ORIGINAL

The Kihon Checklist is a useful screening tool for predicting sarcopenia : A retrospective cross-sectional pilot study

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Abstract : Background : Early detection of sarcopenia is critical in countries with rapidly aging populations. In this study, we investigated the diagnostic accuracy of Kihon Checklist (KCL) in screening sarcopenia among older adults. Methods : This retrospective, cross-sectional study included 442 community-dwelling. A baseline questionnaire and KCL were administered to the participants, and their physical function and body composition were measured. Sarcopenia was defined according to Asian Working Group for Sarcopenia 2019 guidelines. Receiver operating characteristic (ROC) curve analysis was used to examine the diagnostic accuracy of KCL for sarcopenia. In addition, a novel approach using KCL along with patient age was considered. Results : Among the subjects (72.1% women ; average age, 76.7 years), 34 (7.6%) had sarcopenia. The ROC-based diagnostic accuracy for sarcopenia was as follows : Area under the ROC curve (AUC) = 0.805 (95% confidence interval [CI] = 0.735–0.874) for KCL, 0.865 (95% CI = 0.811–0.920) for KCL 5 items model, 0.892 (95% CI = 0.851–0.934) for KCL plus age, and 0.922 (95% CI = 0.886–0.957) for KCL 5 items model plus age. Conclusion : KCL showed good diagnostic accuracy as a screening tool for predicting sarcopenia, suggesting utility in population-based approaches for sarcopenia detection. J. Med. Invest. 72 : 272-280, August, 2025

Keywords **:** *aging, early detection, Kihon Checklist, sarcopenia, screening*

INTRODUCTION

Sarcopenia is a progressive, generalized skeletal muscle disorder characterized by the rapid loss of muscle mass and function and is associated with increased adverse outcomes such as falls, functional decline, frailty, and mortality (1). Early diagnosis and prevention of sarcopenia are particularly important in countries with rapidly aging populations such as Japan. Sarcopenia is typically diagnosed based on the diagnostic criteria established by the European Working Group on Sarcopenia in Older People 2 (EWGSOP2) and Asian Working Group for Sarcopenia 2019 (AWGS2019), which include three indices : grip strength, walking speed (or standing up five times), and skeletal muscle mass (SMI) (2, 3). EWGSOP2 and AWGS2019 recommend using 5-item SARC-F self-administered questionnaire to diagnose sarcopenia among older adults (2, 3). The questionnaire consists of questions related to strength, assistance in walking, rising from a chair, climbing stairs, and falls (4). The Japanese version of the SARC-F questionnaire was introduced in 2016 and its validity and reproducibility have already been confirmed (5, 6). However, the SARC-F demonstrates high specificity in detecting sarcopenia with low sensitivity, which may limit its utility as a standalone screening tool (7). To address this, researchers have improved the specificity, sensitivity, and diagnostic accuracy of the SARC-F by incorporating five additional questions and biometric information. For instance, SARC-F+EBM includes elderly (older adult) body mass index (EBM) and body mass index (BMI), whereas SARC-CalF includes calf circumference (CC). These modifications improved the accuracy of sarcopenia diagnosis by adding five questions and biometric information (8, 9). Although the SARC-F+EBM shows promise for screening sarcopenia, its applicability to the general elderly population remains limited because the researchers primarily targeted patients with musculoskeletal diseases scheduled for surgery while developing this questionnaire. Similarly, SARC-F+CC may produce false negatives in obese individuals, as their CC values may exceed the cutoff despite reduced muscle mass owing to fat tissue interference. Another tool, Mini Sarcopenia Risk Assessment (MSRA) questionnaire, was developed to assess the risk of sarcopenia in older adults (10). However, MSRA exhibits low specificity (approximately 50% for MSRA-5 and 60% for MSRA-7). This results in a high rate of false positives, which can increase the clinical burden by necessitating additional measurements. In Japan, the Kihon Checklist (KCL), a 25-item self-administered questionnaire addressing seven life-related domains, was developed to identify older Japanese adults at risk of requiring long-term care (11). Although its use is no longer mandatory, local governments in Japan continue to employ the KCL to determine the eligibility of high-risk older adults for participation in preventive care and intervention programs. In Japan, KCL is used on a daily basis and has attracted attention for its simplicity and versatility. Previous studies have not examined the effectiveness of the basic checklist in determining sarcopenia. Therefore, it is necessary to clarify whether it is possible to screen for sarcopenia using existing checklists without the use of special equipment.

The purpose of this study was to test the usefulness of the basic checklist in determining sarcopenia. We also examined whether adding an age factor to the KCL would improve the diagnostic accuracy of the sarcopenia screening tool. The results of this study aim to evaluate the possibility of screening for sarcopenia without additional cost by utilizing a basic checklist and to propose practical applications, and may contribute to maintaining and improving the health of the elderly.

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METHODS

Participants

This retrospective cross-sectional study was conducted between 2020–2022. The study site included a salt production facility in Wakasa, Mikata-Kaminaka-gun, Fukui Prefecture, Japan, where older adults gathered for sarcopenia screening. The study survey was conducted across 30 sites. We planned the health checkups, and Wakasa Town Hall sent out the public notice to the residents. Participation was on a voluntary basis. Among the 550 community-dwelling older surveyed, 108 participants with missing data values were excluded, and finally 442 participants (319 women and 123 men ; mean ± standard deviation [SD] age : 76.7±7.8 years) were included in the analysis. This study was approved by the University of Fukui Medical Research Ethics Review Committee (approval no. : 20190014). All researchers involved in this study complied with the Ethical Guidelines for Medical and Biological Research Involving Human Subjects (MEXT/MHLW/METI Notification No. March 1 23, 2021).

Research Design

To the best of our knowledge, this retrospective cross-sectional pilot study is the first exploratory investigation examining the effectiveness of KCL in determining sarcopenia.

Measurements

After obtaining written informed consent from all participants who agreed to participate in the study, the survey was conducted, which consisted of a baseline interview questionnaire, KCL, physical function measurements (walking speed, grip strength, and physical function), Height measurement, body composition measurements (weight, muscle mass, estimated bone mass, and body fat mass), and an explanation of the results. The baseline interview questionnaire developed for this study included questions regarding age, sex, medical history (diabetes, hypertension, dyslipidemia, and cardiac disease), and lifestyle (smoking and alcohol consumption). Walking speed was calculated by timing the participants as they walked 5 m at a normal speed without deceleration. Grip strength was assessed using a Takei III Smedley Type digital grip strength tester (TTM, Tsutsumi Co., Ltd.) for both the left and right sides, and the maximum value was recorded. The reference grip strength values were set at 28.0 and 18.0 kg for men and women, respectively. Body weight, muscle mass, fat mass, and bone mass were measured using body composition analyzers (MC-780A-N and MC-780A ; TANITA Co.), and SMI was calculated by dividing the limb muscle mass (kg) by the square of height (m^2). BMI, calculated as weight (kg) divided by height squared (m^2), was used to express the degree of obesity. Sarcopenia was diagnosed according to the AWGS2019 criteria (3). We also compared the diagnostic performance of sarcopenia using the KCL obtained in this study with the accuracy reported in the literature for other screening tools, including SARC-F, SARC-F+EBM, SARC-CalF, and MSRA (MSRA-5 and MSRA-7) (8-10). However, the validity of KCL superiority was limited because each tool was compared using data from different populations rather than through direct comparison within the same cohort. The KCL is a self-administered questionnaire in which 25 questions regarding living conditions and physical and mental functions are answered with 'yes' or 'no' responses (Table 1) (11). The questions are categorized into seven domains : daily living activities (five items : Items 1–5), physical function (five items : Items 6–10), nutritional status (two items : Items 11 and 12), oral function (three items : Items 13–15), social isolation (two items : Items 16 and 17), cognitive function (three items : Items 18–20), and depressive mood (five items : Items 21–25). In this study, one point was added to the score for each question if the participant faced problems in the corresponding domain (11). The KCL was translated from Japanese into English by two bilingual translators (12). KCL was assessed according to four patterns : KCL alone, KCL plus age, KCL plus KCL items associated with sarcopenia in the multivariate analysis, and KCL with KCL items associated with sarcopenia plus age in the multivariate analysis. MSRA assigns 5 points to individuals aged 70 years older or under (10), whereas SARC-F+EBM allocates 10 points to patients aged 75 years or older (8). In a study of community-dwelling older adults according to AWGS-2019 criteria, the risk of both sarcopenia and severe sarcopenia increases significantly with age (≥70) (13), with prevalence rising to approximately 20% among those aged 75–79 and over 30% in those aged 80 years and older (14). In elderly Chinese populations, the prevalence of muscle weakness (39.1%) and decline in physical function (46.4%) were significantly higher than muscle mass reduction (35.9%) in individuals aged ≥80 (15). The frequency of sarcopenia increases rapidly in people aged 80 and over (15). To account for this, age scoring in this study was stratified as follows : 5 points given to those aged 70–74 years, 10 points to those aged 75–79 years, and 15 points to participants aged 80 years and older.

Statistical analysis

Statistical analyses of the two groups (with and without sarcopenia) and receiver operating characteristics (ROC) were performed using the Easy R (EZR) version 1.61 software package (Saitama Medical Center, Jichi Medical University) (16). Bootstrap analysis was performed using the JMP version 17.2 software package. Age, walking speed, maximum grip strength, and SMI were expressed as mean ± SD. Nominal variables were presented as the number of targets and frequency (%) for each item. The two groups were compared using the Mann–Whitney *U* test for continuous variables and χ^2 test (including Yates' continuity correction) for nominal variables. To determine sarcopenia using KCL, we identified individual KCL items related to sarcopenia and selected the most suitable items for exploring sarcopenia using logistic regression analysis. Multivariate analysis (Binomial Logistic Regression Analysis) was performed to examine which KCL items were associated with sarcopenia. The presence or absence of sarcopenia was used as the dependent variable, while the KCL items that showed significant associations in univariate analyses were analyzed as independent variables. Lifestyle (smoking and alcohol consumption) and comorbidities (diabetes mellitus, dyslipidemia, hypertension, and cardiac disease) were included as adjustment variables in the regression analysis. The accuracy of the Binomial Logistic Regression Analysis model was determined using the area under the ROC curve (AUC) analysis. Sensitivity, specificity, and cutoff values for KCL-based sarcopenia screening were calculated. A simulation analysis with 95% confidence intervals (CIs) was performed using the bootstrap method to assess the reliability of AUC for the four KCL assessment methods. The bootstrap method is a nonparametric method that does not depend on data distribution, making it particularly suitable for low-prevalence conditions such as sarcopenia. From the original dataset (n=442), we resampled the data 1,0000 times while preserving the sample size. Each resampled dataset contained randomly selected observations from the original data, with some data selected multiple times and others not selected. The model was reconstructed for each resampled dataset, and the diagnostic accuracy indices and AUC were calculated for the four KCL screening tools. Statistical significance was set at $p < 0.05$.

Table 1. Kihon Checklist items along with their corresponding questions, answers and scores, and domains (11, 12)

Item	Questions	Answers (scores)	Domains
1	Do you go out by bus or train by yourself?	YES (0) NO (1)	
2	Do you go shopping to buy daily necessities by yourself?	YES (0) NO (1)	
3	Do you manage your own deposits and savings at the bank?	YES (0) NO (1)	Items 1–5 *Daily living activities*
4	Do you sometimes visit your friends?	YES (0) NO (1)	
5	Do your family or friends turn to you for advice?	YES (0) NO (1)	
6	Do you normally climb stairs without using handrail or wall for support?	YES (0) NO (1)	
7	Do you normally stand up from a chair without any aid?	YES (0) NO (1)	
8	Do you normally walk continuously for 15 minutes?	YES (0) NO (1)	Items 6–10 *Physical function*
9	Have you experienced a fall in the past year?	YES (1) NO (0)	
10	Do you have a fear of falling while walking?	YES (1) NO (0)	
11	Have you lost 2 kg or more in the past 6 months?	YES (1) NO (0)	Items 11, 12 *Nutritional status*
12	Height (in cm), weight : (in kg), BMI (in kg/m^2) BMI <18.5, this item is scored.	YES (1) NO (0)	
13	Do you face any recent difficulty in chewing tough foods compared to 6 months ago?	YES (1) NO (0)	
14	Have you choked on your tea or soup recently?	YES (1) NO (0)	Items 13–15 *Oral function*
15	Do you often experience having a dry mouth?	YES (1) NO (0)	
16	Do you go out at least once a week?	YES (0) NO (1)	Items 16, 17 *Social isolation*
17	Do you go out less frequently compared to last year?	YES (1) NO (0)	
18	Do your family or your friends point out your memory loss? e.g., “You ask the same question over and over again.”	YES (1) NO (0)	
19	Do you make a call by looking up phone numbers?	YES (0) NO (1)	Items 18–20 *Cognitive function*
20	Do you find yourself not knowing today’s date?	YES (1) NO (0)	
21	In the last 2 weeks, have you felt a lack of fulfillment in your daily life?	YES (1) NO (0)	
22	In the last 2 weeks, have you felt a lack of joy when doing the things you used to enjoy?	YES (1) NO (0)	
23	In the last 2 weeks, have you felt difficulty in doing what you could do easily before?	YES (1) NO (0)	Items 21–25 *Depressive mood*
24	In the last 2 weeks, have you felt helpless?	YES (1) NO (0)	
25	In the last 2 weeks, have you felt tired without a reason?	YES (1) NO (0)	

RESULTS

Comparison of participant characteristics (without and with sarcopenia)

Table 2 shows a comparison of the background characteristics between participants without sarcopenia (408, 92.3%) and those with sarcopenia (34, 7.6%). Significant differences were observed between the two groups in terms of age, walking speed, maximum grip strength, SMI, and KCL scores.

Univariate and multivariate analyses of KCL

Table 3 presents a comparison of the KCL responses between the participants with and without sarcopenia. Seventeen questions showed significant differences between the two groups : items 1–7, 10, 12, 13, 16, 18, 19, and 22–25. Binomial logistic regression analysis revealed five KCL items associated with sarcopenia : Daily living activities (KCL Item No.2 : odd's ratio (OR), 5.25 ; 95% CI, 1.100–25.000 ; p value, 0.037 and Item No.5 : OR, 4.40 ; 95% CI, 1.140–17.100 ; p value, 0.032), Physical function (KCL Item No.6 : OR, 3.12 ; 95% CI, 1.000–9.720 ; p value 0.049), Nutritional status (KCL Item No.12 : OR, 8.01 ; 95% CI, 2.180–29.400 ; p value, 0.001), and Oral function (KCL Item No.13 : OR, 4.10 ; 95% CI, 1.540–10.900 ; p value 0.004). The AUC for the binomial logistic regression model was 0.889 (95% CI, 0.833–0.945), indicating high accuracy.

Diagnostic accuracy of KCL in determining sarcopenia

Fig 1 shows the diagnostic accuracy of KCL alone (Item No.1 to 25) in determining sarcopenia, with an AUC of 0.805 (95% CI, 0.735–0.874), sensitivity of 70.6%, specificity of 79.2%, and cut-off value of 8. The AUC of KCL (Item No.1 to 25) plus age, which included the factor of age, was 0.892 (95% CI, 0.851–0.934), with a sensitivity and specificity of 88.2% and 78.7%, respectively. The cutoff value for sarcopenia in the KCL plus age group was 20. The AUC of KCL 5 items (Item No.2, 5, 6, 12, 13) model was 0.865 (95% CI, 0.811–0.920), with a sensitivity of 76.5% and specificity of 79.9% for the 5 answers that were significantly different between participants with and without sarcopenia. The cut-off value for sarcopenia in the KCL 5 items model was 2. The AUC of KCL 5 items (Item No.2, 5, 6, 12, 13) model plus age was 0.922 (95% CI, 0.886–0.957), with a sensitivity of 94.1% and specificity of 77.0% after including the factor of age. The cutoff value for sarcopenia in the KCL 5 items model plus age index was 16.

Diagnostic performance of KCL and other sarcopenia screening tools

Table 4 compares the accuracy of KCL model in this study with other screening tools reported in the literature, such as SARC-F, SARC-F+EBM, SARC-CalF, and MSRA (MSRA-7 and MSRA-5) (8-10), although a direct comparison between them was not possible. The AUC for KCL in this study was 0.805–0.922, indicating a high diagnostic accuracy, whereas the reported AUC for other screening tools at the time of validation ranged from 0.557–0.824 (8-10).

Comparison of CIs using ROC and bootstrap methods

Table 5 compares CIs from the ROC analysis and bootstrap method. The 95% CI for KCL alone (Item No.1 to 25) calculated using ROC analysis and bootstrap method were 0.735–0.874 and 0.727–0.868, respectively. The 95% CI for KCL 5 items (Item No.2, 5, 6, 12, 13) model via ROC analysis and bootstrap method were 0.811–0.920 and 0.806–0.915, respectively. Moreover, the 95% CI for KCL (Item No.1 to 25) plus age index determined using ROC analysis bootstrap method were 0.851–0.934 and 0.843–0.928, respectively, whereas the 95% CI for KCL 5 items (Item No.2, 5, 6, 12, 13) plus age index determined using ROC analysis and bootstrap method were 0.886–0.957 and

Table 2. Comparison of participant characteristics

	without and with sarcopenia			Gender differences		
	Without sarcopenia $n = 408$ (92.3%)	With sarcopenia $n = 34$ (7.6%)	p value	male $n = 123$	female $n = 319$	p value
Age (years)	75.8 ± 7.5	86.7 ± 4.0	< 0.001	75.9 ± 8.0	77.0 ± 7.7	0.185
Sex (male/female)	113/295	10/24	0.988	-	-	-
Lifestyle						
Alcohol consumption	110 (27.0)	6 (17.6)	0.326	76 (61.8)	40 (12.5)	< 0.001
Smoking	33 (8.1)	2 (5.9)	0.899	28 (22.8)	7 (2.2)	< 0.001
Disease						
Diabetes mellitus, *n* (%)	44 (10.8)	5 (14.7)	0.678	19 (15.4)	30 (9.4)	0.100
Hypertension, *n* (%)	212 (52.0)	18 (52.9)	1.000	68 (55.3)	162 (50.8)	0.458
Dyslipidemia, *n* (%)	147 (36.0)	8 (23.5)	0.200	38 (30.9)	117 (36.7)	0.303
Cardiac disease, *n* (%)	27 (6.6)	2 (5.9)	1.000	15 (12.2)	14 (4.4)	0.006
sarcopenia, *n* (%)	-	-	-	10 (8.1)	24 (7.5)	0.988
Anthropometry and physical functions						
Walking speed (m/s)	1.49 ± 0.39	0.85 ± 0.25	< 0.001	1.55 ± 0.44	1.40 ± 0.41	0.003
Maximum grip strength (kg)	28.2 ± 8.2	19.6 ± 4.3	< 0.001	37.3 ± 7.6	23.8 ± 4.8	< 0.001
Body composition analyzer						
SMI (kg/m^2)	6.71 ± 0.96	5.50 ± 0.72	< 0.001	7.60 ± 0.96	6.23 ± 0.70	< 0.001
Kihon Checklist (points)	3.0 ± 2.6	7.3 ± 3.2	< 0.001	5.3 ± 3.9	5.2 ± 3.9	0.719

Mean ± standard deviation, number of participants (% or unit).
BMI, body mass index ; SMI, skeletal muscle mass index.
Continuous variables : Mann–Whitney *U* test, nominal variables : χ^2 test (including Yates' continuity correction).

Table 3. Univariate and multivariate analyses of Kihon Checklist items (without and with sarcopenia)

Kihon Checklist	Univariate analysis			Multivariate analysis		
	Without sarcopenia n = 408 (92.3%)	With sarcopenia n = 34 (7.6%)	p value	OR	95% CI lower-upper	p value
Item No.1 (Answer : No)	79 (19.4)	18 (52.9)	< 0.001	1.84	0.593–5.720	0.291
Item No.2 (Answer : No)	22 (5.4)	14 (41.2)	< 0.001	5.25	1.100–25.000	0.037
Item No.3 (Answer : No)	23 (5.6)	11 (32.4)	< 0.001	1.08	0.241–4.840	0.920
Item No.4 (Answer : No)	53 (13.0)	15 (44.1)	< 0.001	0.74	0.1990–2.800	0.664
Item No.5 (Answer : No)	28 (6.9)	14 (41.2)	< 0.001	4.40	1.140–17.100	0.032
Item No.6 (Answer : No)	157 (38.5)	26 (76.5)	< 0.001	3.12	1.000–9.720	0.049
Item No.7 (Answer : No)	68 (16.7)	19 (55.9)	< 0.001	2.54	0.923–6.9700	0.071
Item No.10 (Answer : Yes)	201 (49.3)	25 (73.5)	0.011	0.84	0.304–2.340	0.745
Item No.12 (Answer : Yes)	30 (7.4)	8 (23.5)	0.005	8.01	2.180–29.400	0.001
Item No.13 (Answer : Yes)	100 (24.5)	18 (52.9)	0.001	4.10	1.540–10.900	0.004
Item No.16 (Answer : No)	32 (7.8)	7 (20.6)	0.022	0.76	0.190–3.100	0.710
Item No.18 (Answer : Yes)	52 (12.7)	10 (29.4)	0.015	1.14	0.355–3.650	0.828
Item No.19 (Answer : No)	12 (2.9)	5 (14.7)	0.003	3.34	0.565–19.800	0.183
Item No.22 (Answer : Yes)	52 (12.7)	10 (29.4)	0.015	0.63	0.176–2.280	0.485
Item No.23 (Answer : Yes)	159 (39.0)	20 (58.8)	0.037	0.79	0.271–2.320	0.674
Item No.24 (Answer : Yes)	67 (16.4)	13 (38.2)	0.003	1.55	0.541–4.460	0.413
Item No.25 (Answer : Yes)	123 (30.1)	17 (50.0)	0.028	1.75	0.633–4.820	0.281

Item number of question (%)
Eight items, including Item No.8 (Answer : No), 9 (Answer : Yes), 11 (Answer : Yes), 14 (Answer : Yes), 15 (Answer : Yes), 17 (Answer : Yes), 20 (Answer : Yes), 21 (Answer : Yes), and 21 (Answer : Yes), showed no significant differences between the groups ($p>0.05$).
Univariate analysis : χ^2 test (including Yates' continuity correction) ; Multivariate analysis : Binomial Logistic Regression Analysis
Lifestyle (smoking and alcohol consumption) and comorbidities (diabetes mellitus, Dyslipidemia, Hypertension, and Cardiac disease) revealed no significant differences in the adjustment variables ($p>0.05$).

Table 4. Diagnostic performance of Kihon Checklist and other sarcopenia screening tools

Authors	Screening tool	AUC	95% CI (lower–upper)	Sensitivity	Specificity
Barbosa-Silva, *et al*. (2016) (9)	SARC-F	0.592	0.445–0.739	33.3%	84.2%
	SARC+CalF	0.736	0.575–0.897	66.7%	82.9%
Kurita, *et al*. (2019) (8)	SARC-F	0.557	0.452–0.662	41.7%	68.5%
	SARC-F+older adult	0.663	0.561–0.765	63.9%	66.3%
	SARC-F+EBM	0.824	0.762–0.886	77.8%	69.6%
Rossi, *et al*. (2017) (10)	MSRA-7	0.786	0.725–0.847	80.4%	50.5%
	MSRA-5	0.789	0.728–0.851	80.4%	60.4%
Onishi *et al*. (present study ; 2024)	KCL	0.805	0.735–0.874	70.6%	79.2%
	KCL 5 items model	0.865	0.811–0.920	76.5%	79.9%
	KCL plus age	0.892	0.851–0.934	88.2%	78.7%
	KCL 5 items model plus age	0.922	0.886–0.957	94.1%	77.0%

KCL, Kihon Checklist ; MSRA, Mini Sarcopenia Risk Assessment ; CalF, calf circumference ; EBM, elderly (older adult) body mass index
AUC, area under the receiver operating characteristic (ROC) curve ; CI, confidence interval.
The KCL 5 items model consists of 5 items selected from the multivariate analysis of the presence or absence of sarcopenia (Item No. 2, 5, 6, 12, 13).

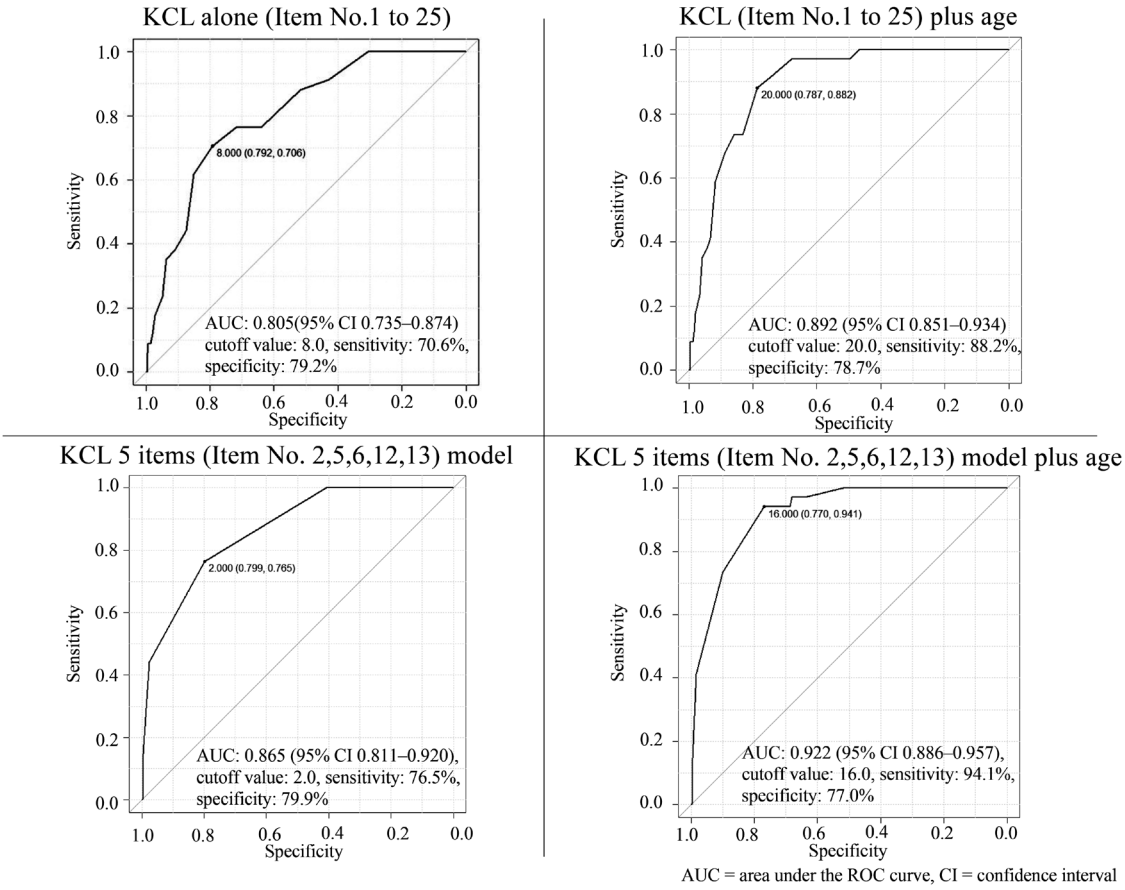

Figure 1. Diagnostic accuracy of KCL in determining sarcopenia
KCL alone (Item No.1 to 25) AUC : 0.805 (95% CI 0.735–0.874) cutoff value : 8.0 ; Sensitivity : 70.6%, Specificity : 79.2%
KCL (Item No.1 to 25) plus age AUC : 0.892 (95% CI 0.851–0.934) ; cutoff value : 20.0 ; Sensitivity : 88.2% ; Specificity : 78.7%
KCL 5 items (Item No. 2, 5, 6, 12, 13) model AUC : 0.865 (95% CI 0.811–0.920) ; cutoff value : 2.0 ; Sensitivity : 76.5% ; Specificity : 79.9%
KCL 5 items (Item No. 2, 5, 6, 12, 13) model plus age AUC : 0.922 (95% CI 0.886–0.957) ; cutoff value : 16.0 ; Sensitivity : 94.1% ; Specificity : 77.0%
AUC, area under the ROC curve ; CI, confidence interval

Table 5. Comparison of CIs using ROC and bootstrap methods

Index	ROC		Confidence intervals using bootstrap method
			10,000 times
	AUC	95% CI lower-upper	95% CI lower-upper
KCL	0.805	0.735–0.874	0.727–0.868
KCL 5 items model	0.865	0.811–0.920	0.806–0.915
KCL plus age	0.892	0.851–0.934	0.843–0.928
KCL 5 items model plus age	0.922	0.886–0.957	0.880–0.952

ROC, receiver operating characteristic ; AUC, area under the ROC curve ; CI, confidence interval.
ROC and bootstrap method were statistically analyzed using the Easy R (EZR) version 1.61 and JMP version 17.2 software packages, respectively.
The KCL 5 items model consists of 5 items selected from the multivariate analysis of the presence or absence of sarcopenia (Item No. 2, 5, 6, 12, 13).

0.880–0.952, respectively. The diagnostic accuracy of each indicator was good, although the CIs for bootstrapping were slightly higher.

DISCUSSION

In this study, we examined whether KCL could predict sarcopenia as a screening tool and found that the KCL demonstrated good diagnostic accuracy. We confirmed that the AUCs of the four indices tested (KCL, KCL plus age, KCL 5 items model, and KCL 5 items model plus age) showed good accuracy in bootstrap simulations. Notably, KCL 5 items plus age index, which integrates age into the KCL along with five KCL items model that are significantly associated with sarcopenia, exhibited the highest accuracy, with an AUC of ≥0.9 and sensitivity and specificity above 70%. Therefore, we highlighted its potential as a practical and reliable sarcopenia screening tool for statistical inference using the bootstrap method. Although not directly comparable with previously reported sarcopenia screening tools, the KCL showed promise as a tool for detecting sarcopenia in this pilot validation study. In this study, although the 25 items of the KCL are theoretically useful, reducing the number of items through multivariate analysis makes it easier to use in actual clinical settings, and it is expected to function as a useful tool for a greater number of elderly people. We believe that it is important in clinical practice that even a small number of items can still be used to make sufficiently effective predictions and that they can be used quickly. In addition, by simplifying the KCL, the burden on the person measuring it is reduced, and the advantage of being able to quickly evaluate it in local settings is born, which increases the possibility of providing early intervention to more elderly people. We believe that this approach is very important clinically. On the other hand, the items selected this time are limited, and further study is needed.

The KCL is a well-established tool for predicting frailty in older adults (17). Frailty is generally characterized by three or more of the following five symptoms : weight loss, exhaustion, reduced physical activity, decreased walking speed, and decreased muscle strength (18). At the core of the frailty cycle is sarcopenia, a condition involving the loss of muscle mass, strength, and function (19). According to the AWGS2019, sarcopenia is determined by grip strength (<28 kg for men and <18 kg for women), SMI (<7.0 kg/m^2 in men measured using Bioelectrical Impedance Analysis (BIA) and Dual Energy X-ray Absorptiometry (DXA), and 5.7 kg/m^2 (measured using BIA) or 5.4 kg/m^2 (DXA) in women), and walking speed (1.0 m/s) (3). Both the revised J-CHS criteria and AWGS2019 sarcopenia diagnostic criteria identify muscle weakness (decreased grip strength) and decreased walking speed as essential diagnostic markers for sarcopenia and frailty (3, 20). The SARC-F questionnaire assesses sarcopenia risk with questions such as "Have you lost 2 kg or more in the past 6 months?" The Japanese version of the revised J-CHS criteria includes a similar question to ascertain self-reported weight loss (4, 20). Both sarcopenia and frailty are characterized by core physical dysfunction (usually measured using objective tests of walking speed and muscle strength), which may contribute to or result from physical disability (21). KCL has been found to be useful in determining sarcopenia (8), as indicated by its ability to assess skeletal muscle mass in relation to daily life frailty, as per the SARC-F+EBM concept proposed by Kurita *et al*. (8). Older age corresponds to age-related muscle loss, whereas a low BMI indicates poor nutrition. To some extent, EBM functions as an additional indicator of muscle mass. KCL is more accurate than SARC-F in determining sarcopenia, because it assesses undernutrition based on two parameters : weight loss and BMI. Old age (75 years or older), lower BMI, and undernutrition increase the risk of both sarcopenia and severe sarcopenia, and are considered in the KCL assessment (13). MSRA questionnaire, similar to the SARC-F+EBM (8), has been designed based on a review of literature on the risk factors for muscle mass and muscle weakness (10). As with the KCL, it is considered more accurate than the SARC-F in diagnosing sarcopenia because of the inclusion of age and other risk factors for muscle mass.

Many KCL domains overlap with the elements of frailty (22). The total basic KCL score is significantly correlated with the frailty phenotype included in the CHS criteria and is useful for determining frailty (14). Frailty and sarcopenia are age-related conditions that share several clinical features and etiologies, making their overlap particularly relevant (23). Considering the usefulness of KCL in determining frailty and the similarities between frailty and sarcopenia, it can be inferred that KCL may also be effective in determining sarcopenia.

In the present analysis, an association was found between consultation with family and friends (Item No. 9) and sarcopenia. It has been suggested that the degree of social support primarily affects muscle mass rather than muscle strength or physical ability, which is negatively correlated with the risk of sarcopenia (24). Furthermore, social support has been found to be negatively correlated not only with sarcopenia but also with cognitive impairment (24, 25). These findings suggest that social support may prevent or slow the progression of sarcopenia, and that in addition to objective support, support strategies should include strengthening subjective support and promoting the use of support (24). A significant association between sarcopenia and family functioning has also been reported, with participants with sarcopenia having lower measures of family functioning than those without sarcopenia, regardless of gender (26). Social isolation and loneliness are significantly associated with sarcopenia, confirming that they interact synergistically (27).Based on these reports, an environment that allows consultation with family and friends may be a factor that aids in the prevention and progression of sarcopenia. In summary, the association between consultation with family and friends and sarcopenia shown in this study suggests that social support may influence the risk of sarcopenia and that it is important to enhance social support in future interventions and support strategies. In the subjects in the current study, there were no significant differences between the presence of sarcopenia and walking for about 15 minutes (Item No. 8) and the question of falls in one year (Item No. 9) were not significantly different. The reasons why no association was shown in this review could be due to the following. The effects of sarcopenia are often manifested in specific gait characteristics such as walking speed and stride length (28). Even if sarcopenia is present in the community resident, it is unlikely to be detected in general endurance indices such as 15-minute walking duration, and it may be possible to walk for more than 15 minutes if slowly. Self-reports of fall experiences have also shown that older adults often downplay past falls or fail to report them, perceiving them as "no big deal" (29, 30). Health-conscious older adults, in particular, are more likely to have decreased subjective risk perception of falls (29), resulting in an underestimation of the reported rate of fall experience (30). The subjects of this study were local residents, suggesting that they may have been influenced by health awareness.

We have planned further investigations and longitudinal studies to optimize KCL selection, which is expected to vary depending on region, generation, and race. At this stage, implementing the KCL plus age model as an early screening tool could be a valuable population-wide approach for governments and stakeholders. It has the potential to screen for sarcopenia, enable preventive programs and interventions to reduce the need for

long-term care, and mitigate health risks at the population level. The adoption of KCL could facilitate early intervention, prevent the progression of sarcopenia, and improve the quality of life of patients. However, further studies are required to refine the tool, standardize its application, and ensure its effective dissemination through education. The efficient and effective management of sarcopenia depends on these continued efforts.

This study had several limitations. First, it only validated the KCL and did not simultaneously compare it with the SARC-F and MSRA. The validity of KCL is limited because the sarcopenia tools were not directly compared within the same population and were based only on previously reported data. In the future, we plan to obtain and examine additional information simultaneously. Second, because this study was conducted in a geographically limited area, targeting the residents of Wakasa Town only, future studies should include participants from other regions. Third, the nature of this study, which was a backward-looking cross-sectional study, limited causal inferences and introduced potential bias. Fourth, we used a logistic regression model to examine the relationship between KCL and sarcopenia ; however, there are concerns regarding model robustness. This study included 34 patients with sarcopenia, and a large number of adjustment variables were incorporated into the multivariate model. Owing to the small number of events per variable, the risk of overfitting can exaggerate the apparent predictive accuracy of the model and impair its generalizability. We included various dependent and adjustment variables to broadly test our hypotheses. As this study confirmed only internal validity Instead, we employed the bootstrap method as an internal validation method to evaluate the diagnostic accuracy (31) and stability of the model, while minimizing the risk of over-fitting and maximizing the use of the entire dataset. Because split validation uses partial data, statistical accuracy may be compromised when sample sizes are small (32). examining external validity through longitudinal and multiregional studies is crucial to move closer to practical applications. In future research, conducting a longitudinal study and further examining the KCL items is necessary. Given that a prospective longitudinal design is better suited for validating screening tools, the relationship between sarcopenia and KCL scores should be explored in future prospective and longitudinal studies.

Despite the aforementioned limitations, we plan to proceed with the following considerations for future research : This study was a regionally limited survey of older adults in Wakasa Town, Fukui Prefecture, and the participant characteristics may not fully represent the entire elderly population in Japan. Therefore, comparative studies should be conducted with older adults in urban areas and other regions to further generalize the results. In addition to regional characteristics, considering health status and lifestyle is also essential. Although the small number of patients with sarcopenia in this study may have reduced the diagnostic accuracy, we aim to increase the number of subjects with sarcopenia and improve the reliability through large-scale studies in our future research. In addition, as the KCL has been translated into English, we believe that conducting research in cross-cultural environments would be pivotal for verifying whether the KCL is useful in determining sarcopenia in different cultural and healthcare contexts. This approach would strengthen its international applicability and ensure its broader relevance.

The basic checklist showed good diagnostic accuracy as a screening tool to predict sarcopenia. The five items selected from the 25 KCL items through multivariate analysis also exhibited high accuracy ; however, further research is required. KCL alone (AUC : 0.805, 95% CI : 0.735-0.874, cutoff value : 8 points, sensitivity : 70.6%, specificity : 79.2%) and KCL plus age, which took age into account (AUC 0.892, 95% CI lower-upper : 0.851–0.934, cutoff value : 20 points, sensitivity : 88.2.0%, specificity : 78.7%), performed well and showed improved diagnostic accuracy. Our findings suggest that the KCL is a useful tool for detecting sarcopenia at the population level.

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COMPETING INTERESTS

The authors declare no conflict of interest.

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AUTHOR CONTRIBUTIONS

O.Y. and H.O. contributed significantly to the conceptualization of the study ; H.O., Y.N., T.O., and O.Y. contributed significantly to data acquisition ; H.O. and O.Y. contributed significantly to data analysis and interpretation ; and H.O. and O.Y. contributed to manuscript preparation. All authors critically reviewed and revised the manuscript, and approved and submitted the final version.

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