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A Comparative Study of 2 Screening Tools for Locomotive Syndrome (The "Loco-check" and the "GLFS-25"): An Orthopedic Outpatient-based Survey

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Authors' contributions

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

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ABSTRACT

Background: In 2007, the Japanese Orthopaedic Association (JOA) proposed the term "locomotive syndrome" (LS) to designate a condition in high-risk groups with musculoskeletal diseases who are highly likely to require nursing care. The JOA developed two screening tools for LS: The 25-question Geriatric Locomotive Function Scale ("GLFS-25") and the "Loco-check". The present study represents the first comparison of these tools.

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Methods: To compare the diagnostic abilities and characteristics of the two diagnostic tools, we investigated the associations of LS with clinical information including the general status, orthopedic diseases (degenerative diseases), past history (general diseases) and exercise activities using a questionnaire survey employing both diagnostic tools at Juntendo University Hospital (Tokyo, Japan) from April to June 2014.
Results: 664 of 1,027 patients answered both questionnaires. Three hundred nineteen (48.0%) and 251 (37.8%) were diagnosed with LS according to the "Loco-check" and "GLFS-25", respectively. Our survey indicated that the "Loco-check" had a 10.2% higher detection rate than the "GLFS-25". The correlation between the scores was investigated. The Spearman's rank coefficient was r=0.454 and the area under the curve (AUC) value was 0.8181, which indicated a moderate correlation. We then investigated the associations between LS and the clinical factors of the patients. The results showed that female gender, advanced age, a high BMI, lumbar spondylosis and heart disease were significantly associated with a diagnosis of LS with both of the diagnostic tools.
Conclusions: We investigated the associations between the prevalence of LS and ortho-clinical information in an outpatient cohort based on both the "Loco-check" and the "GLFS-25". These analyses are the first to report compared statistical associations between both tools. These analyses also provide critical information to help clinicians determine whether to use the "Loco-check" or "GLFS-25" in various situations.

Keywords: Locomotive syndrome; orthopeadics; GLFS-25; loco-check.

1. INTRODUCTION

Locomotive syndrome (LS) is condition associated with a need for nursing care due to unstable posture and locomotion in high-risk groups with musculoskeletal diseases. The concept was initially proposed by The Japanese Orthopedic Association (JOA) in 2007 [1-3]. This syndrome is caused by weakness of the musculoskeletal organs such as the bones, joints and muscles. The musculoskeletal dysfunction induced gait disorder, pain, limited range of joint motion and muscle weakness. "In 2012, "Kenkou-nihon 21" by the Ministry of Health, Labour and Welfare, Japan set a goal that 80% of the population would recognize the term LS in 2020 [4]. Therefore, the JOA and Japanese Locomo Challenge Promotion Conference (JLCPC) launched campaigns to raise awareness of LS [5].

At the present time, there are 2 diagnostic tools used to assess a patient for LS. These are the "Loco-check" and the 25-question Geriatric LS Scale ("GLFS-25") [3,6]. The "Loco-check" was developed in 2007 by the JOA, and the JLCPC has been using it extensively to self-screen the general population [3]. On the other hand, the "GLFS-25" was developed in 2012 and its sensitivity and specificity for predicting disability has been assessed by Seichi et al. [6]. The "GLFS-25" has been described as a new screening tool to detect the risk of LS in subjects of all ages [6]. However, differences in the optimum age, gender, and disease for application between the two screening tools are not completely understood, hampering their appropriate usage in suitable situation Therefore, in this study we conducted a questionnaire survey using both 2 screening tools.

We analyzed the survey in a 3 step process (see below). ① We collected the questionnaire responses for the "Loco-check" and "GLFS-25" along with the clinical information from 1,027 orthopedic patients. ② In order to elucidate the correlations of LS diagnosis between the 2 tools, we calculated the sensitivity of the LS diagnoses in both the "Loco-check" and "GLFS-25" screening tools and analyzed the statistical associations of the LS diagnoses between the 2 tools using Spearman's rank correlation coefficient and receiver operating characteristic (ROC) curve analyses. ③ To clarify and understand the reasons for the discrepancy and differences of LS diagnoses between the 2 tools, we conducted comparative studies to analyze the associations between LS and the clinical information, including the general status, orthopedic diseases (degenerative diseases), past history (general diseases) and excise activities, using the 2 diagnostic tools.

2. MATERIALS AND METHODS

2.1 Outpatient Cohort and Clinical Information

Our project (IRB No.13-007) was approved by the institutional review board (IRB) of the study

centers in the Juntendo University Hospital (Tokyo, Japan). To investigate the associations of LS with the clinical information, including the general status, orthopedic diseases, past history and exercise activities, we performed a questionnaire survey using both the "Loco-check" and the "GLFS-25" at Juntendo University Hospital from April to June 2014. We focused on new patients who came to our department for the first time or who had new diseases, even if they had visited our department in the past. We investigated the data from 1,027 orthopedic patients (450 males and 577 females; age, 5-94 years; mean age, 52.3 years). Our questionnaire consisted of the "Loco-check" and the "GLFS-25", as well as the frequency of exercise and type of exercise. Orthopedic diseases were diagnosed as usual, and the KL classifications of arthritis were defined by board-certified orthopedists. We also acquired clinical information and information about past histories from the medical records.

2.2 The "Loco-check" Questionnaire

We used the "Loco-check", which consisted of 7statements, and participants who checked yes to one or more statements were defined as having LS following the regular diagnostic rules (Supplemental Table 1).

2.3 The "GLFS-25" Questionnaire

We used the "GLFS-25", which consisted of 25 items, including 4questions regarding pain during the last month, 16 questions regarding pain during activities of daily living during the last month, 3 questions regarding social functions, and 2 questions regarding the mental status during the last month (Supplemental Table 2). These 25 items were graded on 5point scales from no impairment (0) to severe impairment (4), and then the scores were added to produce a total score (minimum 0, maximum 100). These scores were classified as LS (Stage Ⅱ): over 16 points, Stage Ⅰ: 7-15 points, and Normal: less than 6 points [7].

2.4 Diagnosis of Orthopedic Diseases and Radiographic Diagnoses

According to the patient's chief complaints and physical examinations, we examined their X-rays and diagnosed orthopedic diseases. All radiographs were graded by 2 orthopedic surgeons. If there was a disagreement in their findings, they came to a conclusion after a discussion amongst themselves. We especially focused on knee osteoarthritis (OA), hip OA, cervical spondylosis and lumbar spondylosis because these diseases are generally considered to be associated with degenerative changes. Regarding the X-rays of patients with OA and spondylosis, the severity of each joint and the intervertebral level were scored according to the Kellgren-Lawrence grade (K-L grade) [8].

2.5 Statistical Analysis

Correlations of LS diagnoses between the "Loco-check" and "GLFS-25" were analyzed by Spearman's rank coefficient and ROC curve analyses. Spearman's correlation coefficient was calculated as r-values and the ROC was estimated by the area under the curve (AUC).

To clarify the factor(s) influencing LS, the relationships between LS according to the "Loco-check" and the variables were assessed using a logistic regression analysis that calculated the odds ratios (OR) after adjusting for age, BMI and gender, and the results included 95% confidential intervals (CI). Another analysis conducted based on the "GLFS-25" was also assessed by a multinomial logistic regression analysis. We used the diagnosis of LS as the dependent variable in our logistic regression models. A value of $p < 0.05$ was considered to be statistically significant, and all tests were 2-sided. The data analyses were conducted using the SPSS software program for Macintosh, version 21.0 (IBM, Chicago, IL, USA).

3. RESULTS

In the first step of our study, 697 (67.9%) patients out of 1,027 total patients answered the "Loco-check" while 754 (73.4%) patients answered the "GLFS-25". Among these patients, 664 (64.7%) answered both the "Loco-check" and the "GLFS-25". A total of 319 (48.0%) of the 664 patients were diagnosed with LS according to the "Loco-check". According to the "GLFS-25", 251 (37.8%) of the 664 patients were diagnosed with LS (stage Ⅱ). Regarding the comparison of the LS diagnostic rate between the 2 diagnostic tools, the "Loco-check" had a 10.2% higher diagnostic rate than the "GLFS-25". We determined that approximately 10.0% of the differences in the LS diagnosis rate were due to "baseline discrepancies" between the "Loco-check" and "GLFS-25" (Table 1).

Table 1. The prevalence of LS based on the patient characteristics

Loco-check & GFLS-25 (n=664)				Loco-check (n=664)		GFLS-25 (n=664)				Difference
Variables	**Subcategory**	**LS**	**% LS**	**LS**	**% LS**	**LS (Stage Ⅱ)**	%	**Stage Ⅰ**	**%**	**% LS (Loco-check-GFLS25)**
	Total (n=664)	**190**	**28.6%**	**319**	**48.0%**	**251**	**37.8%**	**189**	**28.5%**	**10.2%**
Gender	Female (n=387)	118	30.5%	198	51.2%	159	41.1%	119	30.7%	10.1%
	Male (n=277)	72	26.0%	121	43.7%	92	33.2%	70	25.3%	10.5%
Age	≧80s (n=20)	14	70.0%	17	85.0%	16	80.0%	3	15.0%	5.0%
	70s (n=107)	55	51.4%	80	74.8%	62	57.9%	28	26.2%	16.8%
	60s (n=137)	34	24.8%	69	50.4%	50	36.5%	45	32.8%	13.9%
	50s (n=126)	35	27.8%	59	46.8%	46	36.5%	39	31.0%	10.3%
	40s (n=113)	27	23.9%	50	44.2%	38	33.6%	35	31.0%	10.6%
	30s (n=87)	19	21.8%	31	35.6%	29	33.3%	23	26.4%	2.3%
	≦20s (n=74)	6	8.1%	13	17.6%	10	13.5%	16	21.6%	4.1%
BMI	≧30 (n=20)	11	55.0%	16	80.0%	13	65.0%	3	15.0%	15.0%
	＜30 (n=113)	37	32.7%	70	61.9%	46	40.7%	41	36.3%	21.2%
	＜25 (n=366)	99	27.0%	165	45.1%	132	36.1%	96	26.2%	9.0%
	＜20 (n=153)	38	24.8%	59	38.6%	55	35.9%	44	28.8%	2.6%
Exercise	Heavy (n=145)	24	16.6%	52	35.9%	31	21.4%	41	28.3%	14.5%
	Light (n=178)	52	29.2%	88	49.4%	69	38.8%	51	28.7%	10.7%
	No (n=297)	100	33.7%	157	52.9%	133	44.8%	86	29.0%	8.1%
Orthopedic diseases	Knee OA (n=58)	29	50.0%	40	69.0%	31	53.4%	17	29.3%	15.5%
(Degenerative diseases)	Hip OA (n=14)	5	35.7%	10	71.4%	6	42.9%	6	42.9%	28.6%
	Cervical spondylosis (n=35)	9	25.7%	17	48.6%	13	37.1%	12	34.3%	11.4%
	Lumbar spondylosis (n=82)	39	47.6%	60	73.2%	49	59.8%	22	26.8%	13.4%
Past history	No-past history (n=148)	27	18.2%	55	37.2%	40	27.0%	40	27.0%	10.1%
(General diseases)	Past history (n=516)	163	31.6%	264	51.2%	211	40.9%	149	28.9%	10.3%
	Heart disease (n=35)	18	51.4%	27	77.1%	22	62.9%	10	28.6%	14.3%
	Diabetes (n=52)	20	38.5%	37	71.2%	24	46.2%	19	36.5%	25.0%
	Malignant tumor (n=23)	15	65.2%	17	73.9%	17	43.5%	3	69.6%	30.4%
	Mental disease (n=19)	5	26.3%	12	63.2%	6	31.6%	7	36.8%	31.6%
	Brain disease (n=13)	4	30.8%	6	46.2%	8	61.5%	2	15.4%	-15.4%
	Collagen disease (n=22)	11	50.0%	17	77.3%	12	54.5%	8	36.4%	22.7%
	Respiratory disease (n=31)	8	25.8%	14	45.2%	12	38.7%	12	38.7%	6.5%
	Hypertension (n=80)	30	37.5%	46	57.5%	29	36.3%	24	30.0%	21.3%

LS: Locomotive syndrome, GLFS-25: 25-question Geriatric Locomotive Function Scale, BMI: Body mass index, OA: Osteoarthritis

In the second step of our study, we statistically compared the LS groups which were diagnosed by the "GLFS-25" (baseline) with LS groups which were divided by the "Loco-check" using Spearman's rank coefficient and ROC curve analyses to understand the associations of LS diagnoses between the 2 tools. Spearman's rank coefficient was r=0.452 and the ROC curve analysis demonstrated a significant ($p < 0.0001$) AUC of 0.8181 (Table 2). Furthermore, we also compared the baseline LS group with each 7questions in the "Loco-check" (checks 1 - 7) using independent ROC curve analyses. The AUC of each comparison was check 1: 0.6967, check 2: 0.6295, check 3: 0.7150, check 4: 0.7195, check 5: 0.6915, check 6: 0.6577 and check 7: 0.5948 (Table 2); Delong's test demonstrated that these questions (checks 1-7) had factors in each categories ($p<0.0001$) (Table 2). These results indicated that the diagnosis of LS screened by the "Loco-check" was accurate compared to the LS diagnoses by the "GLFS-25" (baseline). According to these results, the 2 tools appeared to be similarly able to identify the LS groups, however, there were slight divergences between the 2 tools. Therefore, we analyzed the associations between the LS, which were determined by the each screening tool, and the clinical factors in the third step.

In the third step, we conducted a comparative study to analyze the associations between LS and the clinical information, including the general status, orthopedic diseases (degenerative diseases), past history (general diseases) and excise activities, using the 2 diagnostic tools. The results are described below.

In the gender-specific analyses, the "Loco-check" survey indicated that 198 (51.2%) of 387 females and 121 (43.7%) of 277 males were diagnosed with LS. Females had a higher prevalence of LS than males (Table 1). Regarding the "GLFS-25", the survey showed that 159 (41.1%) of 387 females and 92 (33.2%) of 277 males were classified as having LS, and females had a tendency to have a higher prevalence of LS compared to males (Table 1). Regarding the discrepancies between the rates of diagnosis of LS between the 2 diagnostic tools, the "Loco-check" had an approximately 10.0% higher diagnostic rate of LS than the "GLFS-25" in both the male and female cohorts, thus we concluded that there was no difference in the rate of LS diagnosis between the baseline discrepancy (total cohorts) and the gender-specific discrepancy (Table 1).

In the age-specific analyses, the "Loco-check" indicated that 166 (62.9%) of 264 patients who were over 60 years of age had LS (Table 1). The "GLFS-25" showed that 128 (48.5%) of 264 patients who were over 60 years of age had LS (Table 1). In both surveys, the group of patients over 60 years of age had an approximately 10% higher prevalence rate of LS compared to the overall rates for patients of all ages. In addition, in both surveys, the prevalence rate of LS tended to increase with age (Table 1). With respect to the discrepancies in the LS diagnosis rates between the 2 diagnostic tools, the "Loco-check" again had higher diagnosis rates of LS than the "GLFS-25" for all age groups. Of note, the groups of patients in their 60s and 70s had bigger discrepancies in the LS diagnosis rates (13.9–16.8%) compared to the baseline discrepancies. On the other hand, the groups of patients in their 20s and 30s had small discrepancies in the LS diagnosis rates (2.3–4.1%; Table 1).

With respect to the associations between the prevalence rates of LS and the BMI, the "Loco-check" demonstrated that 86 (64.7%) of 133 patients who had a BMI ≧25 had LS, while 224 (43.2%) of 519 patients who had a BMI < 25 had LS (Table 1). The "GLFS-25" similarly

Table 2. ROC curve analysis

	AUC	95% CI	Delong's test†
Model	0.8181	0.7834-0.8528	
Separate	0.8181	0.7834-0.8528	
Check 1	0.6967	0.6605-0.7330	
Check 2	0.6295	0.5968-0.6623	χ^2= 172.13111
Check 3	0.7150	0.6801-0.7499	(*df =7*)
Check 4	0.7195	0.6853-0.7538	*p ＜ 0.0001*
Check 5	0.6915	0.6581-0.7249	
Check 6	0.6577	0.6268-0.6886	
Check 7	0.5948	0.5692-0.6204	

ROC: Receiver operating characteristic, AUC: Area under the curve
†Results of testing for the contrast of the ROC

showed that 59 (41.3%) of 143 patients who had a BMI ≧25 had LS, while 187 (36.0%) of 519 patients who had a BMI < 25 had LS (Table 1). In both surveys, the high BMI group had higher prevalence rates of LS than the low BMI group (Table 1). The discrepancies of the LS diagnosis rates between the "Loco-check" and "GLFS-25" in the BMI-specific cohorts showed that in the over 25 BMI group, there was a bigger difference (15.0-21.2%) compared to the baseline discrepancies. On the other hand, there was no major discrepancy (2.6%) in the LS diagnosis rates between the "Loco-check" and "GLFS-25" in the BMI < 20 group.

With respect to the relationships between LS and exercise (heavy and light exercise habit vs. no exercise habit), the prevalence of LS according to the "Loco-check" was 140 (43.3%) of 323 patients who had a habit of exercising had LS, while 157 (52.9%) of 297 patients who did not have any habit of exercising had LS (Table 1). According to the "GLFS-25", 100 (31.0%) of 323 patients who had a habit of exercising were classified as having LS, and 133 (44.8%) of 297 patients who had no habit of exercising were diagnosed with LS (Table 1). According to both surveys, the patients who had a habit of exercising tended to have decreased rates of LS (Table 1). The discrepancies in the LS diagnosis rates again showed that the "Loco-check" had an approximately 10% higher prevalence rate of LS than the "GLFS-25" in all of the sub-groups regarding exercise habits, and there was no difference compared to the baseline discrepancies (Table 1).

In the orthopedic diseases (degenerative diseases) -specific analyses, 40 (69.0%) of 58 patients with knee OA, 10 (71.4%) of 14 with hip OA, 17 (48.6%) of 35 with cervical spondylosis and 60 (73.2%) of 82 with lumbar spondylosis were considered to have LS according to the "Loco-check" (Table 1). According to the "GLFS-25", 31 (53.4%) of 58 patients with knee OA, 6 (42.9%) of 14 with hip OA, 13 (37.1%) of 35 with cervical spondylosis and 49 (59.8%) of 82 with lumbar spondylosis were considered to have LS (Table 1). In both surveys, knee OA, hip OA and lumber spondylosis revealed similar prevalence rates and were associated with a higher prevalence rate than was observed in the overall (total) cohort, with an approximately 20.0% higher rate in the "Loco-check" and an approximately 10.0% higher rate in the "GLFS-25" (Table 1). On the other hand, the prevalence rates of patients with cervical spondylosis were similar to those of the overall cohort (48.6% in the "Loco-check" and 37.1% in the "GLFS-25"). With respect to the discrepancies of the LS diagnosis rates between the "Loco-check" and "GLFS-25", the "Loco-check" had 13.4–28.6% higher prevalence rates than the "GLFS-25" for knee OA, hip OA and lumbar spondylosis patients (compared to the baseline discrepancy of approximately 10%). On the other hand, cervical spondylosis was associated with an 11.4% discrepancy rate between the "Loco-check" and "GLFS-25", which was considered to be the same as the baseline discrepancy.

Regarding the associations between the past history (general diseases) and LS, in the "Loco-check", 264 (51.2%) of 516 patients who had any past history were diagnosed with LS, and 55 (37.2%) of 148 patients who did not have any past history were diagnosed with LS. In the "GLFS-25", 211 (40.9%) of 516 patients who had a past history and 40 (27.0%) of 148 patients who did not have any past history were diagnosed with LS (Table 1). These results revealed that the groups without a past history had an approximately 10% lower prevalence rate compared with the overall cohort in both the "Loco-check" and "GLFS-25" surveys (Table 1). On the other hand, the groups that had a past history had a little bit higher (2–3%) prevalence rates of LS compared to the overall cohort (Table 1). The discrepancies in the diagnosis rates of LS between the "Loco-check" and "GLFS-25" were approximately 10% in the groups with and without a past history, thus there was no significant difference between these cohorts compared to the baseline discrepancy.

We also performed logistic regression analyses using these 2 surveys to identify the factors that had statistically significant associations with LS. In the "Loco-check" survey, female gender, advanced age, a high BMI, lumbar spondylosis, heart disease, mental disorders and collagen disease had statistically significant associations with presence of LS, whereas the group which had a habit of performing heavy exercise had a statistically significant association with a low prevalence of LS (Table 3). The "GLFS-25" survey indicated that female gender, advanced ages, a high BMI, lumbar spondylosis and heart disease had statistically significant associations with presence of LS, and the groups which had habits of heavy exercise or did not have a past history of orthopedic disease had statistically significant associations with a low prevalence of LS (Table 4). In both surveys, we found that

female gender, advanced age, a high BMI, lumbar spondylosis and heart disease were consistent risk factors for LS.

4. DISCUSSION

We collected the questionnaire responses, including the "Loco-check", "GLFS-25", clinical information, from 1,027 orthopedic patients. In order to elucidate the correlations of LS diagnosis between the 2 screening tools, we calculated the sensitivity of LS diagnoses in both the "Loco-check" and "GLFS-25" as well as analyzed the statistical associations of the LS diagnoses between the 2 tools using Spearman's rank correlation coefficient and ROC curve analyses. These results indicated that the diagnoses of LS screened by the "Loco-check" were accurate compared to the LS diagnoses by the "GLFS-25", although there were very slight divergences in the LS diagnoses between the 2 tools. Therefore, to clarify these divergences between the 2 tools, we investigated the relationships between each LS diagnoses and the clinical factors. We successfully found several clinical factors were associated with these diagnosis divergences.

Table 3. The relationship between the patient characteristics and the prevalence of LS based on the loco-check

Independent factor (Reference)	Crude OR LS	Adjusted OR‡ LS
Gender		
Male	**Reference**	
Female	1.4 (10.-1.8), 0.6	1.5 (1.1-2.1), 0.2*
Age		
≦20s	**Reference**	
30s	2.6 (1.2-5.5), 0.1*	2.6 (1.2-5.5), 0.2*
40s	3.7 (1.8-7.5), <0.01*	3.4 (1.6-70.), 0.01*
50s	4.1 (2.1-8.3), <0.01*	3.6 (1.8-7.5), 0.01*
60s	4.8 (2.4-9.5), <0.01*	4.2 (2.1-8.7), <0.01*
70s	13.9 (6.6-29.2), <0.01*	12.7 (5.9-27.5), <0.01*
≧80s	26.6 (6.8-104.1), <0.01*	250. (6.2-101.1), <0.01*
BMI		
<20	**Reference**	
<25	1.3 (0.9-1.9), .17	1.3 (0.9-20.), .19
<30	2.6 (1.6-4.3), <0.01*	2.7 (1.6-4.7), <0.01*
≧30	6.4 (20.-200.), 0.01*	6.3 (1.9-20.9), <0.1*
Exercise		
No	**Reference**	
Light	0.9 (0.6-.1.3), .47	0.8 (0.5-1.1), .20
Heavy	0.5 (0.3-0.8), 0.01*	0.6 (0.4-0.9),0.02*
Orthopedic diseases (Degenerative diseases)		
Knee OA (+)	2.6 (1.5-4.6), 0.01*	1.5 (0.8-2.8), .18
Hip OA (+)	2.8 (0.9-8.8), 0.8	1.9 (0.6-70.), .28
Cervical spondylosis (+)	10. (0.5-20.), .95	10. (0.5-2.2), .85
Lumbar spondylosis (+)	3.4 (20.-5.7), <0.01*	2.2 (1.3-3.8), <0.1*
Past history (General diseases)		
Heart disease (+)	3.9 (1.7-8.7), 0.01*	2.6 (1.1-6.1), 0.1*
Diabetes (+)	2.9 (1.6-5.4), 0.01*	1.7 (0.9-3.2), 0.13
Malignant tumor (+)	3.2 (1.2-8.2), 0.02*	2.2 (0.8-5.8), 0.1
Mental disease (+)	1.9 (0.7-4.9), 19	2.9 (1.1-8.1), 0.03*
Brain disease (+)	0.9 (0.3-2.8), .89	0.8 (0.2-2.3), 0.62
Collagen disease (+)	3.8 (1.4-10.4), 0.1*	3.7 (1.3-10.6), 0.5
Respiratory disease (+)	0.9 (0.4-1.8), .74	0.7 (0.3-1.5), 0.31
Hypertension (+)	1.5 (10.-2.5), 0.7	0.7 (0.4-1.2), 0.26
No past history (+)	0.6 (0.4-0.8), 0.03*	10. (0.6-1.4), 0.77

LS: Locomotive syndrome, GLFS-25: 25-question Geriatric Locomotive Function Scale, BMI: Body mass index, OA: Osteoarthritis

†: Dependent variable: LS, Reference: non-LS

‡: Adjusting for age, BMI and gender.

Values in the boxes represent the "Odds ratio (95% CI), p value"

Table 4. The relationship between the patient characteristics and the prevalence of LS based on the GFLS-25

Independent factor	Crude OR		Adjusted OR‡	
(Reference)	**Stage Ⅰ**	**LS (Stage Ⅱ)**	**Stage Ⅰ**	**LS (Stage Ⅱ)**
Gender				
Male	**Reference**			
Female	1.7 (1.2-2.7), 0.04*	1.8 (1.3-2.6), 0.01*	1.9 (1.3-30.), 0.02*	20. (1.3-30.),< 0.01*
Age				
≦20s	**Reference**			
30s	20. (0.9-4.3), 0.9	40. (1.7-9.2), 0.01*	1.8 (0.8-3.9), 0.16	3.4 (1.4-7.9), 0.05*
40s	2.6 (1.3-5.4), 0.09*	4.6 (20.-10.3), <0.01*	2.2 (10-4.7), 0.39*	3.7 (1.6-8.5), 0.02*
50s	2.9 (1.4-5.8), 0.04*	5.4 (2.4-120.), <0.01*	2.5 (1.2-5.3), 0.14*	4.2 (1.8-9.4), 0.01*
60s	3.2 (1.6-6.5), 0.01*	5.7 (2.6-12.7), <0.01*	2.7 (1.3-5.7), 0.07*	4.6 (20.-10.3), <0.01*
70s	4.9 (2.2-11.3), <0.01*	17.5 (7.4-41.7), <0.01*	4.2 (1.8-9.8), 0.01*	13.7 (5.7-32.9), <0.01*
≧80s	90. (0.9-92.8), 0.6	76.8 (9.1-648), <0.01*	9.3 (0.9-96.9), 0.6	65.1 (7.5-558.4), <0.01*
BMI				
<20	**Reference**			
<25	0.9 (0.5-1.4), .52	0.9 (0.6-1.5), 0.78	10. (0.6-1.6), 0.91	10. (0.6-1.6), 0.99
<30	1.9 (10.-3.6), 0.4*	1.7 (0.9-3.2), 0.8	2.3 (1.2-4.5), 0.2*	1.9 (10.-3.7), 0.6
≧30	0.9 (0.2-4.3), 0.92	3.1 (0.98-10.4), 0.4*	0.9 (0.2-4.7), 0.97	3.1 (0.9-10.7), 0.4*
Exercise				
No	**Reference**			
Light	0.80 (0.5-1.3), 0.36	0.7 (0.4-1.1), 0.12	0.8 (0.5-1.2), 0.25	0.6 (0.4-10.), 0.4*
Heavy	0.5 (0.3-0.8), 0.07*	0.2 (0.2-0.4), <0.01*	0.6 (0.4-10), 0.4*	0.3 (0.2-0.5), <0.01*
Orthopedic diseases (Degenerative diseases)				
Knee OA (+)	2.5 (10.-5.5), 0.3*	40. (1.9-8.2), <0.01*	1.5 (0.7-3.4), 0.35	1.7 (0.8-3.8), 0.15
Hip OA (+)	4.3 (0.9-21.8), 0.8	3.8 (0.8-190.), 0.11	3.4 (0.6-18.2), 0.15	2.3 (0.4-12.4), 0.34
Cervical spondylosis (+)	1.7 (0.7-4.1),0.21	1.6 (0.7-3.8), 0.26	1.7 (0.7-4.1), 0.25	1.4 (0.6-3.5), 0.42
Lumbar spondylosis (+)	2.9 (1.4-6.2), <0.01*	5.6 (2.8-11.1), <0.01*	2.1 (10.-4.6), 0.7	3.2 (1.6-6.7), 0.01*
Past history (General diseases)				
Heart disease (+)	3.3 (0.9-12.5), 0.8	5.9 (1.7-20.4), 0.05*	3.2 (.8-12.2), 0.9	50. (1.4-17.7), 0.1*

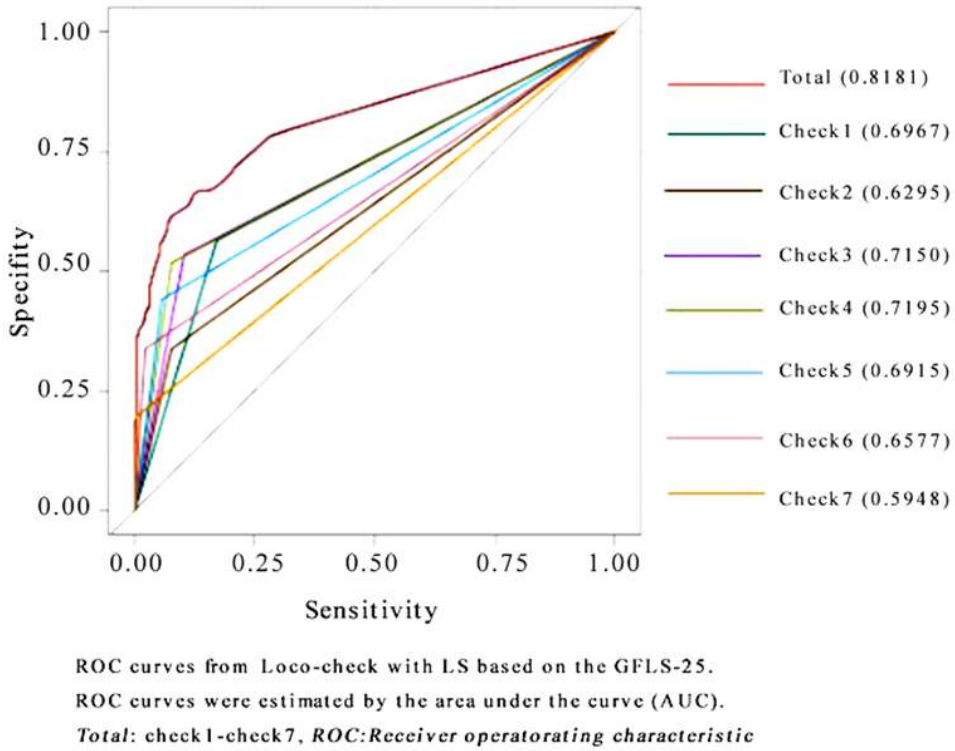
Independent factor	Crude OR		Adjusted OR‡	
(Reference)	Stage Ⅰ	LS (Stage Ⅱ)	Stage Ⅰ	LS (Stage Ⅱ)
Diabetes (+)	2.2 (0.9-5.2), 0.6	1.8 (0.8-4.1), 0.17	1.9 (.8-12.2), 0.9	1.3 (0.6-30), 0.58
Malignant tumor (+)	1.2 (0.2-5.6), .86	4.9 (1.4-17.2), 0.1*	.93 (.2-4.8), .94	3.7 (10.-13.1), 0.5
Mental disease (+)	1.5 (0.5-4.5), 0.49	10. (0.3-3.1), 0.98	1.7 (.5-5.2), .40	1.3 (.4-4.1), 0.71
Brain disease(+)	0.8 (0.1-4.9),0.81	2.2 (0.6-8.8), 0.26	.8 (.1-4.6), .76	20. (0.5-7.9), 0.33
Collagen disease (+)	4.9 (10.-23.7), 0.5	5.7 (1.3-26.1), 0.2*	4.1 (.8-20.2), 0.8	4.7 (10.-220), 0.5
Respiratory disease (+)	1.8 (0.7-4.8), 0.24	1.3 (0.5-3.4), 0.61	1.6 (.6-4.4), .33	1.1 (0.4-30.), 0.8
Hypertension (+)	1.1 (0.6-20), 0.73	10. (0.6-1.8), 0.95	1.2 (.7-2.2), .53	10. (0.6-1.9), 0.87
No past history (+)	0.8 (0.5-1.2), 0.27	0.6 (0.4-0.9), 0.2*	.9 (.6-1.5), .78	0.8 (0.5-.1.4), 0.47

LS: Locomotive syndrome, GLFS-25: 25-question Geriatric Locomotive Function Scale, BMI: Body mass index, OA: Osteoarthritis

†: Dependent variable: Stage Ⅰ, LS (Stage Ⅱ) Reference: non- LS

‡: Adjusting for age, BMI and gender.

Values in the boxes represent the "Odds ratio (95% CI), p value"



ROC curves from Loco-check with LS based on the GFLS-25.
ROC curves were estimated by the area under the curve (AUC).
Total: check1-check7, *ROC:Receiver operatorating characteristic*

Fig. 1. A receiver operating characteristic (ROC) curve analysis for the association between the "Loco-check" and the "GLFS-25". These analyses calculated the area under the curve (AUC) to be 0.8181. Furthermore, we also compared the base-line LS group that was diagnosed by the "GLFS-25" with each of the 7 questions included in the "Loco-check" (checks 1 - 7) using the ROC curve examination. The AUC of each comparisons was check 1: 0.6967, check 2: 0.6295, check 3: 0.7150, check 4: 0.7195, check 5: 0.6915, check 6: 0.6577, and check 7: 0.5948

With respect to the prevalence rate of LS, we investigated the rates according to several factors, including gender, age, BMI, exercise habits, orthopedic diseases (degenerative diseases) and past history (general diseases), using the "Loco-check" and the "GLFS-25" in an orthopedic outpatient cohort. We also examined the discrepancies of the LS diagnosis rates between the "Loco-check" and "GLFS-25". In the overall cohort, the "Loco-check" identified that 319 (48.0%) of 664 patients had LS, and the "GLFS-25" identified that 251 (37.8%) of 664 patients had LS. The "Loco-check" indicated that the prevalence rates of LS were similar to those in a previous report [9] and our previous study [10]. However, the "GLFS-25" indicated that there was a higher rate of LS than was noted in previous reports that employed internet cohorts (4,500 people) [11] and a cohort of elderly females (217 people) [12]. We believe that our assessment of orthopedic outpatients led to this higher prevalence of LS as determined by the "GLFS-25". Additionally, the present study is the first study to demonstrate the prevalence rates of LS using 2 screening tools in the same cohort, and the "Loco-check" had a 10.2% higher detection rate of LS than the GLSF-25.

In the gender- and age-specific analyses in our study, both female gender and older age had statistically significant associations with having LS in both surveys. These findings have been previously described in several articles [9,13]. Regarding the discrepancy between the LS diagnosis rate between the "Loco-check" and "GLFS-25", the gender-specific analysis showed similar rates to the baseline (10.0%) discrepancy for both females and males. On the other hand, in the age-specific analysis, the groups of patients in their 60s and 70s showed bigger differences in the discrepancies between the "Loco-check" and "GLFS-25", and the groups of patients in their 20s and 30s showed smaller differences in the discrepancies between the 2

tools. Therefore, we believe that the “Loco-check” may be a more useful tool (simple screening tool) of LS in younger patients.

In the BMI-specific analyses of our study, it was revealed that a high BMI had a statistically significant association with having LS according to both diagnostic tools. In addition, the exercise-specific analyses indicated that high exercise levels had statistically significant associations with a decreased risk of LS. Previous studies have suggested that the BMI and waist circumference in females was significantly associated with LS [12,14]. Our results emphasize that exercising and maintaining a healthy weight are crucial to avoid locomotor disorders. In addition, our data might indicate that locomotion training can help prevent LS [15].

With regard to the discrepancies between the diagnostic tools, in the BMI-specific analysis, the groups with a BMI ≧25 showed big differences (approximate 18%) in the diagnosis discrepancies between the “Loco-check” and “GLFS-25”. These results demonstrated that the “Loco-check” might not be useful for patients with a high BMI for detecting LS. With regard to the exercise-specific analysis, the discrepancies in the LS diagnosis between the “Loco-check” and “GLFS-25” were similar to the baseline discrepancy (10.0%). These results indicated that it may not be useful to use the “Loco-check”, regardless of whether the patients habitually exercise.

In the analyses of the groups with orthopedic diseases (degenerative diseases), the groups with knee OA, hip OA and lumbar spondylosis had higher prevalence rates of LS compared with the overall cohort. However, the groups with cervical spondylosis had rates similar to those of the overall cohort. With respect to the relationships between the prevalence of LS and degenerative diseases, previous reports described that knee OA and lumbar spondylosis were associated with LS [9,16]. Furthermore, Hirano at al. [17-19] reported that back muscle strength and spinal inclination may be the most important risk factors for LS, and lumbar kyphosis is related to back muscle strength and spinal inclination. Our study showed that only lumbar spondylosis had a statistically significant association with LS in both the “Loco-check” and “GLFS-25”. However, in our study, knee OA had a statistically significant association with the prevalence of LS according to both the “Loco-check” and “GLFS-25” (Supplemental Table 3). Finally, both our present findings and the previous studies suggested that the prevalence of LS is associated with knee OA and lumbar spondylosis. With regard to the discrepancies between the diagnostic tools, in the groups with degenerative diseases (knee OA, hip OA and lumbar spondylosis), there were big differences (approximately 20%) between the “Loco-check” and “GLFS-25”. On the other hand, patients with cervical spondylosis had differences in the LS rates that were similar to the baseline discrepancy (10.0%). According to these findings, the “Loco-check” may not be suitable for screening LS in patients who any type of knee OA, hip OA or lumbar spondylosis (Supplemental Table 4).

With regard to a past history, the groups without past histories had approximately 10% lower prevalence rates of LS than the overall cohorts. On the other hand, the groups that had any past histories had the same prevalence rates of LS as the overall cohorts. With respect to the associations between a past history and LS, heart disease, mental disease and collagen disease were significantly associated with the prevalence of LS in the “Loco-check”. On the other hand, only heart disease had a statistically significant association with the prevalence of LS in the “GLFS-25”. According to the JOA, LS means being restricted in one’s ability to walk or lead a normal life due to a dysfunction in one or more parts of the locomotive system, e.g., muscles, bones, joints, cartilage, or the intervertebral discs without heart disease [3]. Therefore, according to our results, we believe that the “GLFS-25” maybe a suitable tool to screen for LS in patients who have any past history.

5. CONCLUSION

We collected questionnaire responses to both the “Loco-check” and “GLFS-25” from 1,027 orthopedic patients. To elucidate the associations of LS diagnosis between the “Loco-check” and “GLFS-25”, we analyzed the associations between the 2 tools using statistical analyses. According to our results, we found that the diagnoses of LS screened by the “Loco-check” were accurate compared to the LS diagnoses by the “GLFS-25”, although there were slight divergences between the 2 tools. Therefore, to elucidate the slight divergences and differences,

we also investigated the associations between the LS groups that were diagnosed by each 2 tool with the clinical factors and we found several clinical factors to be the cause of these divergences. We believe that our analyses and findings may provide critical information to help clinicians determine whether to use the “Loco-check” or “GLFS-25” in various situations.

CONSENT

This study and project were approved by the institutional review board of Juntendo University.

ETHICAL APPROVAL

All authors hereby declare that all experiments have been examined and approved by the appropriate ethics committee and have therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.

SOURCE OF FUNDING

The corresponding author had full access to all the data in the study and had the final responsibility for the decision to submit the manuscript for publication.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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