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Predictive ability of the total score of the Kihon checklist for the incidence of functional disability in older Japanese adults: An 8-year prospective study

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Aim: To investigate the association between the total score of the Kihon checklist (t-KCL score) and functional disability over an 8-year follow-up period, and to examine whether the t-KCL score in the basic model with risk factors contributes to the incremental predictive ability for functional disability among older adults.

Methods: We followed 2209 older adults aged ≥65 years without functional disability at baseline. The t-KCL score was determined using a baseline survey questionnaire. Functional disability was defined based on information from long-term care certifications. The association between the t-KCL score and functional disability was examined using the Cox proportional hazards model. The incremental predictive ability of the t-KCL score for functional disability was evaluated by the difference of the C-statistic, category-free net reclassification improvement (NRI), and integrated discrimination improvement (IDI).

Results: The median follow-up period was 7.8 years, and 557 participants developed functional disability. The adjusted hazard ratio (95% confidence interval [CI]) of functional disability for a 1-point increase of the t-KCL score was 1.08 (1.06–1.10). Adding the t-KCL score to the basic model significantly improved the C-statistic (95% CI) from 0.747 (0.728–0.768) to 0.760 (0.741–0.781). When the t-KCL score was added to the basic model, the NRI and IDI were 0.187 (95% CI: 0.095–0.287) and 0.020 (95% CI: 0.012–0.027), respectively.

Conclusions: The t-KCL score had an independent positive association with functional disability over an 8-year follow-up. Furthermore, adding the t-KCL score to the basic model improved the predictive ability for functional disability. **Geriatr Gerontol Int 2022; 22: 723–729**.

Keywords: functional disability, Kihon checklist, long-term care needs, older adults, prospective study.

Introduction

The Kihon checklist (KCL) was developed by the Japanese Ministry of Health, Labour and Welfare as a comprehensive scale to identify older adults at risk of functional disability in the near future.[1] Previous prospective studies reported that a higher total score on the Kihon checklist (t-KCL score) and subtotal scores in each domain of the KCL were associated with a higher risk of functional disability.[2–8] In particular, the t-KCL score was reported to be useful as a comprehensive scale predicting functional disability.[7]

Previous studies reported a positive association between the t-KCL score and a future functional disability.[2–8] However, the relatively short follow-up periods (1–3 years) in these studies may have led to an overestimation of the association or raised concerns of reverse causality. In addition, it is unclear whether the t-KCL score is a useful risk prediction scale for functional disability over a longer follow-up period. Such a finding would be informative for the early prevention of functional disability.

Previous studies reported the predictive ability of a crude model including only the KCL for functional disability (C-statistic range: 0.62–0.83).[5,7] They have also reported that the t-KCL score (25 items), which holds more information, shows higher predictive ability than the sub-total KCL score (20 items – excluding the five mood items in nos 21–25), which shows higher predictive than all

the subdomains of the KCL.[5,7] However, these studies did not examine the incremental predictive ability of the t-KCL score in combination with common risk factors for functional disability, making it challenging to clearly define the predictive ability of the t-KCL score as a marker for functional disability. Therefore, it is unclear whether the t-KCL score is more informative than other risk factors and improves the predictive ability for functional disability. Accordingly, there is a need to investigate whether the t-KCL score is a useful independent scale predicting functional disability before it incidences with a longer follow-up period.

The aims of this study were to investigate the association between the t-KCL score and functional disability among older adults over an 8-year follow-up period, and to examine whether adding the t-KCL score to the model consisting of common risk factors contributes to an incremental predictive ability for functional disability.

Methods

Study design and population

The data for this study were taken from the Sasaguri Genkimon Study (SGS), a prospective study to explore the factors associated with functional disability among community-dwelling older adults in Sasaguri town, Fukuoka, Japan. Information on the design and recruiting methods of the SGS is given elsewhere.[9–12] In January 2011, 4979 older people aged ≥65 years who were not certified as needing long-term care by the long-term care insurance (LTCI) system were included in the SGS. Of these subjects, 4913 were recruited to participate in our study, excluding residents who had died or had moved out of town when the study began ($n = 66$), and 2629 consented to participate. In addition, 420 subjects were excluded from the study for the following reasons: they (i) were certified as needing long-term care before the date of the baseline survey, conducted from May to August 2011 ($n = 9$); (ii) had self-reported with dementia or Parkinson's disease ($n = 15$); (iii) had not provided KCL data ($n = 332$); or (iv) had not provided other covariate data ($n = 64$). The final sample comprised 2209 older adults. The subjects were followed up from the date of the baseline survey until they were certified as needing long-term care, died, or were lost to follow-up due to moving out of town, or until March 31, 2019, whichever was earlier. This information was obtained from the resident registration system of the Sasaguri municipal government office.

All subjects provided written informed consent. This study was conducted in accordance with the Declaration of Helsinki and was approved by the Institutional Review Board of Fukuoka Institute of Technology.

Exposure data (t-KCL score)

The t-KCL score was obtained during the baseline survey using a self-report questionnaire. The KCL is a comprehensive geriatric scale that consists of 24 binary (i.e., yes or no) questions and the body mass index (BMI) calculated using self-reported height and weight (Appendix I). It is divided into multiple domains of instrumental activities of daily living, social activities of daily living, physical function, nutrition, oral function, outdoor activities, memory, and mood.[1,13] When an adverse condition is answered for each question, 1 point is added to the t-KCL score.[7] A BMI of <18.5 kg/m^2 is considered an adverse condition, and 1 point is added to the t-KCL score. The t-KCL score is scored on a scale of 0–25 points.

Outcome measures

Functional disability was obtained from the nationally uniform database of the LTCI system, which the Sasaguri municipal government office provided. Certification for needing long-term care is available for all Japanese older adults aged ≥65 years and is based on a standardized assessment of physical and mental functions.[14,15]

After receiving a request from an older adult or their caregivers, the municipality sends trained staff to their home to conduct a standardized assessment of their physical and mental functions. The computer system scores the conditions of physical and mental functions based on information from home visit surveys and physician evaluations and estimates the time required for care. The local Certification Committee of Needed Long-Term Care consists of experts deciding whether to certify older adults requiring long-term care based on this information. If certified, the level of care needed is assigned at seven levels (support level, 1–2; care level, 1–5). Functional disability was determined as the assignment of the first level of long-term care (support level 1) or higher.[12,16]

Covariates

Information on sex and age was obtained from the resident registration system. The covariate data at baseline were selected based on previous studies and collected using questionnaires: living alone (yes or no), number of years of education, economic status (comfortable, relatively comfortable, relatively uncomfortable, or uncomfortable), drinking (current drinker or not), and smoking (current smoker or not).[12,13] Multimorbidity was defined as the presence of ≥2 of 13 chronic diseases (hypertension, stroke, heart disease, diabetes mellitus, hyperlipidemia, respiratory disease, digestive disease, kidney disease, osteoarthritis or rheumatism, trauma fracture, cancer, ear disease, and eye disease) and was obtained by self-report.[12]

Statistical analysis

Baseline characteristics were described using means (standard deviation [SD]), medians (IQR), or proportions across the t-KCL score quartiles (quartile 1: 0–2 points; quartile 2: 3–4 points; quartile 3: 5–7 points; quartile 4: >8 points). The Jonckheere–Terpstra trend test for continuous variables and the Cochran–Armitage trend test for categorical variables were used for trend tests across the t-KCL score quartiles.

The Kaplan–Meier estimation was used to plot the cumulative incidence of functional disability across the t-KCL score quartiles. The Cox proportional hazard model was used to calculate the hazard ratio (HR) and 95% confidence interval (CI) of functional disability for a 1-point increase of the t-KCL score as a continuous variable. Model 1 was adjusted for sex and age. Model 2 was additionally adjusted for living alone, education, economic status, drinking, smoking, and multimorbidity. The HRs and 95% CIs of functional disability across the t-KCL score quartiles were also estimated using Cox proportional hazard models. Spearman's rank correlation coefficients were calculated for each risk factor to confirm multicollinearity, but no risk factor demonstrated an extremely high correlation coefficient. The interactions of sex and age with the t-KCL score were confirmed to examine the effect of modification by sex or age.

The predictive ability of the t-KCL score for functional disability was examined by comparing the basic model (sex, age, living alone, education, economic status, drinking, smoking, and multimorbidity) with the fully adjusted model including the t-KCL score as a continuous variable added to the basic model. We compared the C-statistic between the basic model and the fully adjusted model,[17] and calculated the category-free net reclassification improvement (NRI) and absolute integrated discrimination improvement (IDI) by adding the t-KCL score to the basic model. We used published macros to check statistical significance according to the standard error of the difference in the C-statistic estimated on 1000 bootstrap samples.[18] The NRI and IDI are useful as indexes evaluating the incremental predictive ability of the adding factors, and are recommended to be used as supplements to the C-statistic.[19–21] When calculating the probability of functional disability for each model, the maximum follow-up period of 7.9 years was truncated. The 95% CIs were calculated using the bootstrap method with 1000 repetitions.

In studies of older populations, if the analysis is performed using the Cox proportional hazard model with death before the event as censoring, overestimating the risk of the targeted event has been reported.[22] A sensitivity analysis considering death as a competing risk was carried out using the Fine and Gray extension model.[23] Moreover, a sensitivity analysis was performed that excluded 179 subjects who were certified as needing long-term care during the initial 2 years of follow-up. A two-tailed *P*-value of <0.05 was considered statistically significant. All statistical analyses were performed using SAS, version 9.4 (SAS Institute, Inc., Cary, NC, USA).

Results

The mean age of the participants was 73.0 (SD: 5.9) years, and 54.5% of them were women. The median t-KCL score was 4 (IQR: 2–7) points. Table 1 shows the participants' baseline characteristics by t-KCL score quartiles. Participants with higher t-KCL scores were older and more frequently had less education, uncomfortable economic status, a lower likelihood of drinking, and multimorbidity.

The median follow-up period was 7.80 (IQR: 5.69–7.85) years, and 557 (25.2%) participants developed functional disability, 161 (7.3%) died before the functional disability occurred, and 71 (3.2%) moved out of the town. Cumulative incidence curves for the risk of functional disability differed significantly between the t-KCL score quartiles, with significant differences in all quartile comparisons except for the quartile 2 and quartile 3 pairs (Fig. 1).

Table 2 shows the associations between the t-KCL score and functional disability. In the fully adjusted model, the HR (95% CI) of functional disability for a 1-point increase of the t-KCL score was 1.08 (1.06–1.10). The multivariable-adjusted HRs (95% CIs) of the higher quartiles compared with the lowest were 1.19 (0.90–1.58), 1.43 (1.11–1.85) and 2.19 (1.72–2.80) in model 1, and 1.20 (0.90–1.59), 1.43 (1.10–1.85) and 2.11 (1.63–2.72) in model 2 (both *P* for trend <0.001).

The association between the t-KCL score and functional disability did not interact with age. Although heterogeneity in the association was observed between sexes (*P* for interaction <0.05), there was no difference in the direction of the estimates between sexes. The HRs (95% CIs) of the higher quartiles compared with lowest were 1.33 (0.86–2.05), 1.51 (0.99–2.29) and 2.85 (1.91–4.26) among men (*P* for trend <0.001), and 1.15 (0.79–1.66), 1.39 (0.997–1.95) and 1.85 (1.32–2.57) among women (*P* for trend <0.001).

Table 3 shows that the C-statistic of the fully adjusted model was significantly higher than that of the basic model (0.760 [95% CI: 0.741–0.781] vs. 0.747 [95% CI: 0.728–0.768], respectively;

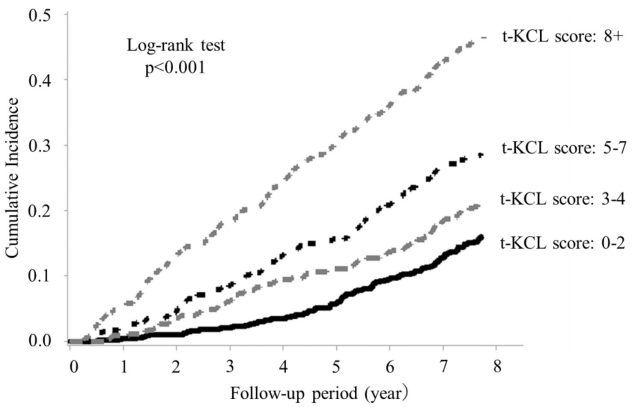

Figure 1 Cumulative incidence for the functional disability by the quartiles of the t-KCL score. Cumulative incidence curves for the risk of functional disability differed significantly between the t-KCL score quartiles, with significant differences in all quartile comparisons except for the quartile 2 and quartile 3 pairs.

Table 1 Baseline characteristics across the t-KCL score quartiles ($n = 2209$)

	Overall ($n = 2209$)		Quartile 1 (low) ($n = 697$)		Quartile 2 ($n = 458$)		Quartile 3 ($n = 528$)		Quartile 4 (high) ($n = 526$)		*P* for Trend
Age, year, mean (SD)	73.0	(5.9)	71.0	(4.8)	72.2	(5.4)	73.7	(6.1)	75.8	(6.4)	<0.001
Women, *n* (%)	1204	(54.5)	370	(53.1)	243	(53.1)	287	(54.4)	304	(57.8)	0.109
Living alone, *n* (%)	268	(12.1)	81	(11.6)	48	(10.5)	62	(11.7)	77	(14.6)	0.123
Low education (<12 years), *n* (%)	1025	(46.4)	230	(33.0)	187	(40.8)	281	(53.2)	327	(62.2)	<0.001
Economic status (relatively) uncomfortable, *n* (%)	1362	(61.7)	370	(53.1)	281	(61.4)	350	(66.3)	361	(68.6)	<0.001
Current drinker, *n* (%)	923	(41.8)	312	(44.8)	202	(44.1)	220	(41.7)	189	(35.9)	0.002
Current smoker, *n* (%)	222	(10.1)	67	(9.6)	47	(10.3)	50	(9.5)	58	(11.0)	0.542
Multimorbidity, *n* (%)	1029	(46.6)	220	(31.6)	193	(42.1)	275	(52.1)	341	(64.8)	<0.001

Values are *n* (%) unless otherwise noted.

The quartile cut-points were 3, 5, and 8 points.

Table 2 Association between the t-KCL score and incidence of functional disability during the 8-year follow-up period

	Total, *n*	Incident, *n* (%)	Crude				Model 1				Model 2			
			HR	95% CI		*P*-value	HR	95% CI		*P*-value	HR	95% CI		*P*-value
The t-KCL score as a continuous variable			1.15	1.13	1.17	<0.001	1.08	1.06	1.11	<0.001	1.08	1.06	1.10	<0.001
The t-KCL score quartiles														
Quartile 1 (low)	697	106 (15.2)	1.00				1.00				1.00			
Quartile 2	458	91 (19.9)	1.39	1.05	1.84	0.021	1.19	0.90	1.58	0.215	1.20	0.90	1.59	0.212
Quartile 3	528	141 (26.7)	2.00	1.56	2.58	<0.001	1.43	1.11	1.85	0.006	1.43	1.10	1.85	0.007
Quartile 4 (high)	526	219 (41.6)	3.83	3.04	4.83	<0.001	2.19	1.72	2.80	<0.001	2.11	1.63	2.72	<0.001
P for trend						<0.001				<0.001				<0.001

Model 1 adjusted for sex and age.

Model 2 adjusted for living alone, education, household finance, drinking, smoking, multimorbidity plus factors in model 1.

The t-KCL score classification in each quartile was 0–2 points for quartile 1, 3–4 points for quartile 2, 5–7 points for quartile 3, and 8 points or more for quartile 4.

$P < 0.001$). Based on the category-free NRI, compared with the basic model, the fully adjusted model significantly improved risk classification (0.187 [95% CI: 0.095–0.287], $P < 0.001$). Similarly, based on the absolute IDI, the risk classification was significantly improved in the fully adjusted model (0.020 [95% CI: 0.012–0.027], $P < 0.001$).

Sensitivity analyses showed that the association between the t-KCL score and functional disability remained unchanged using the competing risk models (Table S1). After excluding participants with the onset of functional disability during the first 2 years of follow-up, the associations and the incremental predictive ability showed similar results (Tables S2 and S3).

Discussion

In the prospective study with an 8-year follow-up period among older adults, a higher t-KCL score was independently associated with a higher risk of functional disability. The t-KCL score was found to have incremental predictive ability for functional disability. To our knowledge, our study is the first report evaluating the incremental predictive ability of the t-KCL score for functional disability over a long follow-up period. Our findings suggest that the t-KCL score is a useful scale for predicting functional disability over a long follow-up period. We also confirmed that the association between the t-KCL score and functional disability did not change in the sensitivity analysis after excluding those who developed functional disability within 2 years of follow-up.

Our findings corroborate the results of previous studies in Japanese cohorts with a short follow-up period (≤3 years) reporting that a higher t-KCL score was independently associated with a higher risk of functional disability.[7,8] Herein, the association between the t-KCL score and functional disability has been demonstrated over an 8-year follow-up period, which is longer than in previous studies.

The present findings suggest that the t-KCL score can be a useful scale not only to screen for a current risk of functional disability but also to predict future risk of incident functional disability.[7] The present study has demonstrated that incremental predictive ability based on the change of the C-statistic when the t-KCL score included the basic model consisting of common risk factors was slight, but statistically significant. Furthermore, the NRI and IDI results also show that a model that includes the t-KCL score has a better risk discrimination than the basic model. These findings add to the previous observations on the association of the t-KCL score with functional disability, giving new evidence that using the t-KCL score as a screening scale can meaningfully improve the identification of older adults at risk of developing future functional disability over a long follow-up period. Moreover, the demonstration that the addition of the t-KCL score provides more useful information than the commonly used information suggests the usefulness of the t-KCL score, a scale that is simple and easy to use, in predicting the risk of functional disability. One possible explanation for these findings is that the t-KCL score, as a comprehensive geriatric scale,[1,13] provides information about aging that is not captured by other risk factors.

This study has several strengths. First, a large sample of older adults was included. In addition, we used the LTCI database, and thus accurately identified functional disability. However, several limitations of the present study must also be considered. First, the generalizability of our findings might be limited, because the subjects were from a town and because some subjects were excluded

Table 3 Comparison between the basic model and the fully adjusted model regarding the predictive ability for the incidence of functional disability

	C-statistic	95% CI		*P*-value	Category-free NRI	95% CI		*P*-value	Absolute IDI	95% CI		*P*-value
Basic model	0.747	0.728	0.768	Reference	Reference				Reference			
Fully adjusted model	0.760	0.741	0.781	<0.001	0.187	0.095	0.287	<0.001	0.020	0.012	0.027	<0.001

The basic model included only covariates (sex, age, living alone, education, household finance, drinking, smoking, and multimorbidity).
The fully adjusted model had the t-KCL score added to the basic model.

from the analysis on account of the lack of KCL data. In addition, nonrespondents for the self-reported questionnaire regarding KCL reported a higher risk of future functional disability.[24] Therefore, our results may underestimate the risk of functional disability. Second, because older adults need to request the municipal government for an official certification of their care needs,[14] it is possible that people who are at a higher risk of functional disability or who already have a functional disability may fail to report their care needs to the municipal government, possibly resulting in an underestimation of the risk of functional disability in this study. Third, while we used common confounders in the analysis, the influence of potential confounders not used in this study was not completely excluded.

In conclusion, the t-KCL score had an independent positive association with functional disability over an 8-year follow-up period. Furthermore, adding the t-KCL score to the model consisting of common risk factors brought a statistically significant improvement to the predictive ability for functional disability. The t-KCL score has been widely used to screen for a high risk of incidence of functional disability. Our data also suggest that the t-KCL score is a useful scale that could predict functional disability. In order to enhance the clinical usefulness of the t-KCL score as a predictor of functional disability, it is a future perspective that the predictive ability of the t-KCL score should be examined by the cause of disability. In addition, it will be an important issue to calculate the appropriate cutoff values using statistical indicators.

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Disclosure statement

The authors declare no conflict of interest.

Author contributions

All authors met all four of the following criteria: substantial contributions to the conception or design of the work, or acquisition, analysis or interpretation of data for the work; drafting the work or revising it critically for important intellectual content; final approval of the version to be published; agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Data availability statement

The authors elect not to share data.

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Supporting Information

Additional supporting information may be found in the online version of this article at the publisher's website:

Table S1 Association of the t-KCL score with functional disability accounting for the competing risk of death (Fine and Gray approach).

Table S2 Association between the t-KCL score and incidence of functional disability, excluding participants who were certified as requiring long-term care in the first 2 years of follow-up.

Table S3 Comparison between the basic model and the fully adjusted model regarding the predictive ability for the incidence of functional disability, excluding participants who were certified as requiring long-term care in the first 2 years of follow-up.

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Appendix I Questions in the Kihon checklist

No.	Question	Answer	
1	Do you go out by bus or train by yourself?	□0. YES	□1. NO
2	Do you go shopping to buy daily necessities by yourself?	□0. YES	□1. NO
3	Do you manage your own deposits and savings at the bank?	□0. YES	□1. NO
4	Do you sometimes visit your friends?	□0. YES	□1. NO
5	Do you turn to your family or friends for advice?	□0. YES	□1. NO
6	Do you normally climb stairs without using a handrail or wall for support?	□0. YES	□1. NO
7	Do you normally stand up from a chair without any aids?	□0. YES	□1. NO
8	Do you normally walk continuously for 15 min?	□0. YES	□1. NO
9	Have you experienced a fall in the past year?	□1. YES	□0. NO
10	Do you have a fear of falling while walking?	□1. YES	□0. NO
11	Have you lost 2 kg or more in the past 6 months?	□1. YES	□0. NO
12	Height: cm, weight: kg, BMI: kg/m^2. If BMI is less than 18.5, this item is scored.	□1. YES	□0. NO
13	Do you have any difficulties eating tough foods compared to 6 months ago?	□1. YES	□0. NO
14	Have you choked on your tea or soup recently?	□1. YES	□0. NO
15	Do you often experience having a dry mouth?	□1. YES	□0. NO
16	Do you go out at least once a week?	□0. YES	□1. NO
17	Do you go out less frequently compared to last year?	□1. YES	□0. NO
18	Do your family or your friends point out your memory loss? e.g. "You ask the same question over and over again."	□1. YES	□0. NO
19	Do you make a call by looking up phone numbers?	□0. YES	□1. NO
20	Do you find yourself not knowing today's date?	□1. YES	□0. NO
21	In the last 2 weeks have you felt a lack of fulfilment in your daily life?	□1. YES	□0. NO
22	In the last 2 weeks have you felt a lack of joy when doing the things you used to enjoy?	□1. YES	□0. NO
23	In the last 2 weeks have you felt difficulty in doing what you could do easily before?	□1. YES	□0. NO
24	In the last 2 weeks have you felt helpless?	□1. YES	□0. NO
25	In the last 2 weeks have you felt tired without a reason?	□1. YES	□0. NO