorbidity, 3) and the Edmonton Frailty Scale (EFS) or Tilburg Frailty Indicator, that evaluates physical condition, cognitive ability, and social interaction<sup>9–11)</sup>. The Fried CHS Index evaluates 5 factors: poor endurance or exhaustion, slowness, weakness, physical inactivity, and weight loss. Importantly, the Fried CHS Index does not assess cognitive ability. The Rockwood FI consists of 70 questions that evaluate multiple physical, cognitive, social, and medical characteristics, and is more time-consuming than the other assessments. The Edmonton frail scale (EFS), or reported EFS, is less time consuming; however, the EFS includes cognitive tests and a mobility test, in addition to a questionnaire<sup>9, 12)</sup>.

Ideally, a multiple-domain frailty screening tool needs to be simpler, faster, and to require fewer resources. We developed

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a screening tool for frailty based on the Edmonton frail scale (EFS), designated as the Kyoto Frailty Scale (KFS). The KFS is a self-reporting screening tool consisting of 9 questions to accurately assess non-frailty, prefrailty and frailty.

## PARTICIPANTS AND METHODS

All clinical data were collected at Kyoto University Hospital. This retrospective study was approved by the Kyoto University Graduate School and Faculty of Medicine Ethics Committee (Number R2603). Data from clinical interviews and physical examinations were collected for 67 elderly participants (30 males and 37 females; average age,  $82.1 \pm 7.0$  years) from the electronic medical database.

In order to develop the Kyoto Frailty Scale (KFS) we evaluated items comprising the Edmonton Frail Scale (EFS). The EFS is an effective diagnostic tool, comprising 10 domains for assessing cognitive ability (clock-drawing test), mobility (TUG test), and fundamental daily activity using a questionnaire in which a score  $\geq 7$  indicates frailty (range, 0–17)<sup>9</sup>. The EFS inquires about functional independence and investigates meal preparation, shopping, transportation, telephone use, housekeeping, laundry, money management, and medications. The TUG test measures the time required for a seated person to stand up, walk normally to a point 3 m away, and return to sitting on the chair<sup>13</sup>. In the EFS, the TUG test cutoff score is defined as follows: 0 points for  $<10$  seconds, 1 point for 10 to 20 seconds, and 2 points for  $>20$  seconds. Participants with difficulty walking automatically score 2 points on the EFS without taking the TUG<sup>9</sup>. The results of each questionnaire, including Yes/No questions, are converted into a score<sup>9</sup>. Similarly, the responses to questions about functional independence are also converted into scores.

We compared the results of each diagnostic item in the EFS between frail and non-frail participants using Student's t-tests. Statistical significance was set at  $p < 0.05$ . Pearson's correlation coefficient was also employed to determine relatedness of different characteristics. For the correlation coefficient,  $p < 0.01$  was considered significant. At first, several combinations for frailty screening were evaluated by their negative predictive value (NPV). After defining the screened items, candidate items for inclusion in the KFS were evaluated for sensitivity, specificity, positive predictive value, and NPV for a diagnosis of frailty<sup>14</sup>. Receiver operating characteristics (ROC) and the area under the ROC curve (AUC) were also evaluated.

## RESULTS

All 23 frail patients (8 males and 15 females), 26 prefrail patients (13 males and 13 females), and 18 non-frail patients (9 males and 9 females) in this study were scored for 21 parameters (Table 1). Of those parameters, 15 were significantly higher in frail participants than in non-frail controls ( $p < 0.05$ ): average age, TUG test score (sec), EFS score, clock-drawing test score, hospitalization, self-evaluated general health status score, shopping ability, transportation use, housework ability, laundry, money management ability, medication management, polypharmacy, self-reported mental status (Table 1), and TUG test scores.

Sixteen parameters were significantly correlated with EFS score ( $p < 0.01$ ): age, TUG test score (sec), clock-drawing test score, hospitalization, self-evaluated health status score, shopping ability, transportation use, telephone use, housework ability, laundry, money management ability, medication management, polypharmacy, forgetting to take medicine, BW loss, self reported mental status, and TUG test score. Eight items were significantly correlated with TUG test score ( $p < 0.01$ ): age, clock-drawing test score, transportation use, telephone use, housework ability, money management ability, forgetting to take medicine, and TUG test score (Table 1).

We also evaluated the correlation between clinical parameters (Fig. 1). First, we noticed significant correlations ( $p < 0.01$ ) between instrumental activity of daily living (IADL) items (meal preparation ability, shopping ability, transportation use, telephone use, housework ability, laundry, and money management ability) (Fig. 1). Moreover, self-evaluated health status score was correlated with polypharmacy ( $p < 0.01$ ). Forgetting to take medicine was correlated with transportation use, and money management ability ( $p < 0.01$ ).

First, we selected 9 items that are correlated with the EFS score as frailty parameters. Combinations of 8 or 9 of these items were designated as prototypes 8a, 8b, or 9a (Table 2). However, the NPVs of prototypes 8a, 8b, and 9a for frailty were 70%, 83%, or 78%, respectively (Table 2). Next, we selected 2 other items (hospitalization and living with reliable caregivers), which are relevant to social interactions. Then, we set up other combinations of 8 or 9 items from these eleven, which are designated as prototypes 8c, 9b, and 9c. NPVs for prototypes 8c, 9b, and 9c were 96%, 91%, and 100% (Table 2).

Based on these findings, we concluded that prototype 9c was the best combination to establish a rapid, self-reporting questionnaire: health status (self-evaluated general health status, and polypharmacy), social interaction (admission to hospital, and living with a reliable caregiver), physical condition (shopping ability and transportation use), and cognitive ability (housework ability, money management ability and forgetting to take medicine). We designated the combination of these nine parameters as the Kyoto Frailty Scale (KFS). KFS scores were highly correlated with those of the EFS ( $R = 0.87$ ,  $p = 0.000001$ ) (Fig. 2).

To assess its clinical efficacy, we evaluated the sensitivity, specificity, and positive or negative predictive value of frailty diagnosis using the KFS (Tables 3, 4). A binary classification test was performed between scores on the EFS and KFS. In this binary classification test, frailty was defined as an EFS score  $\geq 7$ , whereas an EFS score  $\geq 5$  designated either prefrailty or frailty.

**Table 1.** Clinical parameters associated with frailty

	All	Non-frail	Frail	T-test	Correlation	
	N=67	N=44	N=23	P value	EFS	TUG (sec)
Age (years)	82.04 ± 6.90	79.57 ± 5.95	86.78 ± 6.16	*<0.0001	*0.49	*0.40
TUG (s) n=62	13.04 ± 9.02	9.49 ± 2.18	20.49 ± 12.83	*0.001	*0.68	1
EFS (point)	6.21 ± 2.74	4.55 ± 1.32	9.39 ± 1.73	*<0.0001	1	*0.68
Clock-drawing test (point)	0.78 ± 0.73	0.48 ± 0.59	1.35 ± 0.65	*<0.0001	*0.62	*0.56
Hospitalization (point)	0.21 ± 0.45	0.07 ± 0.25	0.48 ± 0.59	*0.004	*0.32	0.19
Self-reported health status (point)	0.97 ± 0.58	0.82 ± 0.5	1.26 ± 0.62	*0.005	*0.35	0.2
Meal preparation ability (point)	0.52 ± 0.56	0.45 ± 0.55	0.65 ± 0.57	0.18	0.24	0.07
Shopping ability (point)	0.34 ± 0.48	0.16 ± 0.37	0.7 ± 0.47	*<0.0001	*0.49	0.3
Transportation use (point)	0.22 ± 0.42	0.07 ± 0.25	0.52 ± 0.51	*<0.0001	*0.64	*0.60
Telephone use (point)	0.16 ± 0.37	0.09 ± 0.29	0.3 ± 0.47	0.06	*0.35	*0.36
Housework ability (point)	0.37 ± 0.49	0.2 ± 0.41	0.7 ± 0.47	*0.0001	*0.53	*0.46
Laundry (point)	0.4 ± 0.49	0.3 ± 0.46	0.61 ± 0.5	*0.02	*0.34	0.24
Money management (point)	0.19 ± 0.4	0.09 ± 0.29	0.39 ± 0.5	*0.01	*0.49	*0.61
Medication management (point)	0.16 ± 0.37	0.07 ± 0.25	0.35 ± 0.49	*0.02	*0.44	0.16
Living with a reliable caregivers (point)	0.67 ± 0.81	0.64 ± 0.78	0.74 ± 0.86	0.64	0.12	-0.04
Polypharmacy (point)	0.72 ± 0.45	0.59 ± 0.5	0.96 ± 0.21	*<0.0001	*0.46	0.26
Forgetting to take medicine (point)	0.4 ± 0.49	0.34 ± 0.48	0.52 ± 0.51	0.17	*0.38	*0.37
BW loss (point)	0.18 ± 0.39	0.14 ± 0.35	0.26 ± 0.45	0.25	*0.32	0.3
Self-reported mental status (point)	0.27 ± 0.45	0.16 ± 0.37	0.48 ± 0.51	*0.01	*0.49	0.24
Incontinence (point)	0.34 ± 0.48	0.3 ± 0.46	0.43 ± 0.51	0.28	0.18	-0.08
TUG (point)	0.78 ± 0.71	0.45 ± 0.59	1.39 ± 0.5	*<0.0001	*0.73	*0.74
General Health (point)	1.69 ± 0.86	1.41 ± 0.82	2.22 ± 0.67	*<0.0001	*0.48	0.27
Social interaction (point)	0.88 ± 0.84	0.7 ± 0.79	1.22 ± 0.85	*0.02	0.29	0.06
Physical condition (point)	0.57 ± 0.8	0.23 ± 0.57	1.22 ± 0.8	*<0.0001	*0.63	*0.49
Cognitive ability (point)	0.97 ± 1.03	0.64 ± 0.87	1.61 ± 1.03	*0.0004	*0.63	*0.63
KFS (point)	4.1 ± 2.09	2.98 ± 1.28	6.26 ± 1.57	*<0.0001	*0.86	*0.62

TUG: Timed up and go test; EFS: Edmonton Frail Scale; BW: Body weight; KFS: Kyoto Frailty Screening-scale; Pearson: Pearson's correlation efficient.

An asterisk indicates significant difference (\*p<0.05).

An asterisk indicates significant correlation (\*p<0.01).

For screening frailty (EFS ≥7), the KFS had excellent sensitivity (100%) and good specificity (70%), if a positive score was set as KFS ≥4 (cutoff=3/4). The KFS had good sensitivity (83%) and good specificity (86%) at a cutoff of 4/5. The KFS had sensitivity (43%) and excellent specificity (100%) at a cutoff of 6/7 (Table 3). Moreover, KFS scores ≥10 points corresponds to a score ≥7 points in the EFS, which indicates frailty (Appendix).

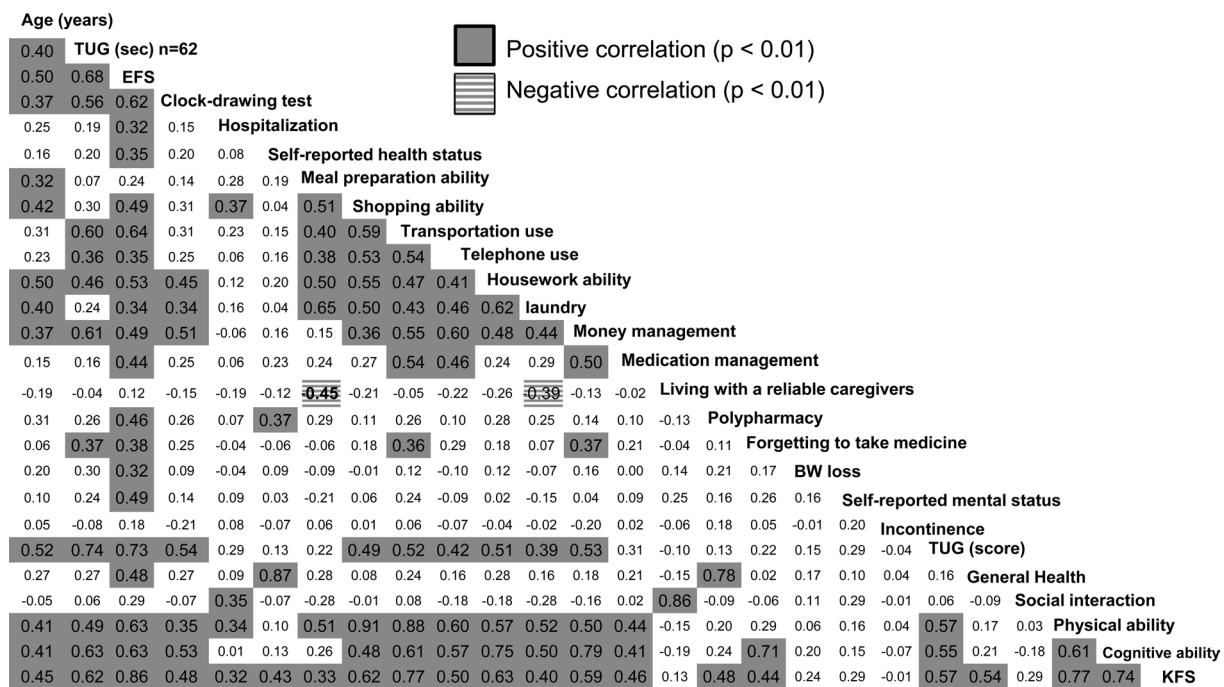
Next, regarding screening for prefrailty or frailty (EFS score ≥5), results of the test with various cutoffs are shown in Table 3. The KFS had good sensitivity (71%) and excellent specificity (94%) for screening prefrailty and frailty at a cutoff of 3/4. The KFS had sensitivity (51%) and excellent specificity (100%) at a cutoff of 4/5 (Table 4).

One hundred percent of participants with KFS scores <4 are non-frail (NPV=100%), and 97% of participants with KFS scores ≥4 are prefrail or frail (EFS ≥5) (PPV=97%). Therefore, we concluded that it is the best to set the cutoff for a positive test as KFS ≥4. Figure 3 and Table 3 demonstrate that the predictive accuracy of the KFS for frailty is high. The AUC was 0.95 for frailty and 0.85 for prefrailty or frailty (Fig. 3). The KFS questionnaire is presented in Appendix.

## DISCUSSION

Here we report development of the Kyoto Frailty Scale as an efficient, rapid assessment of frailty. Based on our observations of EFS scores among 67 elderly people, 9 questions were chosen to create the KFS as a simple, rapid assessment tool for frailty. The KFS effectively resolves non-frailty from pre-frailty and frailty.

Although three major diagnostic tools for frailty (the Fried CHS index, the Rockwood FI, and the EFS) are widely used, a rapid screening tool would be useful to reduce the burden on clinical workers and facilitate detection of imminent frailty.



**Fig. 1.** Correlation between clinical parameters related to frailty diagnosis. Positive and negative correlations are shown as grey and striped boxes, respectively. TUG: Timed up and go test; EFS: Edmonton Frail Scale; KFS: Kyoto frailty Scale. The KFS consists of 9 questions from the EFS.

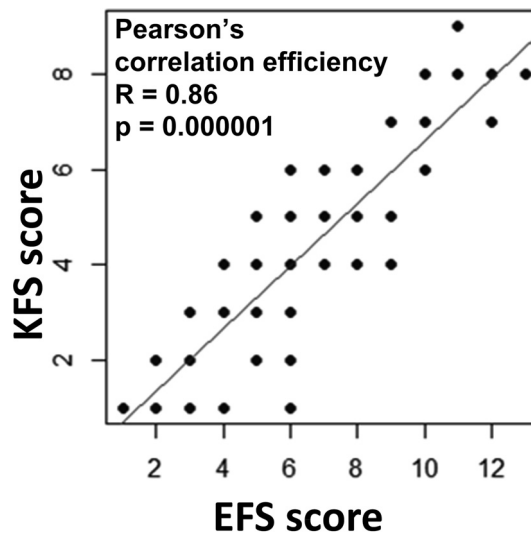
**Table 2.** Items comprising KFS prototypes and NPV results for frailty diagnosis

Frailty screening prototypes	Contents of prototypes													Factors	NPV(%) (cutoff 3/4)
	Hospital-ization	Self-reported health status	Shopping ability	Transportation use	House-work ability	Money manage-ment	Medication manage-ment	Living with a reliable caregivers	Poly-pharmacy	Forgetting to take medicine	Self-reported mental status				
Prototype 8a			○	○	○	○	○		○	○	○		Medical+Physical+Cognition	70	
Prototype 9a		○	○	○	○	○			○	○	○		Medical+Physical+Cognition	78	
Prototype 8b		○	○	○	○	○			○	○	○		Medical+Physical+Cognition	83	
Prototype 8c	○	○	○	○	○	○		○	○	○			Medical+Social+Physical+Cognition	96	
Prototype 9b	○	○	○	○	○	○		○	○	○	○		Medical+Social+Physical+Cognition	91	
Prototype 9c	○	○	○	○	○	○		○	○	○			Medical+Social+Physical+Cognition	100	

There are several questionnaire screening tools for frailty. However, some of these do not assess cognitive function<sup>15, 16)</sup> or social interaction<sup>17)</sup>.

By comparison, the EFS is a rapid diagnostic tool for frailty; however, it requires clock drawing and the TUG test<sup>9)</sup>. The reported EFS is a briefer form of the EFS<sup>12)</sup>; however, both tools require medical personnel. Furthermore, the EFS and the reported EFS require more than 5 minutes<sup>9, 10, 12)</sup>; however, the KFS requires only 2–3 minutes. Therefore, we developed the KFS, a rapid, multi-dimensional frailty screening tool comprising only 9 questions.

Unexpectedly, a combination of items selected on the basis of their correlation with the EFS was less efficient than the KFS (Table 2). Various other reports have evaluated the multicollinearity of diagnostic items using logistic regression or PCA<sup>10, 15, 18)</sup>. As the EFS includes multiple factors<sup>9, 19)</sup>, KFS was designed to include various attributes: general health, social,



**Fig. 2.** Correlation between the EFS and the KFS.

**Table 3.** The sensitivity, specificity, positive predictive value, and negative predictive value of the KFS for frailty

KFS	Sensitivity	Specificity	PPV	NPV
2/3	100%	32%	43%	100%
3/4	100%	70%	64%	100%
4/5	83%	86%	76%	90%
5/6	65%	98%	94%	84%
6/7	43%	100%	100%	77%

**Table 4.** The sensitivity, specificity, positive predictive value, and negative predictive value of the KFS for pre-frailty or frailty

KFS	Sensitivity	Specificity	PPV	NPV
2/3	90%	50%	83%	64%
3/4	71%	94%	97%	55%
4/5	51%	100%	100%	43%
5/6	33%	100%	100%	35%
6/7	20%	100%	100%	32%

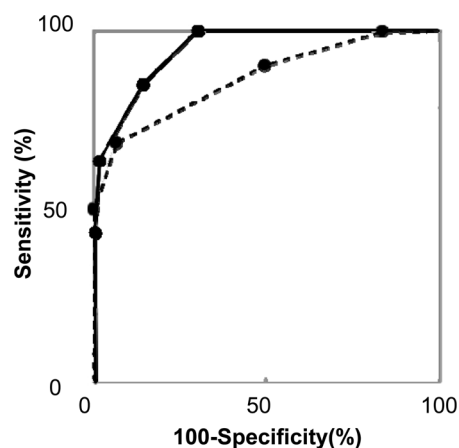
physical, and cognitive ability. Although other works evaluated the sensitivity and specificity for frailty<sup>10, 16, 18</sup>), this study evaluated sensitivity and specificity not only for frailty but also for prefrailty and frailty. As a result, we developed a rapid and accurate evaluation tool, which is expected to be effective in the clinical field.

The KFS has excellent specificity (100%) for screening frailty (KFS score  $\geq 7$ ). Most cases identified by the KFS were prefrail and frail (PPV=97%), if we defined positive of KFS as KFS  $\geq 4$ . A KFS score  $\geq 10$  points corresponds to a value on the EFS  $\geq 7$ , and indicates frailty.

Human resources are vital in clinical settings; hence, it is crucial to employ medical personnel as effectively as possible in diagnosing and managing frail patients. The KFS is a simple, rapid screening tool that enables reliable diagnosis of frailty in daily clinical practice. Moreover, it assesses not only physical frailty, but also cognitive, social, medical, and other aspects of frailty, all of which are also diagnosed by the EFS<sup>20, 21</sup>). Thus, the KFS is expected to decrease the burden of care for frail elderly by enabling early intervention.

### Funding

This study was supported by funding from Kyoto Prefecture, Japan.



### Receiver Operating Characteristic (ROC) curves

— Solid line, Diagnosis of frailty (EFS  $\geq 7$ ) by KFS

- - - Dashed line, Diagnosis of prefrailty and frailty (EFS  $\geq 5$ ) by KFS

**Fig. 3.** Diagnosis of frailty by the KFS.

A Receiver Operating Characteristic (ROC) curve for diagnosis by KFS of frailty (solid line), prefrailty, and frailty (dashed line).

### Conflicts of interest

The authors have no conflicts of interest to declare.

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## Appendix

Kyoto frailty scale (KFS) Questionnaire	0 pts	+1 pts	+2 pts
1, In general, how would you describe your health?	Good	Fair	Poor
2, Do you use five or more different prescription medications on a regular basis?	No	Yes	
3, In the past year, how many times have you been admitted to a hospital?	0	1–2	> 2
4, When you need help, can you count on someone who is willing and able to meet your needs?	Always	Sometimes	Never
5, Do you require help using transportation?	No	Yes	
6, Do you require help in shopping?	No	Yes	
7, Do you require help in managing money?	No	Yes	
8, At times, do you forget to take your prescription medications?	No	Yes	
9, Do you require help in housekeeping?	No	Yes	
Total		_pts	/12 pts

The KFS was developed from the Edmonton Frail Scale (EFS), which was reported by Rolfson DB et al. 2006.