Escalation on Kihon Checklist scores preceding the certification of long-term care need in the older population in Japan. A 9-year retrospective study

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Running title: Increase in Kihon Checklist scores prior to certification of long-term care need

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Abstract

Objectives: The Kihon Checklist (KCL) is valuable for predicting long-term care (LTC) certification. However, the precise association between KCL scores and the temporal dynamics of LTC need certification remains unclear. This study clarified the characteristic trajectory of KCL scores in individuals certified for LTC need. **Methods:** The KCL scores spanning from 2011 to 2019 were obtained from 5,630 older individuals, including those certified for LTC need in November 2020, in Iiyama City, Nagano, Japan. We analyzed the KCL score trajectories using a linear mixed model, both before and after propensity score matching. **Results:** Throughout the 9-year observation period, the KCL scores consistently remained higher in the certified group compared to the non-certified group. Notably, a significant score increase occurred within the 3 years preceding LTC certification.

Discussion: Our findings highlight the effectiveness of continuous surveillance using the KCL in identifying individuals likely to require LTC within a few years.

Keywords: Kihon checklist, logistic multiple regression analysis, long-term care certification, physical strength, retrospective study, self-administered questionnaire

Introduction

The life expectancy in many countries worldwide continues to increase (Vaupel, 2010), with Japan having the longest life expectancy in the world (Murray et al., 2015). The increase in the older population has led to a considerable increase in healthcare costs (Bock et al., 2016). Japan introduced the long-term care insurance (LTCI), a social insurance plan, in 2000 to reduce the burden of nursing care and medical costs (Yamada & Arai, 2020). LTCI is graded into seven levels according to the degree of daily living disruption, and its services are available according to the disruption severity. LTCI has reduced the financial and care burden on individuals and their families (Yamada & Arai, 2020), while the aging population in Japan causes a substantial social burden that surpasses the capacity of relying exclusively on LTCI. Therefore, it is crucial to intervene in people who are suspected to need the LTC in the future through early detection.

Literature Review

The Japanese Ministry of Health, Labour and Welfare developed the Kihon Checklist (KCL), which is recommended for use to accurately and efficiently identify frail older persons. KCL has been shown to be effective in predicting which older adults will require LTC certification and in assessing frailty (Satake et al., 2016). The total KCL scores predict LTC need certification 3 and 8 years in advance (Matsuzaki et al., 2022; Satake et al., 2017), whereas the 20 main items of the KCL (except the "Mood" domain) show the greatest predictive ability for LTC need at 3 years prior to the certification (Kamegaya et al., 2017). The "Physical strength" domain serves as a prognostic factor for the certification of LTC need among men, exhibiting a predictive accuracy for certification at 2 years prior to the actual need (Fukutomi et al., 2015). The "Memory" domain demonstrates predictive capability for LTC need certification at 3 years prior to its actualization (Kojima et al., 2019). Additionally, the associations of KCL scores with LTC need certification have been reported (Hagiyama, Takao, Matsuo, & Yorifuji, 2022). Moreover, KCL scores have exhibited significant correlations with heightened cognitive dysfunction (Tomata et al.,

2017), elevated levels of depression (Kume et al., 2021), and augmented mortality (Satake et al., 2019). Even long-term follow-up studies have validated the predictive ability of KCL scores for functional disability (Matsuzaki et al., 2022; Sone, Nakaya, Sugawara, Matsuyama, & Tsuji, 2023).

The above reports indicate the efficiency and validity of the KCL for assessing frailty and LTC need. However, the predictability of the KCL, as observed in follow-up studies spanning from 2 years to 11 years, does not provide information about when a person would be certified for LTC need. To predict the timing of LTC need certification based on KCL scores, it is necessary to assess the trajectory of KCL scores in individuals until they are certified to require LTC. The present study aimed to elucidate the trajectory of KCL scores between those who were certified to LTC need and those who were not during a 9-year period preceding their LTC certification.

Methods

Study design

This retrospective, longitudinal, observational study was conducted in cooperation with Iiyama City, Nagano, Japan, which is known to have a considerable aging population in Japan. Since the year 2011, the KCL survey has been undertaken annually, targeting exclusively those older individuals aged ≥65 years who maintain an independent status. Iiyama City provided anonymized and de-linked information on KCL scores between 2011 and 2019 and LTC need certification between April 2020 and March 2021. The present study was conducted in accordance with the ethical standards of the Declaration of Helsinki (as revised in Brazil in 2013), and approved by the ethical committees of Gunma University (No. HS2022-178) and Nagano University of Health Sciences (No. 2020-4). Participants provided written informed consent to participate in this study. The details of this study were posted on the Iiyama City website, and participants were offered the opportunity to decline participation in the study.

Participants

The KCL questionnaire was delivered to 6,147 individuals out of a total of 7,608 individuals aged ≥65 years dwelling in Iiyama City in November 2020, as 1,461 individuals had already been certified to have LTC needs. Representatives in each district collected the questionnaires directly from the participants and sent them to Iiyama City. This method of retrieval likely contributed to the higher response rate observed in the current study, in comparison to previous ones (Kojima et al., 2019; Ito et al., 2021; Sato et al., 2022). A total of 5,925 individuals responded to the survey, yielding a response rate of 95.5%. Of these respondents, 1,595 individuals completed all of the questionnaires conducted between 2011 and 2020, while 334 participants responded to only one questionnaire on the year 2020. We excluded 44 individuals who had previously been certified to need for LTC and 9 individuals with missing information. Finally, we analyzed the data of 242 individuals who have been certified to need LTC (certified group) and those of 5,630 individuals who were not certified (non-certified group) between April 2020 and March 2021 (Figure 1).

Measurement of KCL

The KCL, a simple yes/no questionnaire that assesses multiple aspects of daily living, comprises 25 items in which each negative response is equivalent to one point, ranging from 0 to 25 points, with higher scores indicating a higher likelihood of being frail and a higher risk of needing support and care. The 25 items are divided into following seven domains (Arai & Satake, 2015): "Activities of daily living (ADL)" (Nos. 1 - 5), "Physical strength" (Nos. 6 - 10), "Nutrition" (Nos. 11 - 12), "Oral function" (Nos. 13 - 15), "Isolation" (Nos. 16 - 17), "Memory" (Nos. 18 - 20), and "Mood" (Nos. 21 - 25).

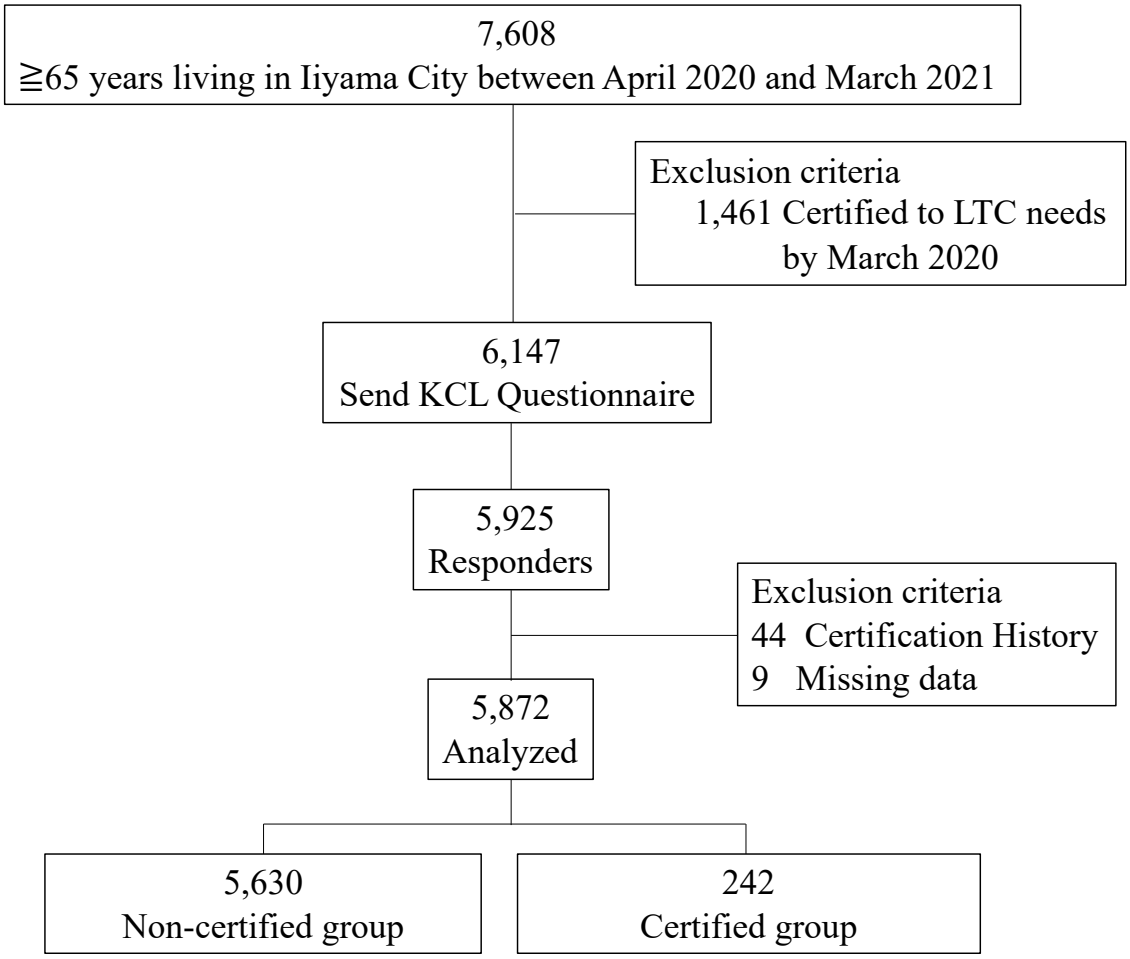

Figure 1. The flow of subjects through the study.

Statistical analysis

To verify the reliability of the data used in this study, we analyzed our data using a method described previously (Satake et al., 2019), which studied 8,091 older persons aged ≥65 years living in Higashiura-Town, Japan, in 2010, and examined their LTC need certification within a 2.5-year period. In the present study, another data set was extracted so that our sample size was similar to that of the previous study. The scores of 3,837 older adults ≥aged 65 years dwelling in Iiyama City in November 2017, without LTC need certification and without missing KCL items were used as the baseline. These individuals were then followed up for 2.5 years. Category assessments were performed according to a previous report (Satake et al., 2019). The cutoff for each domain was as follows: ≥ 3 points "Physical strength" (Nos. 6 - 10); 2 points, "Nutrition" (Nos. 11 and 12); ≥ 2 points "Oral function" (Nos. 13 - 15); ≥ 1 points "Memory" (Nos. 18 - 20); ≥2 points "Mood" (Nos. 21 - 25), and "Isolation" (Nos. 16 and 17) status was defined as an answer of "no" to question No. 16. Participants not meeting each criterion were considered controls. Cox proportional hazards model regression analyses were used to estimate the hazard ratios (HRs) and

construct 95% confidence intervals (CIs) of cases in each domain compared to controls. The analyses were adjusted for age, sex, and all domains, except the target domain.

The linear mixed model (LMM) was used to compare the KCL score trajectories over a 9-year period preceding the certification of LTC need, because it predicts the KCL scores for the years when participants did not respond. Specifically, we examined the variations in trajectory patterns between the certified and non-certified groups. This model enabled us to obtain results that reduce the effects of systematic errors, which are a concern in conventional analysis of variance that excludes missing cases. This model can incorporate parameters related to individual differences, such as baseline values and inter-individual variation over time. The objective variable was whether or not the patient was certified to need LTC, and the explanatory variable was the KCL score. The fixed effects were age and sex. The variable effects were the year of survey (nine times) with repeated measures. The Bonferroni test was used for multiple comparisons between the two groups in each study year and trajectories of KCL scores during a 9-year period. After the analysis using original

data, propensity score matching was conducted to redress the imbalances of age and sex in the certified and non-certified groups. The objective variable was whether or not the individuals were certified to need LTC, and the covariates were age and sex. The caliper value was calculated by multiplying it by 0.25.

We also assessed the KCL domains associated with the certification of LTC need. A multiple logistic regression analysis was then performed with the forced entry method, and adjusted odds ratios (aOR) and their 95% CIs were calculated. The objective variable was whether or not the individuals was certified to need LTC, and the independent variables were scores in each KCL domain annually. The covariates were age and sex.

The statistical significance level was at $p < 0.05$, and all statistical analyses were performed using IBM SPSS Statistics 27 (IBM Corp., Armonk, NY, USA).

Results

The population in this study is similar to that of a previous study

Table 1 shows the participant characteristics and HR for the LTC need certification during the 2.5-year follow-up period in this study and those of a previous report (Satake et al., 2019). The participants' mean age (73.7 ± 0.11 years in this study vs 72.6 years in the previous study), percentage of males (48.5% in this study vs 46.4% in the previous study, p = 0.05, V = 0.02), and the number of individuals with LTC need (249 in this study vs. 415 in the previous study, p = 0.07, V = 0.02) were comparable between the two studies. However, the number of participants in the previous study was 1.44 times greater than our participants. The ratio of the LTC need certification was not significantly different between the two studies [X^2 (1, 9379) = 3.438, p = 0.0637]. Cox proportional hazards model regression analyses showed that "instrumental activities of daily living (IADL)," "Physical strength," "Nutrition," and "Mood" were significant predictors of LTC need certification in both studies. "Oral function" was not a significant predictor of LTC need in the current study, whereas the previous study did not clarify the significance of this domain.

Table 1. Comparison of participants in the current and previous studies.

	this study (2.5 year follow up)	Satake et al. (2.5 year follow up)	P value	Effect size
Number of participants	3,837	5,542		
Number of LTC needs [a]	249	415	0.07	0.02
Mean age [b]	73.7	72.6		
% of men [a]	48.5	46.4	0.05	0.02
	HRs (95% CI)	HRs (95% CI)		
IADL	1.38 (1.04 - 1.85)	1.696 (1.371 - 2.099)		
Physical strength	1.81 (1.33 - 2.46)	1.938 (1.548 - 2.426)		
Nutrition	1.21 (0.61 - 2.41)	1.824 (1.047 - 3.175)		
Oral function	0.79 (0.57 - 1.08)	NS		
Isolation	1.57 (1.14 - 2.17)	NS		
Memory	1.44 (1.09 - 1.91)	NS		
Mood	1.64 (1.23 - 2.19)	1.892 (1.522 - 2.352)		

a: Chi-square test, effect size was φ.

Cox proportional hazards model regression analyses were used to estimate the hazard ratios (HRs) and construct 95% confidence intervals (CIs) for the occurrence of LTC need certification within 2.5 years for the cases in each domain compared to controls. Adjusted for age, sex, and all domains except the target domain.

Analysis of original data indicated that the KCL scores were higher in the certified group even at 9 years prior to the certification and showed further increase from 3 years prior to the certification

Over the course of 12 months (from April 2020 to March 2021), 242 individuals (4.12%) were certified to need LTC care (certified group), whereas the remaining 5,630 were not (non-certified group), among a total of 5,872 participants. The average age of the certified group (84.5 ± 7.05 years) was significantly higher than that of the non-certified group (74.5 ± 7.16 years) ($p < 0.001$, $g = 1.39$). Figure 2 shows the trajectories in KCL scores of the certified and non-certified groups for 9 years using the original data. The significant main

effects of the trajectories of the KCL scores during 9 years ($F (8, 22,156) = 51.65$, $p < 0.001$) and LTC needs certification [$F (1, 5,309) = 287.16$, $p < 0.001$] were observed. Unexpectedly, the KCL scores were significantly higher (5.54 ± 0.25) in the certified group than in the non-certified group (2.85 ± 0.06) even at 9 years prior to the LTC need certification. A significant interaction was observed between the certification of LTC need and the trajectories of KCL scores for 9 years [$F (8, 2,2156) = 31.65$, $p < 0.001$]. Multiple comparisons revealed significant differences in KCL scores between the certified and non-certified groups in each year (Figure 2 and Supplementary table 1: $p < 0.01$). Further, the KCL scores in the certified group showed a rapid and significant increase from 3 years prior to their certification (Supplementary table 1: -1 year vs. -2 years, $p < 0.001$; -1 year vs. −3 years, $p < 0.001$; −2 year vs. −3 years, $p = 0.010$). Contrarily, the increase in KCL scores was gradual even in the last survey year in the non-certified group (−1 year vs. −2 years, $p = 0.197$; -1 year vs. −3 years, $p < 0.001$; −2 years vs. −3 years, $p < 0.405$).

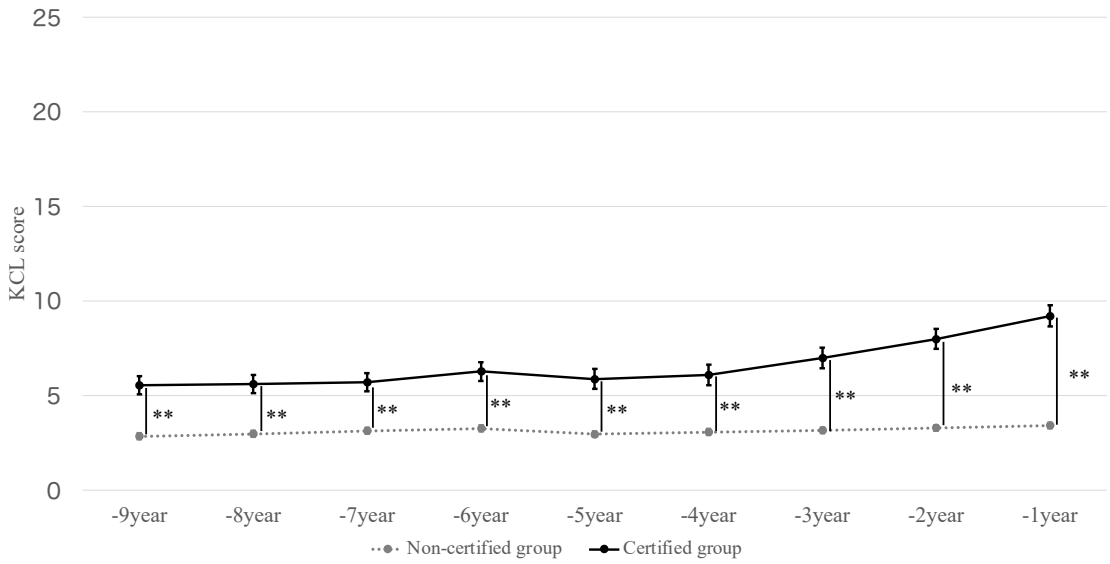

Figure 2. Trajectories in the KCL scores of the certified and non-certified groups for 9 years using the original data.

The results of the analysis of the original data indicate that the KCL scores was significantly higher in the certified group than in the non-certified group, and the scores increased from 3 years prior to the certification of LTC need. The LMM of KCL scores revealed significant main effects (trajectories of KCL scores during 9 years: $F(8, 22{,}156) = 51.65$, $p < 0.001$; LTC certification: $F(1, 5{,}309) = 287.16$, $p < 0.001$) and interaction

between these factors ($F(8, 22{,}156) = 31.65$, $p < 0.001$). There was a significant difference in the KCL scores between the certified and non-certified groups in all survey years (**, $p < 0.01$). Error bars indicate the estimated 95% CI.

Data after propensity scores matching also indicated the higher KCL score in the certified group further increase from 3 years prior to the certification

We noticed, in the original data that a significant difference existed in age between the certified and non-certified groups (Table 2, $p < 0.001$, $g = 1.39$). To redress the discernible in age, propensity score matching was conducted. The matching redressed the discernible in age (Table 2, $p = 0.84$, $g = 0.02$). The numbers of individuals in the certified and non-certified groups were 251 and 239, respectively (Table 2).

Table 2. Propensity score matching redressed the imbalance of age and sex differences between the certified and non-certified groups.

	Original data				Matched data			
	Certified group N = 242 Mean (SE)	Non-certified group N = 5,630 Mean (SE)	P value	Effect size	Certified group N = 242 Mean (SE)	Non-certified group N = 239 Mean (SE)	P value	Effect size
age	84.49 (0.45)	74.54 (0.10)	**< 0.001****	1.39	84.49 (0.45)	84.35 (0.44)	0.84	0.02
male	109	2,688	0.41	0.01	109	101	0.54	0.03
female	133	2,942			138	133		

*: $p < 0.05$, **: $p < 0.01$

For the comparison of age at the end point between the certified and non-certified groups. Independent t-tests were conducted on age and the effect size was calculated as Hedges' g. A chi-square test was conducted for the comparison of the data between men and women in the certified and non-certified groups, and the effect size was calculated as φ.

Statistical analyses conducted on the matched dataset yielded results that closely resembled the outcomes obtained from the analyses using the original dataset (Figure 3).

The significant main effects of trajectories of KCL scores for 9 years [$F(8, 2{,}125) = 25.03$, $p < 0.001$] and the certification of LTC need [$F(1, 459) = 53.72$, $p < 0.001$] were detected. A significant interaction was also observed between the certification of LTC need and the trajectories of KCL scores for 9 years [$F(8, 2{,}125) = 8.52$, $p < 0.001$]. Multiple comparisons revealed significant differences in KCL scores between the certified and non-certified groups in each year (Figure 3 and Supplementary table 2: $p < 0.01$). The KCL scores were significantly higher (5.54 ± 0.30) in the certified group than in the non-certified group (3.72 ± 0.29) at 9 years prior to the certification. Further, the KCL scores rapidly increased from 3 years prior to their certification in the certified group (Supplementary table 2: −1 year vs. −2 years, $p = 0.017$; −1 year vs. −3 years, $p < 0.001$; −2 years vs. −3 years, $p = 0.017$). However, a significant increase was observed only when comparing the score at −1 year with those at −8 and −9 years (−1 year vs. −8 years: $p = 0.007$, −1 year vs. −9 years: $p = 0.008$), suggesting that KCL scores gradually increased in the non-certified group.

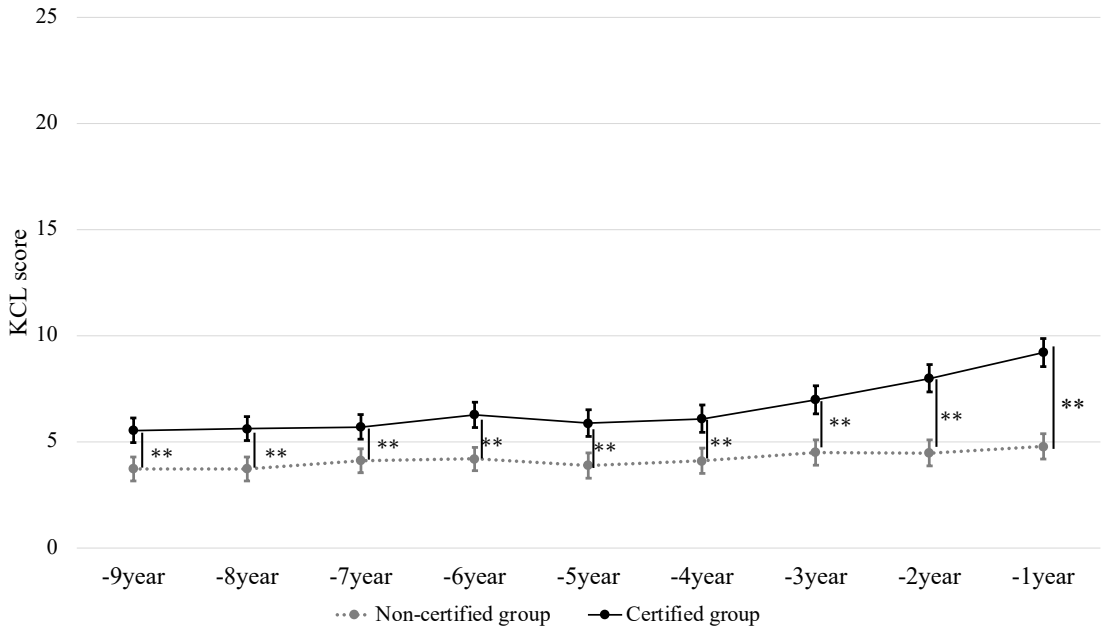

Figure 3. Trajectories in KCL scores of the certified and non-certified groups during a 9 years period using propensity score matched data.

The KCL scores were significantly higher in the certified group than in the non-certified group and they increased from 3 years prior to certification of LTC need even when matching data is used. The LMM analysis using matched data showed significant main

effects of the trajectories of the KCL scores ($F (8, 2,125) = 25.03$, $p < 0.001$) and LTC certification ($F (1, 459) = 53.72$, $p < 0.001$) as well as an interaction ($F (8, 2,125) = 8.52$, $p < 0.001$). There was a significant difference in the KCL scores between two groups in all survey years (**, $p < 0.01$). Error bars indicate the estimated 95% CI.

"Physical strength" was consistently associated with LTC need certification over the entire 9-year period

Table 3 indicates the results of the multiple logistic regression analysis using the matched data. "Physical strength" consistently and statistically exhibited a significant association with the certification of LTC need, spanning the entirety of a 9-year temporal period. The domain "Nutrition" demonstrated a significant association with LTC need certification, as evidenced at 1 year prior to the formal certification. Similarly, the domain "Isolation" displayed a noteworthy relationship with LTC need certification, establishing its significance at 2 years prior to the certification. Moreover, the domain "IADL" had a

significant correlation with LTC need certification, which was observed at 9 years before the formal certification. Notably, a significant association emerged between the “Memory” domain and LTC need certification, this association being substantiated at temporal junctures of 5 and 8 years preceding the formal certification process.

Table 3. Association of KCL scores on the certification of LTC need.

	aOR (95% CI)								
	-9 year	-8 year	-7 year	-6 year	-5 year	-4 year	-3 year	-2 year	-1 year
ADL	**0.66*** **(0.50 - 0.86)**	0.98 (0.74 - 1.29)	0.81 (0.63 - 1.04)	0.92 (0.72 - 1.16)	0.99 (0.73 - 1.35)	1.08 (0.83 - 1.42)	1.21 (0.94 - 1.54)	1.32 (0.98 - 1.78)	1.27 (0.97 - 1.65)
Physical strength	**1.51**** **(1.23 - 1.86)**	**1.41*** **(1.14 - 1.73)**	**1.75**** **(1.42 - 2.14)**	**1.63**** **(1.35 - 1.96)**	**1.60**** **(1.26 - 2.05)**	**1.42*** **(1.15 - 1.76)**	**1.32*** **(1.05 - 1.66)**	**1.50*** **(1.17 - 1.92)**	**1.29*** **(1.01 - 1.66)**
Nutrition	1.12 (0.62 - 2.02)	0.88 (0.51 - 1.50)	0.97 (0.57 - 1.67)	1.23 (0.73 - 2.18)	0.93 (0.44 - 1.98)	1.34 (0.72 - 2.49)	1.04 (0.58 - 1.90)	1.57 (0.86 - 2.85)	**2.06*** **(1.07 - 3.97)**
Oral function	1.16 (0.85 - 1.59)	1.29 (0.96 - 1.74)	0.94 (0.69 - 1.27)	0.93 (0.69 - 1.25)	1.15 (0.81 - 1.63)	1.11 (0.79 - 1.54)	1.24 (0.87 - 1.77)	1.21 (0.85 - 1.74)	1.33 (0.92 - 1.91)
Isolation	1.39 (0.88 - 2.21)	0.87 (0.58 - 1.33)	1.30 (0.81 - 2.07)	1.16 (0.74 - 1.80)	1.40 (0.76 - 2.57)	0.83 (0.46 - 1.49)	1.00 (0.63 - 1.60)	**0.52*** **(0.29 - 0.93)**	1.16 (0.68 - 1.98)
Memory	1.01 (0.69 - 1.47)	**1.54*** **(1.05 - 2.28)**	0.97 (0.65 - 1.44)	1.04 (0.71 - 1.52)	**0.60*** **(0.38 - 0.94)**	0.89 (0.55 - 1.42)	0.90 (0.60 - 1.35)	1.23 (0.84 - 1.81)	1.06 (0.69 - 1.62)
Mood	1.15 (0.91 - 1.46)	1.01 (0.80 - 1.28)	1.01 (0.82-1.25)	1.07 (0.86 - 1.32)	1.22 (0.92 - 1.64)	1.06 (0.84 - 1.32)	1.12 (0.90 - 1.40)	1.23 (0.98 - 1.56)	1.22 (0.97 - 1.55)

Matched data were used in the analysis. Each item is the seven domains of the KCL. aOR: adjusted odds ratio, Covariates: age and sex. Reference group: Non-certified group. “Physical strength” was associated with LTC need consistently over the past 9 years. *: $p < 0.05$, **: $p < 0.01$

Discussion

The comparison of participant's characteristics between the current and a previous (Satake et al., 2019) studies showed no significant differences, elucidating the similarity between our study cohort and the older population from another study. Notably, the analysis of KCL score trajectories revealed a significant increase in scores starting three years prior to LTC certification. It is conceivable that the significant increase in KCL scores may serve as a predictor for LTC certification, as KCL scores are indicative of frailty (Satake et al., 2016; Watanabe et al., 2022). However, further research is necessary to empirically establish this concept. Our novel finding underscores the value of continuous KCL surveillance for identifying individuals likely to require LTC within the next three years. Recognizing such high-risk individuals is essential for the efficient allocation of social and financial resources.

Higher KCL scores in the certified group even 9 years prior to their certification coincide with those of long-term prospective studies. The total KCL score exhibited an independent positive association with functional disability over an 8-year and 13-year follow-up period (Matsuzaki et al., 2022; Sone et al., 2023). Furthermore, it is interesting to note that the certified and non-certified groups obtained KCL sores of 5.54 ± 0.30 and 3.72 ± 0.29,

respectively. The KCL scores of 4 – 7 and 8 – 25 are generally classified as pre-frail and frail situations, respectively (Satake et al., 2016). The classification of our study participants at 9 years prior to the certification was consistent with those of previous studies. Both pre-frail and frail situations are significantly associated with the incidence of functional disability during the 13-year follow-up period (Sone et al., 2023). In another report, individuals with a KCL score of ≥ 5 have a significantly higher risk of developing functional disability as compared to those with a KCL score of 0 – 2 points during a 8-year follow-up period (Matsuzaki et al., 2022). Hence, the risk of LTC need in older adults may become apparent earlier than our initial prediction.

Our retrospective study revealed that individuals with a KCL score of approximately five still appeared to live independently for a number of years; then, the KCL scores deteriorated approximately 3 years prior to their certification. Consistent social activities are known to reduce the progression of frailty in robust and pre-frail individuals (Sone et al., 2023; Yamada, Arai, Sonoda, & Aoyama, 2012). Belonging to sports clubs or hobby groups is reported to be significantly associated with a lower risk of incident disability (Abe et al., 2023). Additionally, positively built environments including convenient access to parks and sidewalks lower the risk of developing frailty (Mori et al., 2022). Such personal

and community situations may delay the need for LTC care among older persons. Together with these reports, our results suggest the importance of consistent surveys by using the KCL scores to detect individuals with an increased risk of LTC need. However, the factors that interfere with the deterioration of the KCL scores prior to the certification need to be clarified as well. Addressing these factors potentially prevents the immediate need for LTC care.

The result of our multiple logistic regression analysis indicated that “Physical strength" was significantly related to the certification of LTC need in each year of the 9-year follow-up period. This finding is consistent with accumulating evidence suggesting that higher scores in the “Physical strength” domain may indicate an elevated risk for LTC need or frailty (Fukutomi et al., 2015). It is reported that physical performance improves with resistance training (Vikberg et al., 2019) or a combination of aerobic, strength, and balance training (Monti et al., 2023). Furthermore, interventions aimed at maintaining or improving physical strength in older individuals have been known to potentially interfere with LTC certification. Physical exercise is effective in preventing the progression of frailty and further disability in older adults living in the community (Yamada et al., 2012). Self-management group exercise, which is composed of mild-intensity aerobic exercise, mild

strength training, flexibility and balance exercises, reduces the hazard ratio for LTC certification (Yamada & Arai, 2017). Interventions for motor function are already utilized in care prevention (Galloza, Castillo, & Micheo, 2017). However, other domains, including "ADL," "Nutrition," Isolation," and "Memory," are found to be transiently associated with the certification of LTC need during the 9-year follow-up period. For these KCL domains, their associations with the risk of LTC need are debatable (Ide et al., 2021).

There are several limitations to the present study. First, the KCL is a self-administered questionnaire and is a subjective assessment of performance, not an evaluation of function and ability. Second, based on propensity score matching results, we focused on participants with an average age of 84 years in 2020/2021 who were approximately 75 years of age at the onset of the survey. We need to examine the trajectory of KCL scores in individuals who were certified to need LTC by 75 years of age, although older age is associated with LTC need certification (Momose et al., 2021). Additionally, our study was conducted in a small city in a rural area with heavy snowfall in Japan. Therefore, making generalizations should be made cautiously. Finally, this study examine retrospectively those who were certified to need LTC in the 1−year period from April 2020 to March 2021. The individuals who were certified to need LTC in the middle of the study period were not taken included

in the analysis. It is necessary to comprehensively study KCL scores for individuals who were certified as needing LTC in the middle of the survey, as well as those residing in multiple districts.

Conclusions

We found that the KCL scores of the certified group had increased 3 years prior to the certification of LTC need. KCL scores were higher in the LTC-certified group than in the non-LTC-certified group for at least 9 years. Our data may be useful for establishing strategies to prevent the need for LTC among older persons.

Declaration of Conflicting Interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

CRediT authorship contribution statement

Kazuki Kitazawa: Conceptualization; Methodology; Data curation; Formal analysis; Writing - Original Draft; Project administration. Kenji Tsuchiya: Conceptualization;

Investigation; Data curation; Formal analysis. Kazuki Hirao: Conceptualization; Writing – Review & Editing; Supervision. Tomomi Furukawa: Conceptualization; Investigation; Data curation; Formal analysis. Fusae Tozato: Conceptualization; Writing - Review & Editing. Tsutomu Iwaya: Conceptualization; Writing - Review & Editing; Project administration; Supervision. Shinichi Mitsui: Conceptualization; Writing - Review & Editing; Project administration; Supervision.

References

Abe, N., Ide, K., Watanabe, R., Hayashi, T., Iizuka, G., & Kondo, K. (2023). Social participation and incident disability and mortality among frail older adults: A JAGES longitudinal study. *J Am Geriatr Soc, 71*(6), 1881-1890. https://doi.org/10.1111/jgs.18269

Arai, H., & Satake, S. (2015). English translation of the Kihon Checklist. *Geriatr Gerontol Int, 15*(4), 518-519. https://doi.org/https://doi.org/10.1111/ggi.12397

Bock, J. O., Konig, H. H., Brenner, H., Haefeli, W. E., Quinzler, R., Matschinger, H., et al. (2016). Associations of frailty with health care costs--results of the ESTHER cohort study. *BMC Health Serv Res, 16*(128), 1-11. https://doi.org/10.1186/s12913-016-1360-3

Fukutomi, E., Okumiya, K., Wada, T., Sakamoto, R., Ishimoto, Y., Kimura, Y., et al. (2015). Relationships between each category of 25-item frailty risk assessment (Kihon Checklist) and newly certified older adults under Long-Term Care Insurance: A 24-month follow-up study in a rural community in Japan. *Geriatr Gerontol Int, 15*(7), 864-871. https://doi.org/https://doi.org/10.1111/ggi.12360

Galloza, J., Castillo, B., & Micheo, W. (2017). Benefits of Exercise in the Older Population. *Phys Med Rehabil Clin N Am, 28*(4), 659-669. https://doi.org/https://doi.org/10.1016/j.pmr.2017.06.001

Hagiyama, A., Takao, S., Matsuo, R., & Yorifuji, T. (2022). Differential Associations of Frailty with the Incidence of Mild and Severe Disabilities in Older Adults: A 3-Year Cohort Study. *Ann Geriatr Med Res, 26*(4), 309-315. https://doi.org/https://doi.org/10.4235/agmr.22.0097

Ide, K., Banno, T., Yamato, Y., Hasegawa, T., Yoshida, G., Yasuda, T., et al. (2021). Relationship between locomotive syndrome, frailty and sarcopenia: Locomotive syndrome overlapped in the majority of frailty and sarcopenia patients. *Geriatr Gerontol Int, 21*(6), 458-464. https://doi.org/10.1111/ggi.14162

Ito, K., Kawai, H., Tsuruta, H., Obuchi, S. (2021). Predicting incidence of long-term care insurance certificaiton in Japan with the Kihon Checklist for frailty secreening tool: analysis of locoal government survey data. *BMC Geritrics,* 21(1), 22. https://doi.org/10.1186/s12877-020-01968-z

Kamegaya, T., Yamaguchi, H., & Hayashi, K. (2017). Evaluation by the Basic Checklist and the risk of 3 years incident long-term care insurance certification. *J Gen Fam Med, 18*(5), 230-236. https://doi.org/https://doi.org/10.1002/jgf2.52

Kojima, S., Murotani, K., Zhou, B., Kothari, K. U., Fukushima, M., & Nagai, Y. (2019). Assessing long-term care risk in older individuals with possible cognitive decline: A large population-

based study using the Kihon Checklist. *Geriatr Gerontol Int, 19*(7), 598-603. https://doi.org/https://doi.org/10.1111/ggi.13677

Kume, Y., Bae, S., Lee, S., Makizako, H., Matsuzaki-Kihara, Y., Miyano, I., et al. (2021). Association between Kihon check list score and geriatric depression among older adults from ORANGE registry. *PLoS One, 16*(6), e0252723. https://doi.org/https://doi.org/10.1371/journal.pone.0252723

Matsuzaki, H., Kishimoto, H., Nofuji, Y., Chen, T., & Narazaki, K. (2022). 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. *Geriatr Gerontol Int, 22*(9), 723-729. https://doi.org/https://doi.org/10.1111/ggi.14435

Momose, A., Yamaguchi, S., Okada, A., Ikeda-Kurakawa, K., Namiki, D., Nannya, Y., et al. (2021). Factors associated with long-term care certification in older adults: a cross-sectional study based on a nationally representative survey in Japan. *BMC Geriatr, 21*(1), 374. https://doi.org/10.1186/s12877-021-02308-5

Monti, E., Tagliaferri, S., Zampieri, S., Sarto, F., Sirago, G., Franchi, M. V., et al. (2023). Effects of a 2-year exercise training on neuromuscular system health in older individuals with low

muscle function. J Cachexia Sarcopenia Muscle, 14(2), 794-804. https://doi.org/10.1002/jcsm.13173

Mori, Y., Tsuji, T., Watanabe, R., Hanazato, M., Miyazawa, T., & Kondo, K. (2022). Built environments and frailty in older adults: A three-year longitudinal JAGES study. *Arch Gerontol Geriatr, 103*(104773),1-7. https://doi.org/10.1016/j.archger.2022.104773

Murray, C. J., Barber, R. M., Foreman, K. J., Abbasoglu Ozgoren, A., Abd-Allah, F., Abera, S. F., et al. (2015). Global, regional, and national disability-adjusted life years (DALYs) for 306 diseases and injuries and healthy life expectancy (HALE) for 188 countries, 1990-2013: quantifying the epidemiological transition. *Lancet, 386*(10009), 2145-2191. https://doi.org/10.1016/S0140-6736(15)61340-X

Satake, S., Senda, K., Hong, Y. J., Miura, H., Endo, H., Sakurai, T., et al. (2016). Validity of the Kihon Checklist for assessing frailty status. *Geriatr Gerontol Int, 16*(6), 709-715. https://doi.org/https://doi.org/10.1111/ggi.12543

Satake, S., Shimokata, H., Senda, K., Kondo, I., Arai, H., & Toba, K. (2019). Predictive Ability of Seven Domains of the Kihon Checklist for Incident Dependency and Mortality. *J Frailty Aging, 8*(2), 85-87. https://doi.org/https://doi.org/10.14283/jfa.2019.3

Satake, S., Shimokata, H., Senda, K., Kondo, I., & Toba, K. (2017). Validity of Total Kihon Checklist Score for Predicting the Incidence of 3-Year Dependency and Mortality in a Community-Dwelling Older Population. *J Am Med Dir Assoc, 18*(6), 552 e551-552 e556. https://doi.org/https://doi.org/10.1016/j.jamda.2017.03.013

Sato, K., Ishii, S., Moriyama, M., Zhang, J., Kanazawa, K. (2022). Development of a predictive model using the Kihon Checklist for older adulats at risk of needing long-term care based on cohort data of 19 months. *Geriatr Gerontol Int*, 22(9), 797–802. https://doi.org/https://doi.org/10.1111/ggi.14456

Sone, T., Nakaya, N., Sugawara, Y., Matsuyama, S., & Tsuji, I. (2023). Effect of social participation on the association between frailty and disability. *Arch Gerontol Geriatr, 110*(104989), 1-7. https://doi.org/10.1016/j.archger.2023.104989

Tomata, Y., Sugiyama, K., Kaiho, Y., Sugawara, Y., Hozawa, A., & Tsuji, I. (2017). Predictive ability of a simple subjective memory complaints scale for incident dementia: Evaluation of Japan's national checklist, the "Kihon Checklist". *Geriatr Gerontol Int, 17*(9), 1300-1305. https://doi.org/https://doi.org/10.1111/ggi.12864

Vaupel, J. W. (2010). Biodemography of human ageing. *Nature, 464*(7288), 536-542. https://doi.org/10.1038/nature08984

Vikberg, S., Sorlen, N., Branden, L., Johansson, J., Nordstrom, A., Hult, A., et al. (2019). Effects of Resistance Training on Functional Strength and Muscle Mass in 70-Year-Old Individuals With Pre-sarcopenia: A Randomized Controlled Trial. *J Am Med Dir Assoc*, 20(1), 28-34. https://doi.org/10.1016/j.jamda.2018.09.011

Watanabe, D., Yoshida, Y., Watanabe, Y., Yamada, Y., Miyachi, M., Kimura, M. (2022). Validation of the Kihon Checklist and the frailty screening index for frailty defined by the phenotype model in older Japanese adults. *BMC Geriatrics,* 22(1), 478. https://doi.org/10.1186/s12877-022-03177-2

Yamada, M., & Arai, H. (2020). Long-Term Care System in Japan. *Ann Geriatr Med Res, 24*(3), 174-180. https://doi.org/https://doi.org/10.4235/agmr.20.0037

Yamada, M., & Arai, H. (2017). Self-Management Group Exercise Extends Healthy Life Expectancy in Frail Community-Dwelling Older Adults. Int J Environ Res Public Health, 14(5), 1-8. https://doi.org/10.3390/ijerph14050531

Yamada, M., Arai, H., Sonoda, T., & Aoyama, T. (2012). Community-based exercise program is cost-effective by preventing care and disability in Japanese frail older adults. *J Am Med Dir Assoc, 13*(6), 507-511. https://doi.org/10.1016/j.jamda.2012.04.001

Supplementary Table 1. Multiple comparisons of KCL scores using the original data during a 9-year follow-up period.

			Certified group			Non-certified group		
			Mean (SE)	Mean (SE)	p value	Mean (SE)	Mean (SE)	p value
-1 year	vs.	-2 year	9.21 (0.28)	7.99 (0.27)	**< 0.001****	3.42 (0.05)	3.29 (0.05)	0.197
		-3 year		6.98 (0.28)	**< 0.001****		3.16 (0.05)	**< 0.001****
		-4 year		6.10 (0.27)	**< 0.001****		3.10 (0.06)	**< 0.001****
		-5 year		5.88 (0.27)	**< 0.001****		2.96 (0.06)	**< 0.001****
		-6 year		6.27 (0.25)	**< 0.001****		3.26 (0.06)	0.064
		-7 year		5.70 (0.25)	**< 0.001****		3.14 (0.06)	**< 0.001****
		-8 year		5.62 (0.24)	**< 0.001****		2.97 (0.06)	**< 0.001****
		-9 year		5.54 (0.25)	**< 0.001****		2.85 (0.06)	**< 0.001****
-2 year		-3 year	7.99 (0.27)	6.98 (0.28)	**0.010***	3.29 (0.05)	3.16 (0.05)	0.405
		-4 year		6.10 (0.27)	**< 0.001****		3.10 (0.06)	**0.001****
		-5 year		5.88 (0.27)	**< 0.001****		2.96 (0.06)	**< 0.001****
		-6 year		6.27 (0.25)	**< 0.001****		3.26 (0.06)	1.000
		-7 year		5.70 (0.25)	**< 0.001****		3.14 (0.06)	0.203
		-8 year		5.62 (0.24)	**< 0.001****		2.97 (0.06)	**< 0.001****
		-9 year		5.54 (0.25)	**< 0.001****		2.85 (0.06)	**< 0.001****
-3 year		-4 year	6.98 (0.28)	6.10 (0.27)	0.060	3.16 (0.05)	3.10 (0.06)	1.000
		-5 year		5.88 (0.27)	**< 0.001****		2.96 (0.06)	**0.004****
		-6 year		6.27 (0.25)	0.190		3.26 (0.06)	1.000
		-7 year		5.70 (0.25)	**< 0.001****		3.14 (0.06)	1.000
		-8 year		5.62 (0.24)	**< 0.001****		2.97 (0.06)	**0.022***
		-9year		5.54 (0.25)	**< 0.001****		2.85 (0.06)	**< 0.001****
-4 year		-5 year	6.10 (0.27)	5.88 (0.27)	1.000	3.10 (0.06)	2.96 (0.06)	1.000
		-6 year		6.27 (0.25)	1.000		3.26 (0.06)	**0.010***
		-7 year		5.70 (0.25)	1.000		3.14 (0.06)	1.000
		-8 year		5.62 (0.24)	1.000		2.97 (0.06)	1.000
		-9 year		5.54 (0.25)	1.000		2.85 (0.06)	**0.004****
-5 year		-6 year	5.88 (0.27)	6.27 (0.25)	1.000	2.96 (0.06)	3.26 (0.06)	**< 0.001****
		-7 year		5.70 (0.25)	1.000		3.14 (0.06)	**0.038***
		-8 year		5.62 (0.24)	1.000		2.97 (0.06)	1.000
		-9 year		5.54 (0.25)	1.000		2.85 (0.06)	1.000
-6 year		-7 year	6.27 (0.25)	5.70 (0.25)	0.356	3.26 (0.06)	3.14 (0.06)	0.723
		-8 year		5.62 (0.24)	0.105		2.97 (0.06)	**< 0.001****
		-9 year		5.54 (0.25)	**0.037***		2.85 (0.06)	**< 0.001****
-7 year		-8 year	5.62 (0.24)	5.62 (0.24)	1.000	3.14 (0.06)	2.97 (0.06)	0.106
		-9 year		5.54 (0.25)	1.000		2.85 (0.06)	**< 0.001****
-8 year		-9 year	5.62 (0.24)	5.54 (0.25)	1.000	2.97 (0.06)	2.85 (0.06)	1.000

Multiple comparisons were performed with Bonferroni test.

*: $p < 0.05$, **: $p < 0.01$

Supplementary Table 2. Multiple comparisons of KCL scores using the matched dataset during a 9-year follow-up period.

			Certified group			Non-certified group		
			Mean (SE)	Mean (SE)	p value	Mean (SE)	Mean (SE)	p value
-1 year	vs.	-2 year	9.20 (0.34)	7.98 (0.33)	**0.017***	4.78 (0.31)	4.47 (0.31)	1.000
		-3 year		6.98 (0.34)	**< 0.001****		4.50 (0.30)	1.000
		-4 year		6.08 (0.33)	**< 0.001****		4.09 (0.30)	0.746
		-5 year		5.87 (0.32)	**< 0.001****		3.89 (0.31)	0.103
		-6 year		6.27 (0.30)	**< 0.001****		4.19 (0.29)	1.000
		-7 year		5.70 (0.30)	**< 0.001****		4.11 (0.29)	0.660
		-8 year		5.62 (0.29)	**< 0.001****		3.72 (0.29)	**0.007****
		-9 year		5.54 (0.30)	**< 0.001****		3.72 (0.29)	**0.008****
-2 year		-3 year	7.98 (0.33)	6.98 (0.34)	**0.017***	4.47 (0.31)	4.50 (0.30)	1.000
		-4 year		6.08 (0.33)	0.132		4.09 (0.30)	1.000
		-5 year		5.87 (0.32)	**< 0.001****		3.89 (0.31)	1.000
		-6 year		6.27 (0.30)	**< 0.001****		4.19 (0.29)	1.000
		-7 year		5.70 (0.30)	**< 0.001****		4.11 (0.29)	1.000
		-8 year		5.62 (0.29)	**< 0.001****		3.72 (0.29)	0.328
		-9 year		5.54 (0.30)	**< 0.001****		3.72 (0.29)	0.346
-3 year		-4 year	6.98 (0.34)	6.08 (0.33)	0.379	4.50 (0.30)	4.09 (0.30)	1.000
		-5 year		5.87 (0.32)	**0.044***		3.89 (0.31)	1.000
		-6 year		6.27 (0.30)	0.917		4.19 (0.29)	1.000
		-7 year		5.70 (0.30)	**0.002****		4.11 (0.29)	1.000
		-8 year		5.62 (0.29)	**< 0.001****		3.72 (0.29)	0.192
		-9year		5.54 (0.30)	**< 0.001****		3.72 (0.29)	0.208
-4 year		-5 year	6.08(0.33)	5.87 (0.32)	1.000	4.09 (0.30)	3.89 (0.31)	1.000
		-6 year		6.27 (0.30)	1.000		4.19 (0.29)	1.000
		-7 year		5.70 (0.30)	1.000		4.11 (0.29)	1.000
		-8 year		5.62 (0.29)	1.000		3.72 (0.29)	1.000
		-9 year		5.54 (0.30)	1.000		3.72 (0.29)	1.000
-5 year		-6 year	5.87 (0.32)	6.27 (0.30)	1.000	3.89 (0.31)	4.19 (0.29)	1.000
		-7 year		5.70 (0.30)	1.000		4.11 (0.29)	1.000
		-8 year		5.62 (0.29)	1.000		3.72 (0.29)	1.000
		-9 year		5.54 (0.30)	1.000		3.72 (0.29)	1.000
-6 year		-7 year	6.27 (0.30)	5.70 (0.30)	1.000	4.19(0.29)	4.11 (0.29)	1.000
		-8 year		5.62 (0.29)	0.661		3.72 (0.29)	1.000
		-9 year		5.54 (0.30)	0.325		3.72 (0.29)	1.000
-7 year		-8 year	5.70 (0.30)	5.62 (0.29)	1.000	4.11 (0.29)	3.72 (0.29)	1.000
		-9 year		5.54 (0.30)	1.000		3.72 (0.29)	1.000
-8 year		-9 year	5.62 (0.29)	5.54 (0.30)	1.000	3.72 (0.29)	3.72 (0.29)	1.000

Multiple comparisons were performed with Bonferroni test.

*: $p < 0.05$, **: $p < 0.01$