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Original Article

Reference values for the locomotive syndrome risk test quantifying mobility of 8681 adults aged 20–89 years: A cross-sectional nationwide study in Japan

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ABSTRACT

Background: The locomotive syndrome risk test was developed to quantify the decrease in mobility among adults, which could eventually lead to disability. The purpose of this study was to establish reference values for the locomotive syndrome risk test for adults and investigate the influence of age and sex.
Methods: We analyzed 8681 independent community dwellers (3607 men, 5074 women). Data pertaining to locomotive syndrome risk test (the two-step test, the stand-up test, and the 25-question geriatric locomotive function scale [GLFS-25]) scores were collected from seven administrative areas of Japan.
Results: The reference values of the three test scores were generated and all three test scores gradually decreased among young-to-middle-aged individuals and rapidly decreased in individuals aged over 60 years. The stand-up test score began decreasing significantly from the age of 30 years. The trajectories of decrease in the two-step test score with age was slightly different between men and women especially among the middle-aged individuals. The two physical test scores were more sensitive to aging than the self-reported test score.
Conclusion: The reference values generated in this study could be employed to determine whether an individual has mobility comparable to independent community dwellers of the same age and sex.

1. Introduction

In the last few decades, Japan have been confronting many issues stemming from a super-aged society, wherein the number of disabled elderly adults along with the associated financial burden has rapidly increased [1,2]. The total expenses for the national long-term care insurance (LTCI) system, which the Japanese Government launched in 2000 to provide appropriate care services for elderly adults with disability, has now reached over one hundred billion dollars, which is thrice the expense that was required 20 years ago [1].

Decrease in mobility is a key driving force of disability [3–5], and musculoskeletal disorders, which are strongly associated with decrease in mobility, was reported as the second largest cause of disability worldwide and the primary cause of disability among the elderly [6]. It is thus no wonder that musculoskeletal disorders are the most frequent cause for LTCI certification in Japan [7]. In light of these circumstances, the Japanese Orthopaedic Association (JOA) proposed the concept of "Locomotive Syndrome" in 2007: the idea located midway between musculoskeletal disorders and disability and defined it as "a condition of decreased mobility in everyday activities, such as walking, climbing stairs, and standing up from a chair, as a result of musculoskeletal disorders" [7–9]. This concept had two purposes: one was to attract the attention of the public, regardless of age, to locomotive syndrome, since decrease in mobility leading to disability might start at a young age [4,8–10]. The second purpose was to establish management strategies for locomotive syndrome by identifying the predictors in different age or attribute groups [5,8–10].

To quantify decrease in mobility that could lead to disability, the JOA developed the locomotive syndrome risk test composed of two physical tests and one self-reported questionnaire [7,11–13]. The most notable feature of this simple and feasible screening tool was its ability to consistently quantify mobility, from young-to-middle-aged comparatively healthier populations to the already disabled elderly [14–16]. However, sex- and age-specific reference values for the locomotive syndrome risk test have not been determined, although they are essential for the appropriate evaluation and intervention.

Therefore, the purpose of the present study was to generate reference values for the locomotive syndrome risk test for different age groups and sex among independent ambulatory community dwellers aged 20–89 years, so that the reference values could be employed as numerical target values which individuals of the same age and sex could aim for, in order to maintain their mobility. We also investigated the influence of age and sex on mobility.

2. Methods

2.1. Participants

The study population consisted of independent community dwellers aged 20–89 years across Japan who could respond to self-administrated questionnaires. The exclusion criteria were i) individuals who had a certified need for care under the LTCI in Japan, ii) individuals who required a caregiver when walking, iii) individuals who were admitted to hospital within a month of enrollment, iv) individuals who experienced trauma or surgeries of spine or lower extremity within three months of enrollment, v) individuals who were under treatment for issues related to the

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spine or lower extremities. We excluded iii) and iv) as their mobility could be temporarily worse than usual after the episode of admission or surgeries. We also excluded v), since their mobility status fluctuates owing to their medical conditions including pain. We intended to collect data of 10,208 individuals (both men and women) from eleven age categories (aged 20–29, 30–39, 40–44, 45–49, 50–54, 55–59, 60–64, 65–69, 70–74, 75–79, 80–89 years); we calculated the target sample size after studying the reports of previous studies and ensured that our sample size was sufficient to avoid an overlap between two adjacent age groups in terms of the standard errors of the two-step test score [14,15].

We divided Japan into seven administrative areas: Hokkaido, Tohoku, Kanto, Chubu, Kinki, Chugoku & Shikoku, and Kyushu, and planned to collect the subjects in proportion to the population of the seven areas. Participants were recruited when they attended public medical check-ups or health lecture meetings in their residential areas. In some areas, participants of other cohort studies were also recruited. We examined the locomotive syndrome test set score (the two-step test score, stand-up score, and 25-question geriatric locomotive function scale [GLFS-25] score), age, sex, height, weight, zip code, occupation, physical activities, nutrition, comorbidities, and history of musculoskeletal surgeries. All participants provided written informed consent and this study was approved by the authors affiliated organizations and institutions.

2.2. Locomotive syndrome risk test

Locomotive syndrome risk test was developed to detect decrease in mobility closely associated with disability and comprises two functional tests (the two-step test and the stand-up test) and a self-administrated questionnaire evaluating motor dysfunction (GLFS-25) [11–13]. The validity, reliability, and feasibility of this test have been confirmed in previous studies [13,16]. The deterioration of the three test scores reportedly independently predicted reduced mobility or immobility leading to disability, as well as the accumulation of the deterioration of each test score exponentially increased the risk of immobility [14]. Summaries of the three tests are provided below and more detailed descriptions are provided elsewhere [11–14,16].

2.3. Two-step test

This test measures the maximum length of the two-step stride of participants. Individuals carry out this test from the standing posture without losing balance. The two-step test score is a standardized value of the maximum two-step stride length (cm) divided by individual's height (cm). The two-step test score was reported to be strongly correlated with maximum walking speed [12].

2.4. Stand-up test

This test assesses an individual's ability to stand up from stools of four different heights (10, 20, 30, and 40 cm). For the judgment of the successful trial of this test, individuals are required to stand up from stools of four different heights on one or both legs and maintain their posture for 3s after standing up. A score of 0–8 are allocated to the successful performance of subjects, as described in Table 1. Higher scores show better ability. Stand-up test score and weight-bearing index were reportedly highly correlated with one another (weight-bearing index: knee extensor strength normalized by one's weight) [11,17].

2.5. 25-Question geriatric locomotive function scale

This test is a self-reported questionnaire, evaluating the motor dysfunction. The questionnaire is composed of 25 items related to body pain, usual care, social activities, movement difficulties, and mental health status. Each of the 25 items had scores ranging from 0 to 4, therefore, the total score ranges from 0 to 100. A full score indicates worst self-perceived locomotive condition, while zero score suggests best condition. A previous study set an optimal cutoff score of 16 for the GLFS-25 to identify locomotive syndrome among the elderly [13].

2.6. Statistical analysis

We calculated the mean for the two-step test score because of its normal distribution. For the stand-up test score and GLFS-25 score, we provided median as the representative value, since the stand-up test score and GLFS-25 score had leptokurtic and right-skewed distribution, respectively. To confirm the robustness of the results as reference values for the Japanese population, we calculated the weighted representative values based on the population of the seven administrative areas in Japan in 2018 (Statistics Bureau of Japan). Differences in the proportion were assessed using the chi-square test. Differences in the continuous scores were assessed using *t*-test or analysis of variance as appropriate. The Tukey-Kramer's multiple comparison procedure was used for the analysis of the difference scores in the two-step test scores between the different age categories, while the Dwass-Steel-Critchlow-Fligner (DSCF)'s multiple comparison procedure was used to analyze the age-wise difference in the stand-up score and GLFS-25 score [18]. Pearson's correlation coefficient was used to calculate the correlations between age and the two-step test score, while Spearman's rho was used to calculate the relation between age and the stand-up score/GLFS-25 score. A p-value of <0.05 was considered statistically significant. Spline interpolation was used for smoothing the trend graph of mean/standard deviation of the two-step test score in each age category by using the cubic spline method with continuous second derivatives [19]. All statistical analyses were performed using SAS 9.4 (SAS Institute., NC, US).

3. Results

From September 2017 to March 2019, the data of 10,444 individuals were collected. According to the exclusion criterion, we included 9044 community dwelling independent adults aged 20–89 years. Finally, we used the data from 8681 individuals (3607 men, 5074 women) who completed all the three tests of the locomotive syndrome risk test. Distribution of individuals' sex, age

Table 1
Scoring system of the stand-up test.

Height	Two-leg stand					One-leg stand			
	Fail at 40 cm	40 cm	30 cm	20 cm	10 cm	40 cm	30 cm	20 cm	10 cm
Score	0	1	2	3	4	5	6	7	8

One-leg stand requires subjects to succeed at indicated height in both *right* and *left* leg.

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Table 2a
Background characteristics of male participants (n = 3607).

Age categories (years)	20–29	30–39	40–44	45–49	50–54	55–59	60–64	65–69	70–74	75–79	80–89	Total	
n	590	582	325	313	282	290	238	301	273	234	179	3607	
Age (years), mean	24.5	34.2	41.9	46.9	51.9	56.9	62.0	67.1	71.8	76.7	83.4	50.2	
(SD)	(2.9)	(3.0)	(1.4)	(1.4)	(1.4)	(1.4)	(1.4)	(1.5)	(1.5)	(1.4)	(2.9)	(18.3)	
BMI (kg/m2)*	22.5	23.2	23.7	23.9	23.5	23.4	23.6	23.6	23.0	23.3	22.7	23.3	n = 3588
(SD)	(3.5)	(3.3)	(3.2)	(3.4)	(2.9)	(2.8)	(3.0)	(2.7)	(2.4)	(2.8)	(2.8)	(3.1)	
Smoking (%)*	15.5	25.0	27.7	26.2	27.7	24.6	20.3	12.0	11.7	7.3	2.8	19.3	n = 3602
Occupation (%)*													n = 3562
Agricultural, forestry and fishery workers	0.9	3.7	3.4	2.6	2.5	5.6	7.6	16.0	7.0	4.7	3.4	4.8	
Production workers	2.1	3.5	4.3	5.1	6.1	3.9	4.7	2.7	1.9	1.3	0.0	3.3	
Sales workers	18.8	25.7	27.2	27.3	25.6	16.1	12.7	7.3	6.7	2.2	2.8	17.6	
General office workers	6.1	9.8	16.7	19.0	21.3	26.0	28.4	8.6	4.8	2.2	0.6	12.6	
Managers/Professionals	20.7	34.0	31.5	30.2	26.4	27.7	19.9	9.0	8.9	3.0	2.8	21.7	
Homemakers	0.2	0.0	0.0	0.0	0.0	0.4	0.0	1.3	2.2	2.2	2.2	0.6	
Other occupation	49.1	22.6	15.7	15.1	17.3	18.3	16.5	20.6	11.9	12.5	5.6	22.0	
Unemployed	2.3	0.7	1.2	0.6	0.7	2.1	10.2	34.6	56.7	72.0	82.7	17.6	
Frequency of physical activities (%)*													n = 3600
Almost Everyday	17.3	7.1	8.6	10.2	9.2	14.2	19.4	26.0	39.7	40.5	36.3	18.4	
A few times/week	29.2	26.9	26.8	24.0	23.4	24.9	24.9	31.0	22.8	26.3	25.1	26.3	
A few times/month	30.5	26.3	23.4	21.4	19.5	20.1	16.0	13.7	11.0	8.2	9.5	20.4	
Rarely or Never	23.1	39.8	41.2	44.4	47.9	40.8	39.7	29.3	26.5	25.0	29.1	34.9	
Dietary Variety Score*	2.5	2.6	2.6	2.4	2.6	2.8	2.7	2.8	3.2	3.5	3.6	2.8	n = 3539
(SD)	(2.1)	(2.2)	(2.2)	(2.2)	(2.3)	(2.0)	(2.2)	(2.2)	(2.2)	(2.4)	(2.2)	(2.2)	
History of orthopedic surgery*	11.2	13.1	14.6	18.8	15.2	15.5	17.0	16.7	20.5	21.0	19.5	15.7	n = 3340

SD, standard deviation, BMI, body mass index, *significant sex difference (<0.001).

Table 2b
Background characteristics of female participants (n = 5074).

Age categories (years)	20–29	30–39	40–44	45–49	50–54	55–59	60–64	65–69	70–74	75–79	80–89	Total	
n	724	625	457	472	396	377	375	517	477	370	284	5074	
Age (years), mean	24.3	34.6	42.2	46.8	51.9	56.9	61.9	67.1	71.8	76.7	82.8	52.5	
(SD)	(2.9)	(2.8)	(1.4)	(1.4)	(1.4)	(1.4)	(1.5)	(1.4)	(1.5)	(1.3)	(2.5)	(18.1)	
BMI (kg/m^2)*	20.6	20.9	21.4	21.6	22.0	21.9	22.4	22.4	22.4	22.2	22.4	21.7	n = 5016
(SD)	(2.7)	(3.0)	(3.3)	(3.0)	(3.4)	(3.1)	(3.2)	(3.0)	(3.0)	(3.1)	(2.9)	(3.1)	
Smoking (%)*	3.3	7.7	10.1	6.4	6.1	7.4	3.5	2.1	0.8	0.5	0.0	4.6	n = 5058
Occupation (%)*													
Agricultural, forestry and fishery workers	0.0	2.0	0.9	0.9	2.8	3.5	3.5	4.3	5.3	3.3	4.7	2.6	n = 5012
Production workers	1.1	2.8	0.9	1.5	2.8	3.5	1.6	1.6	0.0	0.0	0.0	1.5	
Sales workers	11.0	9.7	13.4	8.3	12.2	9.7	9.7	8.0	2.7	0.5	1.8	8.3	
General office workers	14.4	25.2	24.0	29.3	22.4	21.6	9.9	3.5	1.1	0.5	0.0	14.6	
Managers/Professionals	28.3	32.4	32.4	25.0	24.9	19.2	8.9	2.0	0.6	0.8	0.4	17.6	
Homemakers	1.6	5.9	9.3	15.6	18.6	24.6	45.8	59.8	69.2	62.1	49.1	29.9	
Other occupation	42.5	21.1	18.5	19.4	15.5	16.2	13.1	9.0	5.3	3.5	2.9	17.3	
Unemployed	1.1	1.0	0.7	0.0	0.8	1.6	7.5	11.9	15.8	29.2	41.2	8.2	
Frequency of physical activities (%)*													n = 5060
Almost Everyday	5.7	5.1	7.2	6.4	10.9	16.2	19.5	28.1	31.7	35.4	31.4	16.3	
A few times/week	18.0	14.9	18.4	19.7	24.0	23.7	33.2	36.6	40.9	31.9	32.9	25.7	
A few times/month	24.0	16.8	16.5	18.4	13.1	15.7	8.6	10.6	10.8	11.2	10.7	15.0	
Rarely or Never	52.4	63.1	57.9	55.5	52.0	44.4	38.8	24.8	16.7	21.5	25.0	42.9	
Dietary Variety Score*	2.3	2.9	3.1	3.4	3.4	3.5	3.7	3.8	4.4	4.7	4.9	3.5	n = 4876
(SD)	(2.0)	(2.1)	(2.0)	(2.2)	(2.2)	(2.3)	(2.2)	(2.4)	(2.3)	(2.6)	(2.3)	(2.3)	
History of orthopedic surgery*	7.3	7.8	8.6	8.6	9.2	11.6	12.5	15.2	17.6	21.3	18.1	11.8	n = 4560

SD, standard deviation, BMI, body mass index, *significant sex difference (<0.001).

categories, and seven administrative areas of Japan are shown in Supplemental Table 1 (Available Online).

The background characteristics of participants are shown in Table 2a,b. The body mass index [BMI] of women was significantly lower than that of men ($p < 0.001$). The frequency of physical activities was different between men and women ($p < 0.001$). Both middle-aged men and women performed lesser physical activity compared to younger or elderly individuals. Dietary variety score assessing nutrition [20,21] was significantly worse in men than that in women ($p < 0.001$).

The scatter plots of the three test scores vs. age is presented in Fig. 1a–c. The reference values for the locomotive syndrome risk test stratified by age categories and sex are shown in Table 3a,b. The changes in the locomotive syndrome risk test scores with advancing age are shown in Figs. 2–4. The mean two-step score of those in their 40s were significantly lower than that of those in their 20s both among men and women ($p < 0.001$). The mean two-step test score of men in their 50s was lower than that of men in their early 40s ($p < 0.005$), while the scores of women in 40s and 50s were not significantly different. Individuals aged over 60 years had worse mean two-step test score with increase in age with little sex difference; however, it was still above 1.1 even among individuals in their 80s (1.20; 95%CI 1.17–1.24 in men, 1.18; 95%CI 1.15–1.21 in women). The median stand-up test score of individuals in their 30s was significantly lower than that of those in their 20s ($p < 0.001$); the scores decreased with increase in age. Individuals in their 80s, both among men and women, had significantly worse median score of GLFS-25 compared to that among other age

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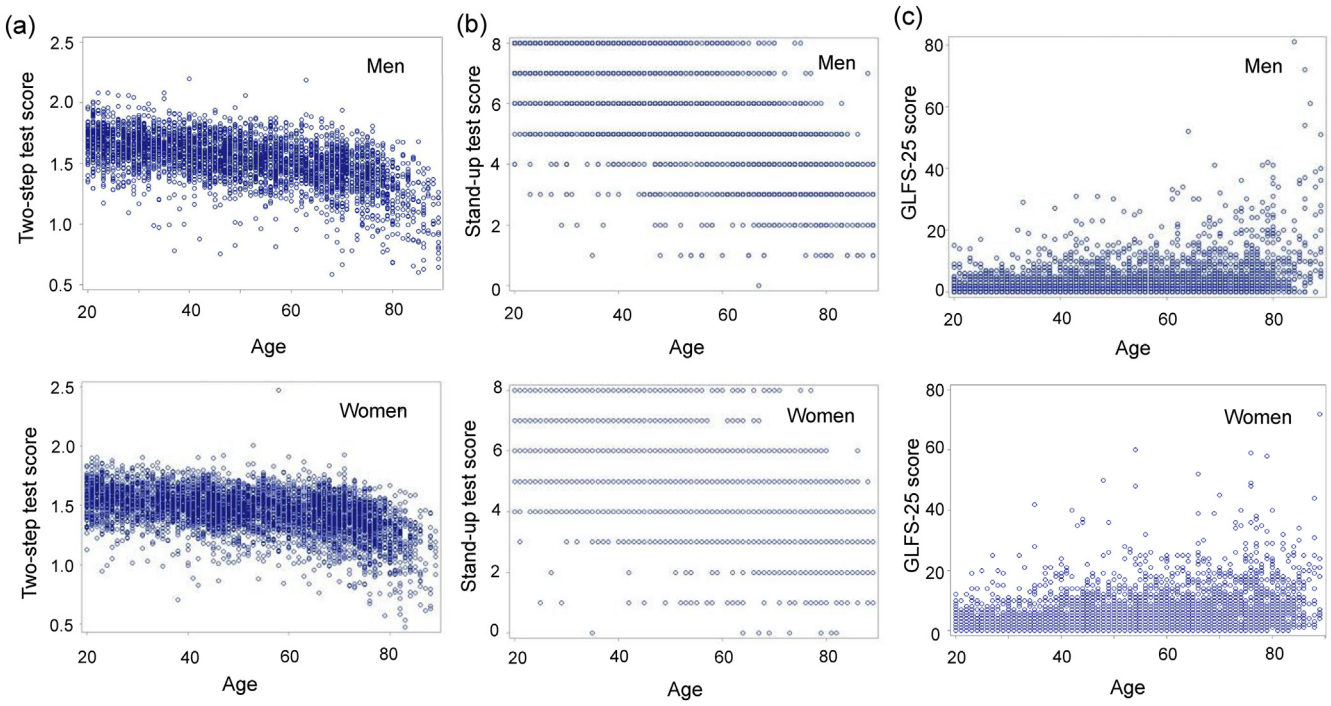

Fig. 1. Scatterplots of (a) Two-step test, (b) Stand-up test, and (c) 25-question geriatric locomotive function scale (GLFS-25) scores. The scatter plots show scores of the (a) two-step test, (b) stand-up test, and (c) GLFS-25 vs. age in both men and women.

Table 3a
Results of the two-step and stand-up tests and the geriatric locomotive function scale score of men in each age category (n = 3607).

Age categories (y)	20–29	30–39	40–44	45–49	50–54	55–59	60–64	65–69	70–74	75–79	80–89
n	590	582	325	313	282	290	238	301	273	234	179
Two-step test score											
Mean	1.66	1.63	1.59	1.56	1.54	1.52	1.51	1.45	1.42	1.36	1.20
SD	0.15	0.15	0.15	0.16	0.15	0.16	0.16	0.18	0.18	0.19	0.23
95%CI	1.64–1.67	1.62–1.64	1.58–1.61 ab	1.54–1.58 ab	1.52–1.56 abc	1.50–1.54 abc	1.49–1.53 abcd	1.43–1.47 abcdefg	1.40–1.44 abcdefg	1.34–1.39 abcdefghi	1.17–1.24 abcdefghij
Stand-up test score											
Median (IQR)	8 (7–8)	7 (6–8) a	6 (5–8) ab	6 (5–7) abc	5 (5–7) abc	5 (5–6) abcd	5 (4–6) abcde	5 (4–5) abcdefg	5 (4–5) abcdefg	4 (3–5) abcdefghi	3 (3–4) abcdefghij
GLFS-25 score											
Median (IQR)	1 (0–2)	1 (0–3)	2 (0–4) a	2 (0–5) ab	2 (1–4) ab	2 (1–5) abc	3 (1–6) abc	3 (1–6) abcd	3 (1–6) abc	3 (1–9) abcdef	7 (3–16) abcdefghij

SD, standard deviation; CI, confidence interval; IQR, interquartile range; GLFS, geriatric locomotive function scale.
a Significantly different ($p < 0.05$) from values of individuals aged 20s.
b Significantly different ($p < 0.05$) from values of individuals aged 30s.
c Significantly different ($p < 0.05$) from values of individuals aged early 40s.
d Significantly different ($p < 0.05$) from values of individuals aged late 40s.
e Significantly different ($p < 0.05$) from values of individuals aged early 50s.
f Significantly different ($p < 0.05$) from values of individuals aged late 50s.
g Significantly different ($p < 0.05$) from values of individuals aged early 60s.
h Significantly different ($p < 0.05$) from values of individuals aged late 60s.
i Significantly different ($p < 0.05$) from values of individuals aged early 70s.
j Significantly different ($p < 0.05$) from values of individuals aged late 70s.

categories. Weighted representative values of the three test scores are shown in Supplemental Table 2(Available Online), which showed similar values of as those in Table 3a,b. Age and two physical test scores were moderately correlated, while age and GLFS-25 score was weakly correlated both in men and women ($p < 0.001$) (Table 4).

4. Discussion

This study has established reference values for the locomotive syndrome risk test stratified by age and sex of independent community dwellers. We found a decrease in mobility leading to disability could start even as early as 30–40 years of age; this decrease in mobility was gradual in middle-aged individuals and rapid in older adults. Trajectories of decrease in mobility might differ by sex, especially among the middle-aged population.

Increasing age is known to be a main cause of decrease in mobility, besides other predictors including socioeconomic status, physical activities, or chronic conditions [4,22,23]. Age-dependent decrease in mobility was reported among community dwellers in previous studies [4,14,15,24] and decrease in mobility reportedly accelerated later in life [4,14,15,25]. Although it rarely became an

Table 3b
Results of the two-step and stand-up tests and the geriatric locomotive function scale score of women in each age category (n = 5074).

Age categories (y)	20–29	30–39	40–44	45–49	50–54	55–59	60–64	65–69	70–74	75–79	80–89
n	724	625	457	472	396	377	375	517	477	370	284
Two-step test score											
Mean	1.55	1.53	1.50	1.47	1.47	1.47	1.43	1.41	1.38	1.30	1.18
SD	0.14	0.14	0.14	0.14	0.14	0.16	0.16	0.16	0.17	0.18	0.22
95%CI	1.54–1.56	1.52–1.54	1.49–1.51 ab	1.46–1.48 ab	1.45–1.48 ab	1.45–1.48 ab	1.41–1.45 abcdf	1.40–1.42 abcdef	1.36–1.39 abcdefg	1.28–1.32 abcdefghi	1.15–1.21 abcdefghij
Stand-up test score											
Median (IQR)	6 (5–8)	6 (5–6) a	5 (5–6) ab	5 (5–6) ab	5 (5–5) abc	5 (4–5) abcd	5 (4–5) abcde	5 (4–5) abcdef	5 (4–5) abcdefg	4 (3–5) abcdefghi	4 (3–4) abcdefghij
GLFS-25 score											
Median (IQR)	1 (0–3)	2 (1–4) a	3 (1–6) ab	3 (1–6) ab	3 (1–7) ab	4 (2–7) abc	4 (2–7) abc	4 (2–7) abc	4 (2–8) abcd	6 (3–11) abcdefghi	8 (4–14) abcdefghij

SD, standard deviation; CI, confidence interval; IQR, interquartile range; GLFS, geriatric locomotive function scale.
a Significantly different ($p < 0.05$) from values of individuals aged 20s.
b Significantly different ($p < 0.05$) from values of individuals aged 30s.
c Significantly different ($p < 0.05$) from values of individuals aged early 40s.
d Significantly different ($p < 0.05$) from values of individuals aged late 40s.
e Significantly different ($p < 0.05$) from values of individuals aged early 50s.
f Significantly different ($p < 0.05$) from values of individuals aged late 50s.
g Significantly different ($p < 0.05$) from values of individuals aged early 60s.
h Significantly different ($p < 0.05$) from values of individuals aged late 60s.
i Significantly different ($p < 0.05$) from values of individuals aged early 70s.
j Significantly different ($p < 0.05$) from values of individuals aged late 70s.

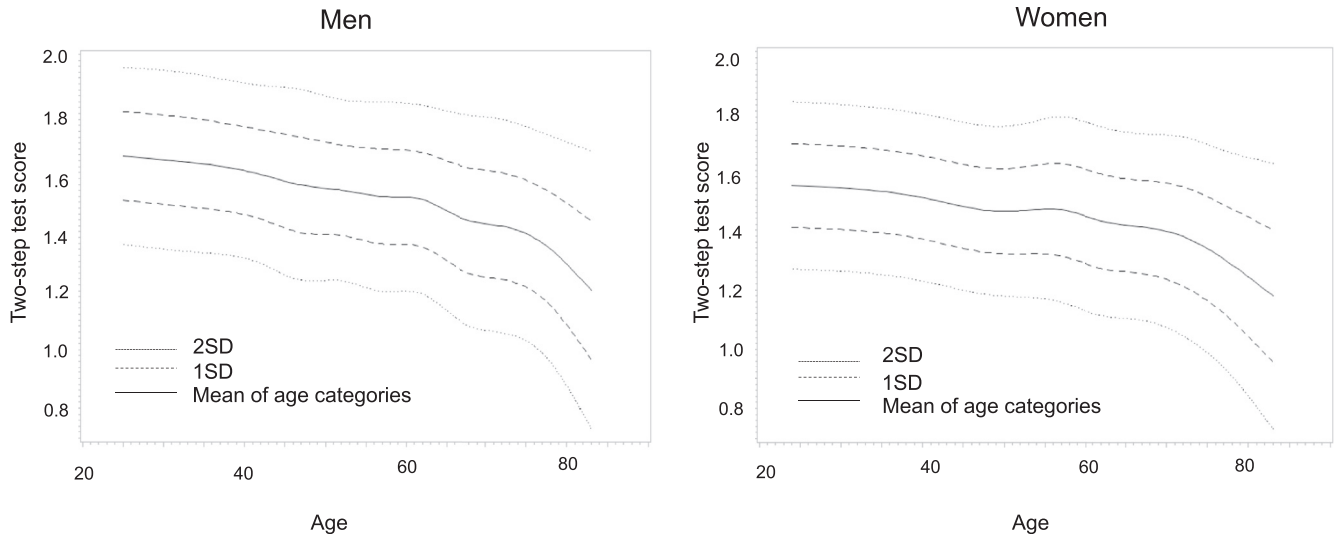

Fig. 2. Spline curves of the two-step test score (Mean with standard deviation [SD]/2SD) in different age categories. The spline curves of the two-step scores show gradual age-dependent decrease among young- and middle-aged individuals and accelerated decrease among the elderly.

issue unless the mobility of the individuals was severely impaired, disabling independent movement, it would be unsurprising to find that decrease in mobility could start early in life, since basic physical abilities closely associated with mobility (e.g. lower extremity muscle strength, flexibility or balance) were the highest in one's twenties and declined with age [24,26,27].

The detailed trajectory of decrease in mobility leading to disability across the lifespan among healthy individuals remains unclear, although it is essential to implement and evaluate specific, targeted interventions for people from different age groups. The reference values in this study would help clarify the trajectories of decrease in mobility across the lifespan. They were generally consistent with those reported in previous studies investigating mobility across the lifespan; however, direct comparison is limited because of the difference in various type of tests quantifying mobility [4,24]. As for the locomotive syndrome risk test, the reference values determined in this study were compatible with the values reported among independent community dwellers [15] and better than those observed in a cohort study [14]. The discrepancy could result from the difference in the study population between independent community dwellers and participants in the cohort study.

We found that the stand-up test score started to decrease even in young individuals (as young as those in their 30s). Previous studies demonstrated an age-dependent decline in knee extensor strength and joint flexibility in adulthood [26,28]. As knee extensor strength and stand-up test score are strongly correlated, decrease in the test score might also be attributed to this age-dependent decline in knee extensor strength [11]. Considering these results, we would need to develop specific interventions for young or middle generations, including health education in order to generate awareness regarding the locomotive syndrome, which would promote behavioral modifications against decrease in mobility and might help to reduce the number of disabled elderly in the future.

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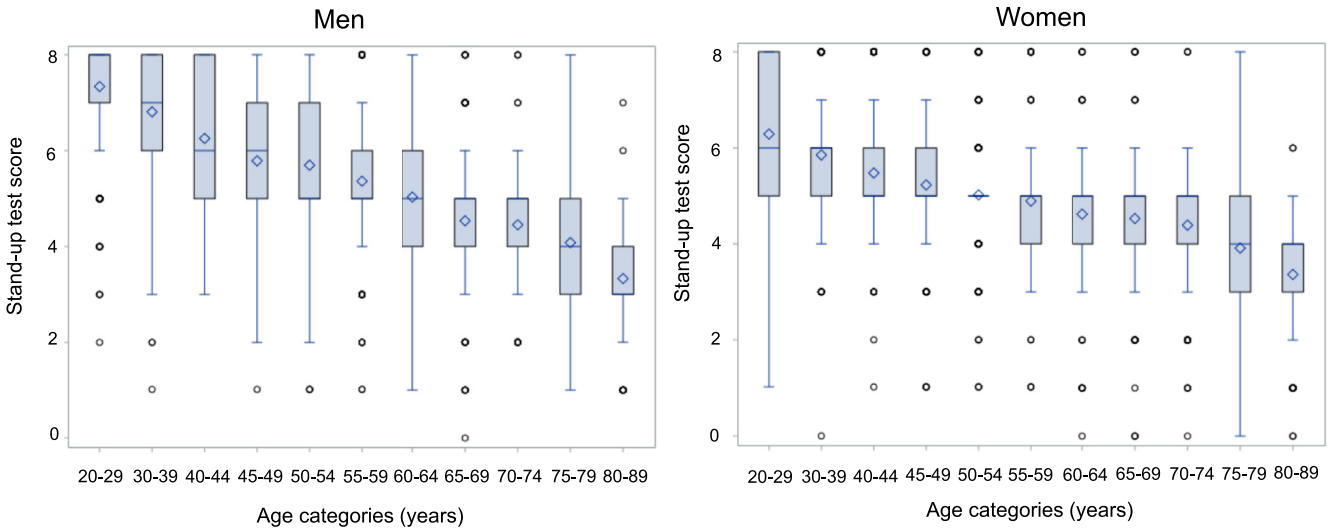

Fig. 3. Median and interquartile range of stand-up test score in age categories. The stand-up test scores decrease with aging after 30 years both in men and women.

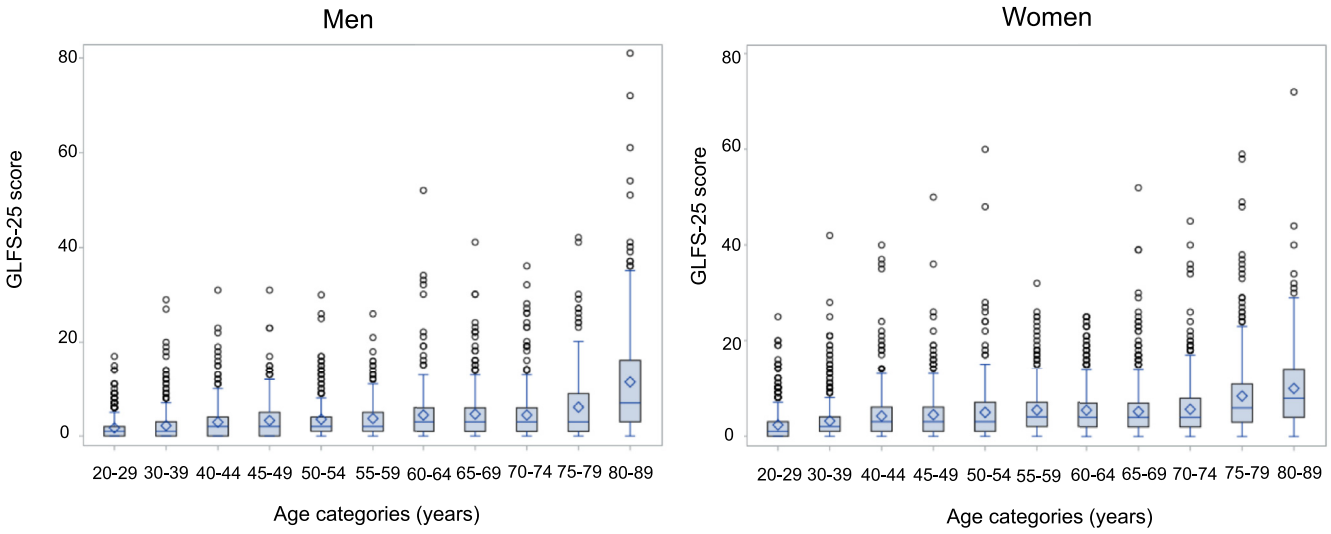

Fig. 4. Median and interquartile range of 25-Question Geriatric Locomotive Function Scale (GLFS-25) scores in age categories GLFS-25 test scores decrease gradually with age for young-to-middle aged subjects and decrease rapidly among the elderly men and women.

Table 4
Correlations between age and the three test scores.

	Two-step test score Pearson's r	Stand-up test score Spearman's rho	GLFS-25 score Spearman's rho
Age (Men)	−0.56*	−0.69*	0.32*
(Women)	−0.47*	−0.58*	0.34*

Pearson's r, Pearson's correlation; *p < 0.001 two-tailed; GLFS, geriatric locomotive function scale.

Our findings also showed that the two-step score started to deteriorate among individuals in their 40s, and its trajectories slightly differed by sex in middle-aged individuals. The difference by sex in the decrease in muscle strength across the lifespan, especially in terms of its onset and magnitude, as reported in previous studies [24,28], might affect our results. In addition, we found the trace of reference values in the two-step test score with a closer look seemed to have several change points, although such patterns of mobility decrease with age has not been previously reported. Further investigations are warranted for the detailed characteristics of the trajectory of the two-step test score across the lifetime.

Two physical test scores were more sensitive to age increase than the self-reported test. Objective performance-based physical tests were reportedly significantly associated with self-reported tests [29,30]. Our study additionally suggested that physical tests would be more helpful in detecting the mobility change among people of different ages.

Our findings indicated that the mobility of independent community dwellers was maintained to some extent even among the elderly. For example, half of individuals in their early 70s could stand up from a 40-cm stool on one leg. A majority of the elderly in this study had a better score compared to the GLFS-25 cutoff score

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of 16 [13], as well as the clinical decision limits of Stage 1 of the locomotive syndrome: starting stage of decrease in mobility, defined by the JOA (two-step test score < 1.3, or stand-up test score ≤4, or GLFS-25 score ≥ 7) [14], which would result from the characteristics of our study population, that is, the independent community dwellers who could walk without assistance of caregivers. Although decrease in mobility has been thought to have an extremely heterogeneous time course depending on individuals, especially among the elderly [4], the existence of elderly adults who could maintain one's mobility and further detailed investigation of the predictors of decrease in mobility might give us insights for maintaining mobility in the elderly population.

This study has several limitations. First, since this was a cross-sectional study, and further longitudinal studies are warranted to clarify decrease in mobility across a person's lifetime. Second, our data was not adjusted for other possible factors influencing mobility, such as physical activities or socioeconomic status. Third, there is a potential selection bias in the participants because some of them were recruited when they attended public medical check-ups or health lecture meetings and other were participants of cohort study. Additionally, the reference values in this study was derived from the independent community dwellers who could walk without caregiver's assistance, but not from all residents in Japan. As we mentioned in the background, the reference values in this study were designed as target values which the same age and sex individuals should aim to get closer, in order to maintain their mobility across the lifespan.

5. Conclusion

The reference values generated in this study could be employed to determine whether an individual has enough mobility compared to independent community dwellers of the same age and sex. We suggest that the locomotive syndrome risk test could be adopted, not only in Japan but also globally, to address the concerns of decrease in mobility leading to disability, as this study demonstrated the applicability of this test to people of widely different age groups.

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Declaration of Competing Interest

There are no conflicts of interest to declare.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jos.2020.01.011.

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