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The First Study on Locomotive Syndrome in Lower Amputees in Japan

Kei Sano[1], Yoshiyuki Suehara[1*], Yu Tanabe[1], Taketo Okubo[1], Youngji Kim[1], Midori Ishii[1], Takayuki Kawasaki[1], Atsuhiko Terakado[2], Keisuke Akaike[1], Kenta Mukaihara[1], Daisuke Kubota[1], Naoko Okubo[3], Yuichiro Maruyama[1], Tsuyoshi Saito[4] and Kazuo Kaneko[1]

[1]Department of Orthopaedic Surgery, Juntendo University School of Medicine, Japan.
[2]The Prosthetic and Orthotic Care Center of the Tetsudo Kosaikai Foundation, Tokyo, Japan.
[3]Faculty of Health and Sports Science, Juntendo University, Japan.
[4]Department of Human Pathology, Juntendo University School of Medicine, Japan.

Authors' contributions

This work was carried out in collaboration between all authors. Authors KS, YS, YT, AT 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. Authors KS and TK did analyses of the study, performed the spectroscopy analysis. Authors YT, TO, MI, KA and KM collected the data. Authors NO, 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 describe a condition in high-risk patients with musculoskeletal disease. So far, there are many studies that are designed for non-handicapped people. However, the study using a cohort of handicapped people are limited. In this study, we therefore conducted a study on LS in lower amputees.
Methods and Participants: We surveyed 47 lower amputees. A questionnaire that included the 25-question Geriatric Locomotive Function Scale (GLFS-25) and the Loco-check was distributed to the participants.

**Corresponding author: E-mail: ysuehara@juntendo.ac.jp;*

Results: According to GLFS-25, the classifications of the amputee patients were as follows: no locomotive dysfunction, n=21 (44.7%); grade I locomotive syndrome, n=17 (36.2%); and grade II locomotive syndrome, n=9 (19.1%). The mean GLFS-25 was 10.4. According to the Loco-check, 43 (91.5%) patients were at risk of LS.
Conclusion: We have surveyed the GLFS-25 and Loco-check to investigate the risk of LS in lower limb amputees. We found that lower limb amputees had unique risk factors for LS, including amputation level, phantom pain, stump wound and frequency of wheelchair use. Both non-handicapped people and lower limb amputees need to be considered in studies on LS and more specific countermeasures are required for LS in lower limb amputees.

Keywords: Lower amputees; locomotive syndrome; GLFS-25 and Locomotor function.

1. INTRODUCTION

Since the year 2000, the Ministry of Health, Labour and Welfare in Japan has promoted the "National Health Promotion Movement in the 21st Century (Health Japan 21)" based on the health promotion policies of the World Health Organization. "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 describe a condition in high-risk patients with musculoskeletal diseases who are likely to require nursing care [1,2]. LS is caused by the weakening of the musculoskeletal organs, such as the bones, joints and muscles and is related to several diseases [3-8]. Disorders of these organs lead to self-transportation disabilities. These conditions force people who suffer from LS to require outside care and support. To prevent a decline into disability, such patients need to maintain their health, especially their locomotor function.

LS has received increased attention in Japan since 2007, and there have been numerous studies on the topic [9] . However, the studies in question were designed for non-handicapped people, and it seems that there have been no studies for amputees [3-8]. Lower limb amputees require prosthetics to walk; thus, they lack mobility and would seem to have a high risk of developing LS. LS in lower limb amputees should be considered, and the risk factors for LS should be determined in both lower limb amputees and non-handicapped people. We also supposed LS data displayed variation on several points and that it could reflect the condition of the general amputee community. To elucidate the association between LS and some factors of amputees, we conducted a questionnaire survey that used the 25-question Geriatric Locomotive Function Scale (GLFS-25) and Loco-check to evaluate LS. We chose these self-answering questionnaires (GLFS-25 and Loco-check) because the ADL of each subject may be determined by the objective function of the motor system as well as the self-rated functional ability. Finally, these results might provide the useful information on how to use GLFS-25 and/or Loco-check for the amputees.

2. METHODS

2.1 Participants

We have surveyed 47 lower limb amputees (age: 46.3 ± 16.4 years, Male 32, Female 15) in a clinic of the Prosthetic and Orthotic Care Center of the Tetsudo Kosaikai Foundation, Tokyo, Japan, from April 2015 to April 2016. We surveyed them with questionnaires that included the GLFS-25 and the Loco-check.

2.2 Instruments

2.2.1 The 25-question geriatric locomotive function scale questionnaire [9]

We used the GLFS-25, which consists of 25 items, including four questions regarding pain during the last month, 16 questions regarding pain during activities of daily living during the last month, three questions regarding social functions, and two questions regarding the mental status during the last month. These 25 items were graded on a five-point 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 grade II locomotive syndrome: ⩾16 points, grade I locomotive syndrome: 7-15 points, and Normal: < 7 points [9].

The GLFS-25 has been adjudged to offer a valid and reliable tool for detecting locomotive syndrome in elderly Japanese individuals [9].

2.2.2 The Loco-check questionnaire [10]

We used the Loco-check, which consists of seven statements and "yes or no" answer. Participants who checked yes to one or more statements were defined as having LS according to the regular diagnostic rules [10].

2.3 Data Analyses

Based on normality analyses, we verified the results of normality using Kolmogorov-Smirnov test. Finally, we performed statistically analyses including ⅰ) Amputation level, ⅱ) Amputee in comparing to ohter patient based on GLFS-25 using Mann-Whitney U test and Kruskal-Wallis Test as appropriate ($p < 0.05$ as significant).. We also compared data between orthopedic patients and lower limb amputees.

3. RESULTS

3.1 The Results of Amputation Levels

The mean age at the time of amputation was 35.6 years and the mean term of using a prosthesis was10.1 years. Below knee (BK) was the main amputation level (53.2%). Our data included several levels: above knee (AK) (34.0%), hip disarticulation (4.3%), rotation knee plasty (4.3%), and both sides lower limb amputations (4.3%). Trauma was the main reason for amputation (55.3%) and malignant tumor (19.1%) was the second most common reason (Table 1).

3.2 The Results of the GLFS-25

The average GLFS-25 value was 10.4 (range 0 to 42) points with 19.1% of the patients classified as having grade I locomotive syndrome while 36.2% were classified as having grade II locomotive syndrome (Table 2). Q13 "To what extent has it been difficult to walk briskly?" showed the highest average score (1.36 points) and Q21 "To what extent has it been difficult to perform sporting activities (jogging, swimming gate ball, dancing, etc.)?" showed the second highest average score (1.00 points). The average scores for the other 23 questions were under the 1.00 points. In particular, the scores for Q5 (0.02 points), Q8 (0.04 points), and Q19 (0.06 points) were quite low and were below 0.10 points (Supplemental Table1). We found some unique risk factors for LS in lower limb amputees (Table 3). With regard to the level of amputation, the scores of 25 BK patients and 16 AK patients were compared and there was no significant difference, but BK (7.6 points) tended to score lower than AK (11.8 points) ($p=0.071$). In this study, 47.8% of the amputees reported that they had phantom pain. The pain level was divided into 4 grades (severe, moderate, mild, none). The grade of phantom pain seems to be related with the GLFS-25 score, although, not statistically significant ($p=0.06$). Patient

Table1. The details of the amputees

Abstract Information		
	Number (male)	47(32)
	Mean age at study	46.3±16.4
	Mean age at amputation	35.6
	Mean term of using prosthesis (year)	10.1
Amputaion level		
	BK	25(53.2%)
	AK	16(34.0%)
	Hip disarticulation	2(4.3%)
	Rotation knee plasty	2(4.3%)
	Both sides lower limb amputation	2(4.3%)
Reasons of amputation		
	Trauma	26(55.3%)
	Malignant tumor	9(19.1%)
	Diabetes metabolism	4(8.5%)
	Arteriolosclerosis	3(6.4%)
	Congenitial	2(4.3%)
	Vasculitis	1(2.1%)
	Others	2(4.3%)

with stump wounds tended to score higher in GLFS-25 scores (14.5 points) than patients without stump wounds (8.8 points)(p = 0.057). In the present study, 84.0% of the lower amputees never used a wheelchair; the remaining 16.0% used a wheelchair for several reasons, including rest, stump wound, and because they were required to travel long distances. Even rare wheelchair users had a much higher score (26.0 points) than patients who never used a wheelchair (7.6 points). Thus, the prevention of wheelchair use is very important for maintaining the locomotor function. In general, exercise is a very important factor for maintaining the locomotor function; 66% of the amputees had an exercise habit; however, the difference was not statistically significant (p=0.173). We considered an exercise habit to be also important for amputees.

3.3 The Results of the Loco-check

The results of Loco check showed that 91.5% of lower leg amputees and 50.4% of orthopedic patients have risk of LS. 89.3% of patients with lower limb amputation answered “No” to Question 1 (Can you put on a pair of socks while standing on one leg). Question 1 seemed to be unsuitable for amputees and this factor seemed to influence the result.

3.4 The Comparison between Orthopedic Patients and Lower limb Amputees

Since 2013, we annually surveyed orthopedic patients at Juntendo University, Tokyo using the same tools [11-14]. We considered that the comparative data need to be improved to

Table 2. The results of GLFS-25 and loco-check

GLFS-25	
Minimum	0
Maximum	42
Average	10.4
Number of patients without locomotive dysfunction (score: 0-6)	21 (44.7%)
Number of patients with grade 1 locomotive syndrome (score: 7-15)	17 (36.2%)
Number of patients with grade 2 locomotive syndrome (score: 16-100)	9 (19.1%)
Loco-check	
Risk	43 (91.5%)
No risk	4 (8.5%)

Table 3. Unique risk factors for lower amputees

Risk factors	Type	GLFS-25	p-value
Amputation level	AK	11.8	0.071
	BK	7.6	
Phantom pain	Severe pain	18.75	0.06
	Moderate pain	13.375	
	Mild pain	9.5	
	No pain	7.166	
Stamp wound	with wound	14.46	0.057
	without wound	8.82	
Frequency of wheelchair use	Not at all	7.6	0.007*
	Rare	26	
	Sometimes	19.2	
	Often	20.5	
Excercise habit after amputation	Yes	8.839	0.173
	No	13.375	
Excercise habit before amputation	Yes	9.8	0.801
	No	13.29	

**Compared "not at all" with others (rare, sometimes, often)*

evaluate LS in lower-amputees. We compared orthopedic patient data from 2015 and the data of our 47 lower limb amputees. We surveyed 1122 orthopedic patients, and received 512 valid responses. The average age of orthopedic patients was 50.9 years, with 256 men and women each. (Supplemental Table 2) [11]. The mean score of the orthopedic patients (17.2) was much higher than that of the amputees (10.4), (p=0.049). After adjustment for differences in age and the sex ratio, the mean score became very similar (amputees, 10.4 points; orthopedic patients, 11.3 points; p=0.13).

4. DISCUSSION

Based on the results of the GLFS-25, 55.3% of lower limb amputees were diagnosed as having a locomotive syndrome (grade I, 36.2%; grade II, 19.1%,). The mean score was 10.4 points. This is the first study of LS in lower limb amputees; thus, it is difficult to evaluate these unstable results objectively or quantitatively.

With respect to our comparison between lower limb amputees and orthopedic patients, we found the mean score of the orthopedic patients was much higher than that of the amputees in the GLFS-25. However, orthopedic patient group was older and included a greater proportion of female patients. In general aging and female sex are associated with a lower locomotor function. Contrary to our original hypothesis the similarity of these scores indicates that lower limb amputees have the same degree of locomotor trouble as general orthopedic patients. However, all of the amputees were assessed when using a prosthetic limb; thus the similarity was very dependent on their prosthesis. This assessment was based on a simple comparison of the GLFS-25 and should only be used as a guide.

Numerous studies have shown that the amputation level is an important factor for mobility and activities of daily life. Patients with AK amputations required more time in the timed up and go test, had shorter distance in the 9-min walk test, a lower ability in the stand up from chair test, and took fewer steps in 2 mins in comparison to the patients with BK amputations; they also had a greater fall risk [15]. The prostheses of patients with AK amputations are more difficult to wear and patients with AK amputations tend to experience more falls in comparison to patients with BK amputations [16]. In the present study, we compared the scores of patients with BK amputations and 16 patients with AK amputations and found that the score of the BK group (7.6 points) was not significantly lower than that of the AK group (11.8 points). With regard to Q21 (To what extent has it been difficult to perform sports activity?), the score of the AK Group was not significantly higher than that of the BK group. According to previous reports, 7.0-80.0% of amputees experience phantom pain [17,18]. Phantom pain is essential for the satisfaction of amputees [19]. Our data showed that 47.8% of the amputees experienced phantom pain. Our results showed that the phantom pain level was not related to the GLFS-25 score. Stump wounds are a unique problem for amputees and some reports have shown that the stump wound influences rehabilitation after amputation [20-24]. Regarding wheelchair use, lower limb amputees require prosthetics to walk; thus, in comparison to non-handicapped people, more energy is required to walk [25,26]. For this reason, some amputees use a wheelchair for long distance transport. Some amputees have to remove their prosthetics to maintain cleanliness due to the presence of a stump wound. In our study, 15.9% of the patients used a wheelchair and their scores were higher than those of non-users (P=0.007). The avoidance of wheelchair use is one of the keys to maintaining the locomotor function. With regard to exercise habits, a previous study showed that an exercise habit has a good preventive effect against LS [12]. We asked the patients about their exercise habits before and after amputation. However, there was no apparent relationship with the GLFS-25 score. Despite this finding, we still consider an exercise habit to be an important factor for maintaining the locomotor function.

The Loco-check results showed that 91.5% lower limb amputees and 50.4% orthopedic patients were at risk of LS. It seems that lower limb amputees were at much greater risk than orthopedic patients; this result seems to totally contradict the GLFS-25 results (p=0.000). However, we thought that Q1 (Can you put on a pair of socks while standing on one leg?) was not suitable for evaluating the locomotor function of lower amputees. Even athletic young amputees may answer that they are unable to put on socks while standing on one leg. In fact, 89% of the amputees checked “No” for Q1. Thus, we thought that care needs to be taken when using the Loco-check to evaluate lower amputees.

The present study revealed that the recognition rate of lower limb amputees was critically low (9%) and it must be improved immediately. This

was lower than the 80% targeted goal by 2020 [23] and in comparison with previous reports [11-14]. Since lower limb amputees tend to have lower recognition of LS than healthy subjects, efforts are needed to improve awareness. This extremely low recognition may also be due to the situation that amputees feel that tools to evaluate LS are only designed for healthy people and that the results are not applicable for amputees. In contrast, the present study apparently revealed that the GLFS-25 was effective, even for lower limb amputees, and showed that the gap in risk between lower limb amputees and general orthopedic patients was relatively small.

5. LIMITATION

In this study, we had some limitations, as we could not collect many patients with lower limb amputees. We believe further studies may elucidate these limitations.

6. CONCLUSION

We performed a survey to investigate the risk of LS in lower limb amputees using the GLFS-25 and Loco-check. The GLFS-25 was thought to be a good tool for evaluating the risk of LS in lower limb amputees. However, we should pay attention when using the Loco-check to assess lower limb amputees. The GLFS-25 results showed that the risk of LS in lower limb amputees was similar to that of orthopedic outpatients. We hope that our study will help to prevent LS in lower limb amputees. Next, we should develop more specific countermeasures against LS in lower limb amputees.

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.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Appendix 1. 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

	0 points	1 point	2 points	3 points	4 points
(16) To what extent has it been difficult to go out to visit neighbors?	Not difficult	Mildly difficult	Moderately difficult	Considerably difficult	Extremely difficult
(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.					

Appendix 2. The loco-check

(1) Can you put on a pair of socks while standing on one leg?
(2) Do you stumble or slip in your house.
(3) You need to use a handrail when going up stairs.
(4) You cannot get across the road at a crossing before the traffic light changes.
(5) You have difficulty walking continuously for 15 min.
(6) You find it difficult to walk home carrying a shopping bag weighing about 2 kg.
(7) You find it difficult to do housework requiring physical strength.
All questions are closed questions.

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