The Development of the Short-form of "25-Question Geriatric Locomotive Function Scale"

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Authors' contributions

This work was carried out in collaboration between all authors. Authors YT, YS and YK designed the study, wrote the protocol and first draft of the manuscript. Author YS designed the study, managed the study and literature searches, wrote the first draft of the manuscript. Authors SN, KM and TK analyses of the study performed the spectroscopy analysis. Authors YT, TO, MI, KA, and KM collected the data. Author NO, TS, and KK supervised the study and the data. All authors read and approved the final manuscript.

Article Information

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ABSTRACT

Objectives: In 2007, the Japanese Orthopaedic Association (JOA) proposed the term "locomotive syndrome" (LS) to describe a condition in high-risk musculoskeletal disease patients who are highly likely to require nursing care. The JOA developed a screening tool, the 25-question Geriatric Locomotive Function Scale "GLFS-25" and the 5-question Geriatric Locomotive Function Scale "GLFS-5" in 2012.
However, there are some issues about these screening tools. GLFS-25 has 25 questions, and complete response is needed to diagnose LS, but our previous studies revealed that the complete

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response rates were extremely low (50-70%). GLFS-5 which has only 5 questions and it can only screen Normal and LS, but it can't classify Grade 1 LS and Grade 2 LS. We thought we need short-form of GLFS-25 which is easier than GLFS-25 and more accurate than GLFS-5.

Methods: We developed a short-form of GLFS-25 by performing an exploratory/explanatory factor analysis (EFA) of approximately 1000 orthopaedic outpatients. We also performed confirmation studies in an additional cohort using an item response theory (IRT) analysis, a principal component analysis (PCA) and a receiver operating characteristic (ROC) analysis.

Results: We used an EFA to develop a short-form of GLFS-25 (GLFS-9), which consisted of 9 questions that were included in the GLFS-25. These 9 items were graded on the 5-point scale; the total score (0–36) was used to diagnose patients with Grade 1 LS (3–5 points) or Grade 2 LS (≥6 points) LS; while No-LS (normal) was defined by a score of ≤2 points. The ability of GLFS-9 to predict LS was confirmed by an IRT analysis, a PCA, and an ROC analysis.

Conclusion: We developed the GLFS-9 which can classify Grade 1 LS and Grade 2 LS, a short-form of the GLFS-25. We believe that the GLFS-9 may allow for the more accessible screening and prevention of LS.

1. INTRODUCTION

In 2007, the Japanese Orthopaedic Association (JOA) proposed the term "locomotive syndrome" (LS) to describe a condition in high-risk individuals with the musculoskeletal disease who are highly likely to require nursing care [1,2]. LS is caused by the weakening of the musculoskeletal organs [3-8]. The concepts of LS have been established for both elderly and young people who may be at risk of LS. Orthopaedic disease includes several diseases, such as arthritis, spondylosis, osteoporosis and trauma. Patients with these diseases might have higher risks of developing locomotor disorders in comparison to healthy individuals. Thus, to investigate the situation regarding LS and promote awareness of LS in Japan, we have been surveying orthopaedic outpatients at Juntendo University (Tokyo, Japan) since 2013 [9-12]. In 2012, the JOA developed a screening tool for LS, the 25-question Geriatric Locomotive Function Scale (GLFS-25) and the 5-question Geriatric Locomotive Function Scale (GLFS-5) [13]. The GLFS-25 consists of 25 questions. The respondent selects an answer to each question from a 5-point scale, which ranges from no impairment (0 points) to severe impairment (4 points). Upon completion of the questionnaire, the total score is calculated based on the responses to each of the 25 questions (minimum 0, maximum 100) (Tables 2, 4). Finally, GLFS-25 divides into 3 grades as Grade 1 LS, Grade 2 LS and Normal. However, GLFS-5 can't divide Grade 1 LS and Grade 2 LS [14,15]. Our previous studies conducted surveys regarding the use of the GLFS-25 and found that the response rate was low. Our survey revealed that

only 50–70% of patients answered all of the questions in the GLFS-25; we were of the opinion that this represented a critical issue both for LS and for the GLFS-25 [9-12].

Based on the results of our previous studies, we considered it necessary to develop a more straightforward questionnaire that could be used to screen for Grade 1 LS, Grade 2 LS and Normal. We, therefore, performed the present study to develop a short version of the GLFS-25 which has the ability of screen for Grade 1 LS, Grade 2 LS and Normal. The short-form of the GLFS-25 was developed using a cohort of approximately 2000 orthopaedic patients. We believe that the short-form of GLFS-25 is highly beneficial for identifying individuals with the LS, especially in the elderly population, especially in orthopaedic outpatient clinics.

2. METHODS

2.1 Subjects

We surveyed orthopaedic patients who were treated at Juntendo University Hospital (Tokyo, Japan) from March to June (a 3-month period) in the 2 years from 2014 to 2015. The total numbers of participants in 2014 and 2015 were 1027 and 1021, respectively. The final cohorts of the study included 664 of the 1027 patients (64.7%) who took part in the 2014 survey and 513 of the 1021 (50.2%) patients who took part in the 2015 survey. In this study, patients who answered all of the questions from the GLFS-25 were included (Table 1). To develop the short-form of the GLFS-25, we divided the 2 cohorts into a discovery cohort [2014] and validation

cohort (2015). All studies were conducted according to protocols approved by the Ethics Committee of Juntendo University.

2.2 The GLFS-25 Questionnaire

The GLFS-25 consists of 25 items: i) 4 questions on pain during the previous month; ii) 16 questions on pain during activities of daily living during the previous month; iii) 3 questions on social functions; and iv) 2 questions on the subject's mental status during the previous month (Table 2) [13]. The respondents selected the answers to these 25 items from a 5-point scale that ranged from no impairment (0) to severe impairment [4]. The responses were then summed to determine the total score (minimum 0, maximum 100). Based on their scores, the patients were classified into one of the following grades: No-LS (normal) (≤6 points), Grade 1 LS (7–15 points), or Grade 2 LS (≥16 points) (Tables 2,4) [13].

2.3 Statistical Analysis

All of the statistical analyses were performed using the SAS software program (version 9.4) (SAS Institute, State of North Carolina, America) and the SPSS software program for Windows, version 21.0 (IBM, Chicago, IL, USA).

2.3.1 The exploratory/explanatory factor analysis

To select the question items and develop the short-form of GLFS-25, we performed an exploratory/explanatory factor analysis (EFA) using the 664 cases of the 2014 cohort (Fig. 1). A dimensionality assessment was performed by combining an exploratory factor analysis (EFA) with maximum likelihood estimation and an expert review of the content. The factors were rotated both orthogonally (Varimax) and obliquely (Promax).

2.3.2 The item response theory analysis

An item response theory (IRT) analysis was employed to reveal both the test information of the GLFS-25 and the temporal short-form of the GLFS-25. The IRT analysis also demonstrated the item characteristic curves of each of the questions on the GLFS-25. (Fig. 2A).

2.3.3 The principal component analysis

To assess the degree of correlation among items, a principal component analysis (PCA) was

performed to determine Cronbach's α, which reflected the internal consistency of the scale in each of the questions [16]. A Cronbach's α value of 0.7 is widely considered to reflect an acceptable correlation, 0.7–0.9 reflects good correlation, and >0.9 reflects excellent correlation (some of the scales may have included redundancies) [17-19] (Fig. 2B).

2.3.4 The receiver operating characteristic analysis

A receiver operating characteristic (ROC) analysis was performed and the ROC curve was used to evaluate the diagnostic value of the short-form of GLFS-25 (Fig. 3).

3. Results

3.1 The Exploratory/Explanatory Factor Analysis

The EFA using our 2014 cohort (n=664) showed a 3-factor solution produced the best results by the maximum likelihood estimation. Based on the grouping, we selected 9 questions (3 questions for each group of factors) (Fig. 1). We finally selected the following question items: 1st group (Q18, 22, 23); 2nd group (Q8, 10, 11); and 3rd group (Q3, 12, 13). The items with higher value factors were selected (Fig. 1). Each of the 3 groups was also categorised by the mean clinical values (shown in detail in Discussion). We next performed a confirmation analysis using these 9 selected questions as the short-form of GLFS-25 (Figs 2, 3).

3.2 The Item Response Theory Analysis

An IRT analysis of the 2014 cohort (n=664) was performed. Each question in the GLFS-25 was graded on a 5 point scale from no impairment (0) to severe impairment [4]. The item characteristic curve (ICC) reveals the probability of an item response to the trait that is being measured (θ). The threshold (location) parameters revealed the level to which an underlying attribute is most likely to be reflected in a particular response category. The discrimination (slope) parameters reflected the item's discrimination between different levels of the attribute [20-23].

The IRT analysis was used to determine the 5-item characteristic curves (scales) from the 5-point scales of the GLFS-25 for each of the 25 questions (Fig. 2A). In the lower number questions (e.g., Q4, 5, and 6), responses of 2, 3,

and 4 tended to indicate significant separation and an excellent analysis. However, in the higher number questions (e.g., 22, 23, and 24), these scales had similar characteristic curves and poor separation (Fig. 2A). These findings might be significant for supporting the rationality of the present (we discussed details of our findings regarding IRT analysis in Discussion).

3.3 The Principal Component Analysis

A PCA of the 25 questions was performed to determine the Cronbach's α values. The results showed that the 1st (including Q18, 22, 23), 2nd (including Q8, 10, 11) and 3rd groups (including Q3, 12, 13) had Cronbach's α values of 0.8801, 0.8786 and 0.8052, respectively, which was considered to reflect an adequate correlation [14-17] (Fig. 2B).

3.4 The Receiver Operating Characteristic Analysis

3.4.1 The ROC analyses of the 2014 cohort as a test study

Consistently with the original GLFS-25, in the 9 selected questions in the short-form of GLFS-25 we also used a 5-point scale that ranged from no

impairment (0) to severe impairment [4]. The minimum and maximum total scores were 0 and 36, respectively (Tables 3, 4).

We performed an ROC analysis to determine the cut-off value for a diagnosis of LS in the short-form of GLFS-25. The analysis revealed that the area under the ROC curve values were 0.96746 (Grade 2 LS) and 0.95439 (Grade 1 LS) (Fig. 3). The ROC analysis demonstrated the sensitivity and specificity of each cut-off value (0-36) for diagnosing LS (Fig. 3). Finally, based on the cutoff values that were calculated from the results, we determined that a score of 3–5 points corresponded to Grade 1 LS (sensitivity, 0.8591; specificity, 0.9244) and that a score of ≥6 points corresponded to Grade 2 LS (sensitivity, 0.8765; specificity, 0.9469) (Fig. 3).

3.4.2 The ROC analysis of the 2015 cohort as a validation study

To verify the diagnostic value of the short-form of GLFS-25, we performed an ROC analysis using the 2015 cohort. The sensitivity and specificity of the definition for Grade 1 LS was 0.8480 and 0.7554. Similarly, the sensitivity and specificity of the definition for Grade 2 LS was 0.9270 and 0.8896.
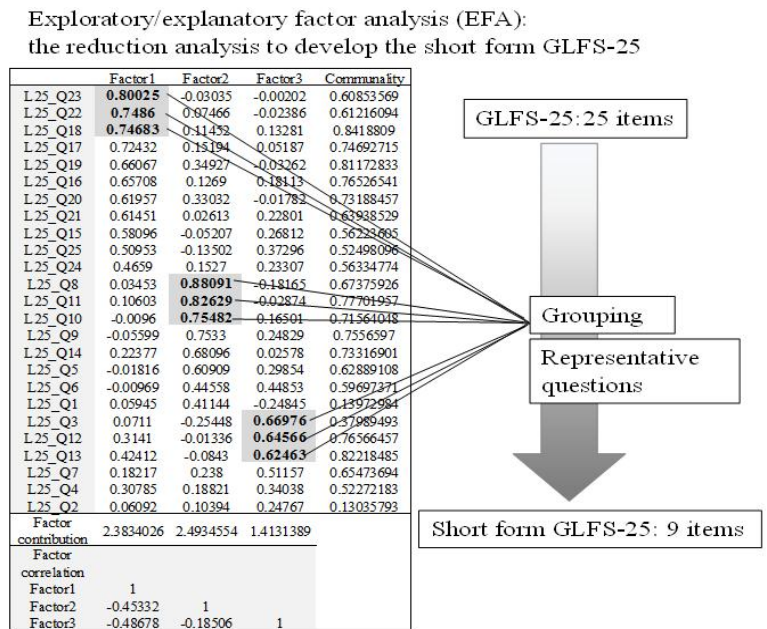

Fig. 1. The statistical analyses to develop the short-form of GLFS-25 questionnaire.
First, we performed the reduction analysis to develop the short form of GLFS-25. The EFA was performed to divide all of the questions into 3 domains. We selected 3 questions from each dimension and finally selected 9 questions for the short-form of GLFS-25 questionnaire

2A. Item response therapy (IRT)

Amount of test information

Item characteristic curve
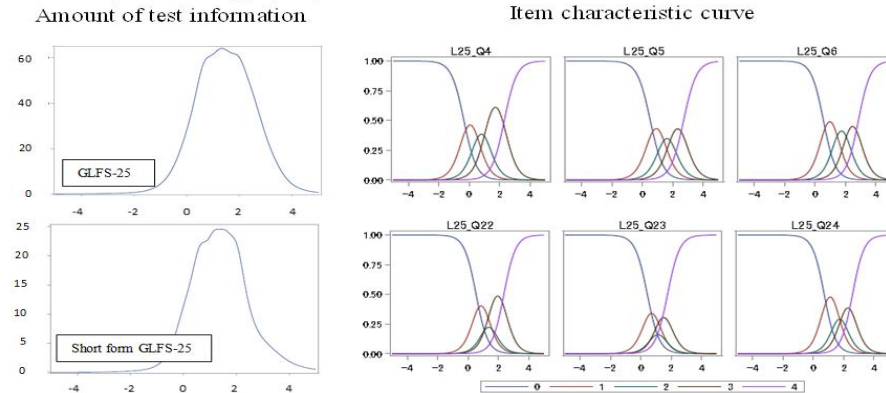
2B. Principal component analysis (PCA)

|		Cronbach α		Correlation		
	Total	0.8801		L25_Q18	L25_Q22	L25_Q23
	L25_Q18	0.8733	L25_Q18	1.0000		
Factor 1	L25_Q22	0.7974	L25_Q22	0.6848	1.0000	
	L25_Q23	0.8121	L25_Q23	0.6821	0.7880	1.0000
	Total	0.8786		L25_Q8	L25_Q10	L25_Q11
	L25_Q8	0.8705	L25_Q8	1.000		
Factor 2	L25_Q10	0.8428	L25_Q10	0.621	1.000	
	L25_Q11	0.7634	L25_Q11	0.729	0.777	1.000
	Total	0.8052		L25_Q3	L25_Q12	L25_Q13
	L25_Q3	0.9006	L25_Q3	1.000		
Factor 3	L25_Q12	0.6466	L25_Q12	0.476	1.000	
	L25_Q13	0.6371	L25_Q13	0.478	0.829	1.000
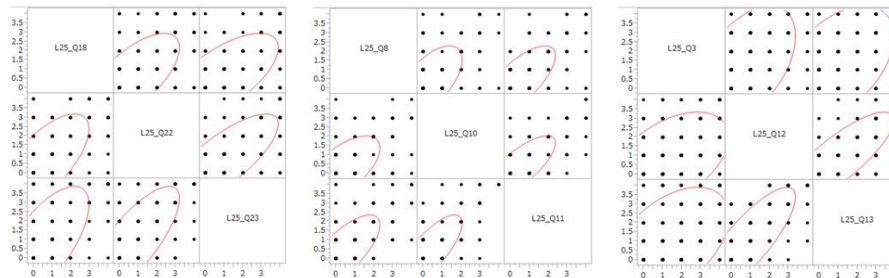
Fig. 2. The confirmation analyses including IRT and PCA.

The IRT and the PCA analyses confirmed the ability of the short-form of GLFS-25 to diagnose LS. (A) IRT was applied to the investigate aspects such as the amount of test information and the item characteristic curves. (B) The PCA was used to determine the Cronbach's α values.

3.5 The Introduction of the Test Criteria for the short-form of GLFS-25

As noted previously, the short-form of GLFS-25 consisted of 9 items that were selected from the original 25 question items in the GLFS-25. The 9 items were divided into 3 groups (1st group, Q18, 22, and 23; 2nd group, Q8, 10, and 11; 3rd group, Q3, 12, and 13) based on our analyses. These 9 items were graded on the abovementioned 5-point scale (Tables 3, 4); the total score (0–36) was used to diagnose patients with Grade 1 LS (3–5 points) or Grade 2 LS (≥6 points) LS; while No-LS (normal) was defined by a score of ≤2 points (Tables 3, 4).

4. DISCUSSION

Based on the health promotion policies of the World Health Organization, the Ministry of Health, Labour and Welfare in Japan has promoted the "National Health Promotion Movement in the 21st Century (Health Japan 21)" since 2000. "Health Japan 21" aims to reduce the number of deaths of people in the prime of their life, prolong the healthy years of life, and to improve people's quality of life (QOL) to facilitate the establishment of a vigorous society in which all citizens can live in good physical and mental health. In 2007, the Japanese Orthopaedic Association (JOA) proposed the term locomotive syndrome (LS) to
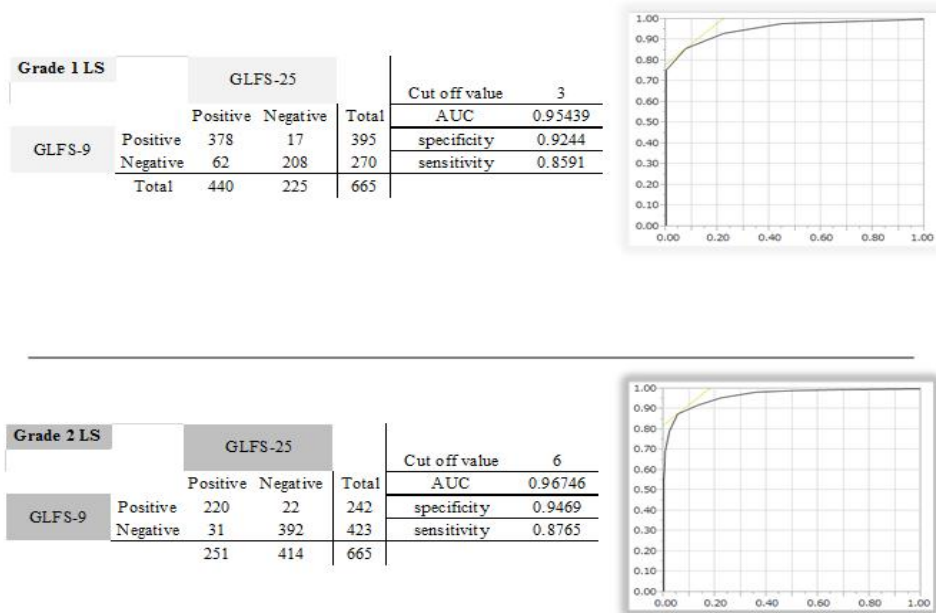
Grade 1 LS		GLFS-25				Cut off value	3
		Positive	Negative	Total		AUC	0.95439
GLFS-9	Positive	378	17	395		specificity	0.9244
	Negative	62	208	270		sensitivity	0.8591
	Total	440	225	665			

Grade 2 LS		GLFS-25				Cut off value	6
		Positive	Negative	Total		AUC	0.96746
GLFS-9	Positive	220	22	242		specificity	0.9469
	Negative	31	392	423		sensitivity	0.8765
		251	414	665			

Fig. 3. The confirmation analyses of the ROC analysis.
The ROC analysis confirmed the ability of the short-form of GLFS-25 to diagnose LS. The ROC analysis confirmed the sensitivity, specificity and cut-off value of the short-form in the diagnosis of LS

describe a condition in high-risk musculoskeletal disease patients who are highly likely to require nursing care [1, 2]. "In 2012,"Kenkou-nihon 21", the Ministry of Health, Labour and Welfare, Japan set a goal that 80% of the population would recognize the term LS in 2020. Thus, the JOA and Japanese Locomo Challenge Promotion Conference (JLCPC) launched campaigns to raise awareness in relation to LS. The JLCPC reported that the recognition rate is grown steadily higher, from 17.3% in 2012 to 47.3% in 2016 [24]. The JOA developed the GLFS-25 as one of the tools for screening for LS.

Officially, three tools are currently used to detect LS: the GLFS-25, the 2-steps test, and the stand–up test [25]. The stand-up test and the 2-steps test are exercise tests and are sometimes difficult and dangerous for elderly individuals to perform, especially those with disease or pain. In contrast, the highly versatile GLFS-25 is a questionnaire, which makes it applicable to all patients. The GLFS-25 therefore seems to be the most useful and convenient test. Furthermore, it may help to increase awareness about LS and even become a tool that can be used in the prevention of LS (Tables 2, 4). However, in our 4-year study, in which we analyzed approximately 1000 patients per year, we found that it was difficult for participants to answer all 25 questions of the GLFS-25, due to the length of the

questionnaire [9-12], it takes time and effort for elderly individuals to answer the questions completely. Our data revealed that the questionnaire completion rate was only 50-70% [9-12]. Unfortunately GLFS-5 can't classify Grade 1 LS and Grade 2 LS. Based on our studies and these backgrounds, we thought that this was a critical limitation, both in its use as a screening tool and in its use in efforts to prevent LS. Thus, we performed the present study to develop a short-form of the GLFS-25 which can divides into Grade 1 LS, Grade 2 LS and Normal for ortho-outpatient clinic to allow for simpler LS screening.

With respect to our previous studies, since 2013, we have distributed questionnaires regarding LS to the approximately 1000 outpatients who visit the department of orthopedics in our hospital each year [9-12]. In order to develop the short-form of GLFS-25 for ortho-outpatient clinic, we analyzed the data of 2048 outpatients who visited our hospital in 2014 (test set) and 2015 (validation set) (Table 1). In the test set, to establish the short-form of GLFS-25, we analyzed the results of the 664 patients who completely answered the questionnaire in 2014 and conducted statistical analyses, including an EFA, IRT, a PCA, and an ROC analysis (Figs 1-3). To confirm the validity of our short-form of GLFS-25, we conducted a validation study of the 513 patients who completely answered our

questionnaire in 2015 and performed an ROC analysis. The sensitivity and specificity of the definition for Grade 1 LS was 0.8480 and 0.7554. Similarly, the sensitivity and specificity of the definition for Grade 2 LS was 0.9270 and 0.8896.

In the EFA, the analysis classified the 25 questions of the GLFS-25 into 3 factors. Based on these results, we selected 3 questions from each group and we created the short-form of GLFS-25, which consisted of 9 questions. We verified the 9 questions that were selected by the EFA with IRT, a PCA, and an ROC analysis. The EFA revealed the characteristics of each factor in the GLFS-25 and allowed us to extract the 9 questions that represented each group. We found that the 3-factor classification best reflected the GLFS-25 by the maximum likelihood method (Fig. 1). Interestingly, the classification of the 3 categories by the EFA indicated that: i) Factor 1 mainly included daily outdoor living matters; ii) the Factor 2 questions were associated with daily indoor living matters; and iii) the Factor 3 questions were associated with the lower limb functions.

The IRT analysis of the item characteristic curves revealed significant differences in the item characteristic curves of the 5-grade answer options of the lower question numbers (e.g., Q4, 5, and 6). This result suggested that these questions were useful for diagnosing LS. In contrast, the characteristic curves of the later questions (e.g., Q22, 23, and 24), had similar and closed lines and there were no significant differences in the item characteristic curves of the 5-grade answer options (Fig. 2A). These results suggest that these questions were not suitable. Based on these findings, we hypothesized that the respondent gradually became tired or bored when completing the GLFS-25. We therefore believe that our short-form of GLFS-25 will make it possible to screen large numbers of people for LS, especially elderly individuals and patients.

In the PCA, the Cronbach's α values revealed that the results of our short-form of GLFS-25 were significantly correlated with the results of the GLFS-25 and showed statistical significance among the 3 categories that were selected by the EFA (Fig. 2B).

In the ROC analyses of the verification set, we verified the diagnostic ability of our short-form of GLFS-25 to divide the patients (from the 2014 cohort) with and without LS who had been diagnosed using the GLFS-25. It was found that the short-form of GLFS-25 could accurately divide the patients with and without LS and that the diagnoses were highly correlated with the diagnoses made using the GLFS-25. These results show that we were successful in developing a short-form of GLFS-25, which consisted of 9 questions with 3 dimensions. The ROC values revealed the high accuracy in the two different groups, with "Sensitivity-(1-specificity)" values of 0.7835 (Grade 1 LS in 2014), and 0.8234 (Grade 2 LS in 2014) (Fig. 3).

Table 1. The data of the participants

Year			2014	2015
General Information		Number surveyed	1027	1021
		Number analyzed	664	513
		Male	277	256
		Female	387	257
		Age	52.3	51.0
GLFS25	Mean		17.11	17.35
	95% Confidence	Lower Bound	15.75	15.68
	Interval for Mean	Upper Bound	18.48	19.02
	5% trimmed mean		15.12	15.14
	Median		11.00	10.00
	Variance		322.69	371.03
	Standard deviation		17.96	19.26
	Minimum		0.00	0.00
	Maximum		93.00	96.00
	Range		93.00	96.00
	Interquartile range		18.00	20.50
	Skewness		1.68	1.72
	Kurtosis		2.55	2.59

Table 2. The 25-Question geriatric locomotive function scale

	0 points	1 point	2 points	3 points	4 points
(1) Did you have any pain (including numbness) in your neck or upper limbs (shoulder, arm, or hand)?	No pain	Mild pain	Moderate pain	Considerable pain	Severe pain
(2) Did you have any pain in your back, lower back or buttocks?	No pain	Mild pain	Moderate pain	Considerable pain	Severe pain
(3) Did you have any pain (including numbness) in your lower limbs (hip, thigh, knee, calf, ankle, or foot)?	No pain	Mild pain	Moderate pain	Considerable pain	Severe pain
(4) To what extent has it been painful to move your body in daily life?	No pain	Mild pain	Moderate pain	Considerable pain	Severe pain
(5) To what extent has it been difficult to get up from a bed or lie down?	Not difficult	Mildly difficult	Moderately difficult	Considerably difficult	Extremely difficult
(6) To what extent has it been difficult to stand up from a chair?	Not difficult	Mildly difficult	Moderately difficult	Considerably difficult	Extremely difficult
(7) To what extent has it been difficult to walk inside the house?	Not difficult	Mildly difficult	Moderately difficult	Considerably difficult	Extremely difficult
(8) To what extent has it been difficult to put on and take off shirts?	Not difficult	Mildly difficult	Moderately difficult	Considerably difficult	Extremely difficult
(9) To what extent has it been difficult to put on and take off trousers and pants?	Not difficult	Mildly difficult	Moderately difficult	Considerably difficult	Extremely difficult
(10) To what extent has it been difficult to use the toilet?	Not difficult	Mildly difficult	Moderately difficult	Considerably difficult	Extremely difficult
(11) To what extent has it been difficult to wash your body in the bath?	Not difficult	Mildly difficult	Moderately difficult	Considerably difficult	Extremely difficult
(12) To what extent has it been difficult to go up and down stairs?	Not difficult	Mildly difficult	Moderately difficult	Considerably difficult	Extremely difficult
(13) To what extent has it been difficult to walk briskly?	Not difficult	Mildly difficult	Moderately difficult	Considerably difficult	Extremely difficult
(14) To what extent has it been difficult to keep yourself neat?	Not difficult	Mildly difficult	Moderately difficult	Considerably difficult	Extremely difficult
(15) How far can you keep walking without rest?	More than 2-3 km	Approximately 1 km	Approximately 300 m	Approximately 100 m	Approximately 10 m
(16) To what extent has it been difficult to go out to visit neighbors?	Not difficult	Mildly difficult	Moderately difficult	Considerably difficult	Extremely difficult

	0 points	1 point	2 points	3 points	4 points
(17) To what extent has it been difficult to carry objects weighing approximately 2 kilograms (2 standard milk bottles or 2 PET bottle each containing 1 liter of liquid)?	Not difficult	Mildly difficult	Moderately difficult	Considerably difficult	Extremely difficult
(18) To what extent has it been difficult to go out using public transportation?	Not difficult	Mildly difficult	Moderately difficult	Considerably difficult	Extremely difficult
(19) To what extent have simple tasks and housework (preparing meals, cleaning up, etc.) been difficult?	Not difficult	Mildly difficult	Moderately difficult	Considerably difficult	Extremely difficult
(20) To what extent have load-bearing tasks and housework (cleaning the yard, carrying heavy bedding, etc.) been difficult?	Not difficult	Mildly difficult	Moderately difficult	Considerably difficult	Extremely difficult
(21) To what extent has it been difficult to perform sports activity (jogging, swimming gate ball, dancing, etc.)?	Not difficult	Mildly difficult	Moderately difficult	Considerably difficult	Extremely difficult
(22) Have you been restricted from meeting your friends?	Not restricted	Slightly restricted	Restricted about half the time	Considerably restricted	Gave up all activities
(23) Have you been restricted from joining social activities (meeting friends, playing sport, engaging in activities and hobbies, etc.)?	Not restricted	Slightly restricted	Restricted about half the time	Considerably restricted	Gave up all activities
(24) Have you ever felt anxious about falls in your house?	Have not felt anxious	Have occasionally felt anxious	Have sometimes felt anxious	Have often felt anxious	Have constantly felt anxious
(25) Have you ever felt anxious about being unable to walk in the future?	Have not felt anxious	Have occasionally felt anxious	Have sometimes felt anxious	Have often felt anxious	Have constantly felt anxious

All questions are closed questions.

Table 3. The short form of the 25-question Geriatric Locomotive Function Scale (GLFS-9)

	0 points	1 point	2 points	3 points	4 points
Did you have any pain (including numbness) in your lower limbs (hip, thigh, knee, calf, ankle, or foot)?	No pain	Mild pain	Moderate pain	Considerable pain	Severe pain
To what extent has it been difficult to put on and take off shirts?	Not difficult	Mildly difficult	Moderately difficult	Considerably difficult	Extremely difficult
To what extent has it been difficult to use the toilet?	Not difficult	Mildly difficult	Moderately difficult	Considerably difficult	Extremely difficult
To what extent has it been difficult to wash your body in the bath?	Not difficult	Mildly difficult	Moderately difficult	Considerably difficult	Extremely difficult
To what extent has it been difficult to go up and down stairs?	Not difficult	Mildly difficult	Moderately difficult	Considerably difficult	Extremely difficult
To what extent has it been difficult to walk briskly?	Not difficult	Mildly difficult	Moderately difficult	Considerably difficult	Extremely difficult
To what extent has it been difficult to go out using public transportation?	Not difficult	Mildly difficult	Moderately difficult	Considerably difficult	Extremely difficult
Have you been restricted from meeting your friends?	Not restricted	Slightly restricted	Restricted about half the time	Considerably restricted	Gave up all activities
Have you been restricted from joining social activities (meeting friends, playing sport, engaging in activities and hobbies, etc.)?	Not restricted	Slightly restricted	Restricted about half the time	Considerably restricted	Gave up all activities

All questions are closed questions.

Furthermore, the total score in our short form could range from 0 to 36 points and the distribution of the total scores allowed the patients to be divided into three categories: No-LS (normal) (0–2 points), Grade 1 LS (3–5 points), and Grade 2 LS (≥6 points) (Tables 3, 4). In contrast, the definitions according to the original total score (0–100) of the GLFS-25 were as follows: No-LS (0–6 points), Grade 1 LS (7–15 points), and Grade 2 LS ≥16 points) (Table 2, 4). We are of the opinion that the short-form of GLFS-25 might do more than simply assign a value—rather, we think that it might provide a screening with a theoretical basis. In the ROC analyses of the validation set (the 2015 cohort), we verified the diagnostic ability of the short-form of GLFS-25 with the new cut-off values for LS. The validation study showed the high accuracy in two different groups The sensitivity and specificity of the definition for Grade 1 LS was 0.8480 and 0.7554. Similarly, the sensitivity and specificity of the definition for Grade 2 LS was 0.9270 and 0.8896. Additionally, we compared the accuracy of the diagnosis between GLFS-9 and GLFS-5 using the validation cohort consisting of ortho-outpatient clinic data in 2015. The analyses of GLFS-5 demonstrated that sensitivity 0.7416 and specify 0.9940 (for Grade LS 2). These comparison between GLFS-5 and GLFS-9 indicated the sensitivities of GLFS-9 was slightly higher than GLFS-5. Furthermore GLFS-5 couldn't detect Grade 1LS due to screening systemic issues. We believe that these results show that the new short-form of GLFS-25 which can classify Grade 1 LS and Grade 2 LS maybe be useful for both research and clinical applications in ortho-outpatient clinic.

The present study is associated with some limitations. Importantly, we analyzed the patients of the department of orthopedics in our hospital. Thus, the results might need to be confirmed in studies of other populations to define whether the short form is useful or not.

Table 4. GLFS-9 and GLFS-25

	GLFS-9	GLFS-25
Items Number	9	25
Total points Cut-off value	0-36 points	0-100 points
Normal	0-2 points	0-6 points
Locomo grade Ⅰ	3-5 points	7-15 points
Locomo grade Ⅱ	6-36 points	16-100 points

5. CONCLUSION

Every year, since 2013, we have surveyed approximately 1,000 patients on the topic of a locomotive syndrome in Juntendo University Hospital (Tokyo, Japan). In this study, we analyzed the results of approximately 2,000 patients who were treated in 2014 and 2015 to develop the short-form of GLFS-25. Several confirmation studies revealed that our short-form of GLFS-25 had good screening value that was comparable to the original GLFS-25. We believe that the short-form of GLFS-25 may be useful for facilitating the easier screening of LS and for efforts to prevent LS.

CONSENT

It is not applicable.

ETHICAL APPROVAL

As per international standard or university standard, written approval of Ethics committee has been collected and preserved by the author(s).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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