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Original Article

Adverse effects of the coexistence of locomotive syndrome and sarcopenia on the walking ability and performance of activities of daily living in Japanese elderly females: a cross-sectional study

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Abstract. [Purpose] The aim of this study was to investigate whether the coexistence of locomotive syndrome and sarcopenia is associated with the risk of fall or performance of activities of daily living in elderly females. [Participants and Methods] We categorized 112 Japanese elderly female participants under three groups: control, locomotive syndrome, and locomotive syndrome and co-existing sarcopenia. We compared the groups based on the mean scores of anthropometric and physical function measurements, the Timed Up and Go test, and the Tokyo Metropolitan Institute of Gerontology Index of Competence to evaluate activities of daily living. [Results] The Timed Up and Go test score significantly differed among the groups. The score of the Timed Up and Go test significantly correlated with scores of the skeletal muscle mass index, skeletal muscle strength grading, and usual gait speed. The total score of the Tokyo Metropolitan Institute of Gerontology Index of Competence significantly decreased in all the groups. [Conclusion] The coexistence of locomotive syndrome and sarcopenia is associated with an increased risk of fall and worsened performance of activities of daily living. Further, the risk of fall is associated with the skeletal muscle mass, skeletal muscle strength, and gait speed. It seems likely that, compared to sarcopenia, locomotive syndrome is more sensitive to lower limb dysfunctions.

Key words: Locomotive syndrome, Muscle dysfunction, Fall risk

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INTRODUCTION

Approximately 40% of elderly individuals in Japan receive nursing care for age-related weakness, joint diseases, bone fractures, or falls[1]. Among these, age-related weakness is considered to be related to sarcopenia, while joint diseases, bone fractures, and falls are considered to be related to locomotive syndrome. Sarcopenia is defined as age-related declines in skeletal muscle mass and low muscle strength and/or physical performance[2, 3]. The diagnosis of sarcopenia requires measurements of muscle mass, muscle strength, and physical performance according to criteria set forth by, e.g., the European Working Group on Sarcopenia in Older People and the Asian Working Group for Sarcopenia[2, 4]. According to the Japanese

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Orthopedic Association, locomotive syndrome involves a decrease in mobility due to locomotive organ dysfunction, and increases risk for dependency on nursing care service[5)]. A diagnosis of locomotive syndrome requires measurements of the two-step test, standing test, and the 25-question Geriatric Locomotive Function Scale (GLFS-25)[6)]. Previous study supports that sarcopenia and locomotive syndrome is closely related, and that sarcopenia is one of the course for locomotive syndrome[5, 6)]. However, the main causes of locomotive syndrome and sarcopenia are considered to differ, because sarcopenia is strongly associated with aging while locomotive syndrome is mainly associated with orthopedic diseases. And that a diagnosis of locomotive syndrome cannot evaluate sarcopenia. Previous study showed that sarcopenia is associated with increased risk of fall and worse ADL. Thus, it is necessary to evaluate sarcopenia for elderly with locomotive syndrome.

A previous study reported a relationship between sarcopenia and fall risk in 1,110 community-dwelling elderly Japanese individuals, with odds ratios for fall risk in the sarcopenia group relative to the normal group of 4.4 among men and 2.3 among females[7)]. Other studies have established that sarcopenia is associated with changes in activities of daily living (ADLs), as assessed by the Tokyo Metropolitan Institute of Gerontology Index of Competence (TMIG-IC)[7, 8)]. Yoshimura et al. reported that locomotive syndrome predicted fall risk and that locomotive syndrome criteria findings correlate with exponential increases in fall risk[9)]. Akahane et al. reported that locomotive syndrome was associated with a high risk for falls[10)], and other studies have also established that locomotive syndrome is associated with ADL performance[10, 11)].

The prevalence of locomotive syndrome and sarcopenia in those aged ≥80 years is reported to be 50–60% with each cases, with the prevalence of locomotive syndrome in those with sarcopenia being 4.6 times higher than those without sarcopenia[9, 12)]. Locomotive syndrome is also associated with sarcopenia in community-dwelling elderly Japanese females[13)]. However, it is not clear whether the coexistence of locomotive syndrome and sarcopenia has associated with increased risk of falls and worse ADL performance.

We hypothesized that the coexistence of locomotive syndrome and sarcopenia further increases these risks in elderly females. To this end, this cross-sectional study aimed to investigate if the coexistence of locomotive syndrome and sarcopenia are associated with an increased risk of fall and worse ADL performance.

PARTICIPANTS AND METHODS

Participants were 112 elderly that included 88 elderly community-dwelling Japanese females and 24 hospitalized elderly recovered from bone fracture. Mean age was 77.3 ± 5.7 years, and none of the participants had cardiovascular or metabolic diseases. All participants were informed of the benefits and risks of the study prior to providing written informed consent. This study was approved by the Seihu Hospital Ethics Committee (Approval number 29-7-025).

Anthropometric parameters were measured, including height, weight, body mass index (BMI), waist circumference, appendicular skeletal muscle mass index (ASM), and skeletal muscle index (SMI). ASM was measured by bioelectrical impedance analysis (BIA), using the Body Composition Analyzer InBodyS10 (InBody Japan Inc.). ASM was derived as the sum of lean soft tissue mass of the arms, legs, and trunk, and SMI was calculated as ASM (kg)/height^2 (m^2).

Measures of physical function included handgrip strength (kg) and usual gait speed (m/sec). Measurement of handgrip strength was performed with a handgrip dynamometer. In the sitting position, with the arm straight by the side, participants gripped the dynamometer as hard as possible for three seconds without pressing the instrument against the body or bending at the elbow. Two trials for each hand was performed, the value was recorded as the greatest measurement that was carried out for both hands two times. For usual walking speed, participants were requested to walk straight for 10 meters at their usual speed, and speed from the middle six meters was calculated. Measurement of usual walking speed was performed twice, and the fastest speed was recorded.

Locomotive syndrome classification was based on locomotive syndrome risk testing that included the two-step test, stand up test, and 5-question Geriatric Locomotive Function Scale (GLFS-5)[6, 14)]. If at least one of the 3 tests is positive, the individual is defined as having locomotive syndrome. The two-step test measures stride length to assess walking ability, including muscle strength, balance, and flexibility of the lower limbs[9)]. The length of the two steps from the starting line to the tips of the participant's toes where she stopped to be measured. The two-step test score was calculated using the following formula: length of the two steps (cm) ÷ height (cm). When the two-step value is less than 1.3, an individual is considered to have locomotive syndrome. The stand-up test was performed to test leg strength by having participants stand up on one or both legs from a seat of specified height. In the present study, if the participant was unable to stand up on one leg (right or left) from a height of 40 cm, then she/he was determined to have locomotive syndrome[9)]. The GLFS-5 is provided as a short version of the 25-question Geriatric Locomotive Function Scale (GLFS-25). Seichi et al. determined that the GLFS-5 can be applied as a rapid self-check tool for locomotive syndrome. The GLFS-5 is graded using a five-point scale, from no impairment (zero points) to severe impairment (four points), with each individual value added to produce a total score (minimum=0, maximum=20). Higher GLFS-5 scores are associated with greater impairments of locomotive function. Validity of the scale has been assessed, and a cut-off point of six was determined to have the highest sensitivity and specificity for detecting disability resulting from locomotive syndrome[15)].

Sarcopenia classification was based on recommendations of the Asian Working Group for Sarcopenia (AWGS)[4)]. The AWGS consensus recommends cut-off values for muscle mass as SMI measured by BIA (7.0 kg/m^2 for men and 5.7 kg/m^2 for females), handgrip strength (<26 kg for males and <18 kg for females), and usual gait speed (<0.8 m/sec). Participants were divided into the following three groups based on locomotive syndrome and sarcopenia classification: control (CON; n=75), locomotive syndrome alone (L; n=30), and coexistence of locomotive syndrome and sarcopenia (L+S; n=10), sarcopenia alone not classified.

Fall risk was assessed via the Timed Up and Go Test (TUG). The TUG is recommended as a useful screening test for falls in guidelines published by the American Geriatric Society and the British Geriatric Society[16)]. TUG time was measured using a digital stopwatch. The test was performed using a height of 40 cm chairs, as well as a turning point that was marked at three meters from the chair. A faster time indicates better functional performance and a time ≥13.5 sec is used as a cut-off to identify those at increased risk for falls in the community setting[17)].

Assessment of ADLs was performed using the TMIG-IC. The TMIG-IC is a multidimensional 13-item scale that consists of three subscales: instrumental activities of daily living (IADLs; five items), intellectual activity (four items), and social role (four items). The response to each item was either ‘‘yes’’ (able to do; 1 point) or “no’’ (unable to do; 0 points), for a maximum score of 13 points. Higher scores reflect a higher level of competence. A person was defined as having a disability if she/he reported a score of one or more below the respective full mark[7)].

All measurements and calculated values are expressed as mean ± standard deviation (SD). We compared mean values of anthropometric and physical function measurements, fall risk, and ADL performance between groups using one-factor repeated-measures analysis of variance (ANOVA), in addition to one-way analysis of covariance (ANCOVA) adjusted for age. A post hoc test (Bonferroni test) was used for variables showing significant differences to determine which groups were different. For non-normally distributed variables, the alternative Kruskal-Wallis test was used, followed by the Mann-Whitney test with Bonferroni correction.

Pearson’s correlation coefficients and partial correlation coefficients adjusted for age were used to analyze differences between muscle mass, muscle strength, usual gait speed, and fall risk. A χ^2 test was calculated to compare the high risk of falling using the cut off value of TUG of 13.5 second. The alpha level for testing significance was set at $p<0.05$. Statistical analyses were performed using SPSS Statistical Software, Version 25 (SPSS, Inc., Tokyo, Japan).

RESULTS

In physical characteristics of participants, the anthropometric and physical function measurements of participants are shown in Table 1. There were significant differences between groups in mean age by one-way ANOVA (CON, L, and L+S groups; p<0.01; Table 1). There were no significant differences between groups in body height and body weight by one-way ANCOVA adjusted for age (Table 1). However, there were significant differences between the three groups in SMI, handgrip strength, and gait speed by one-way ANCOVA adjusted for age (p<0.01; Table 1).

In fall risk, Significant differences in TUG times were observed between groups by one-way ANCOVA adjusted for age (CON, L, and L+S groups; p<0.01; Table 1). Table 2 shows fall risk in participants classified as high risk (≥13.5 sec) and low risk (<13.5 sec) using TUG time. The χ^2 test was performed to compare fall risk using TUG time among groups; a significant interaction was observed (χ^2 (2)=73.77; p<0.01). The L+S were the most likely to have high risk of falling than CON and L. Of the 10 participants with L+S group, 9 had high fall risk as determined by a TUG score of ≥13.5 sec. There were significant correlations between TUG time and SMI, and muscle strength in all participants (p<0.01; Figs. 1, 2). And gait speed also was significant correlations TUG similarly (R^2=0.6435, p<0.01).

Table 1. Physical characteristics of participants

	Total	CON	L	L+S	ANOVA	Post hoc test	ANCOVA#	Post hoc test
	n=112	n=72	n=30	n=10				
Age (years)	77.3 ± 5.7	75.6 ± 5.0	78.8 ± 4.0	85.4 ± 7.1	<0.01	a,b,c		
Body height (cm)	150.3 ± 4.8	150.5 ± 5.1	150.3 ± 4.1	149.2 ± 4.0	0.734	n.s.	0.663	n.s.
Body weight (kg)	50.4 ± 7.2	50.6 ± 7.1	52.1 ± 6.9	43.8 ± 4.6	0.005	b,c	0.059	n.s.
BMI (kg/m^2)	22.3 ± 3.0	22.3 ± 2.9	23.1 ± 3.1	19.7 ± 2.3	0.008	b,c	0.035	b
ASM (kg)	17.6 ± 2.9	18.5 ± 1.9	17.6 ± 2.8	11.4 ± 0.9	<0.01	b,c	<0.01	b,c
SMI (kg/m^2)	7.8 ± 1.2	8.2 ± 0.6	7.8 ± 1.2	5.1 ± 0.4	<0.01	b,c	<0.01	b,c
Handgrip strength (kg)	21.8 ± 5.5	24.1 ± 4.0	19.7 ± 4.9	11.9 ± 1.3	<0.01	a,b,c	<0.01	a,b,c
Gait speed (m/sec)	1.3 ± 0.3	1.4 ± 0.2	1.2 ± 0.3	0.8 ± 0.2	<0.01	a,b,c	<0.01	a,b,c
TUG (sec)	7.6 ± 4.1	5.9 ± 1.1	8.4 ± 3.9	17.5 ± 4.3	<0.01	a,b,c	<0.01	a,b,c
TMIG-IC (scores)	11.6 ± 2.2	12.5 ± 0.8	10.8 ± 2.8	8.0 ± 2.8	<0.01	a,b,c	<0.01	a,b,c
IADL (scores)	4.6 ± 1.1	5.0 ± 0.1	4.1 ± 1.5	3.0 ± 1.4	<0.01	a,b,c	<0.01	a,b,c
Intellectual activity (scores)	3.6 ± 0.7	3.8 ± 0.5	3.4 ± 0.8	3.2 ± 0.8	0.01	a,c	0.093	n.s.
Social role (scores)	3.4 ± 0.9	3.7 ± 0.6	3.3 ± 1.1	1.8 ± 1.0	<0.01	b,c	<0.01	b,c

Mean ± SD. BMI: body mass index; ASM: appendicular skeletal muscle mass; SMI: skeletal muscle mass index; TUG: Timed Up and Go Test; TMI-IC: Tokyo Metropolitan Institute of Gerontology Index of Competence; IADL: instrumental activities of daily living; CON: control group; L: locomotive syndrome group; L+S: coexistence of locomotive syndrome and sarcopenia group; Post hoc test: a: significant difference between CON and L groups; b: significant difference between L and L+S groups; c: significant difference between CON and L+S groups; n.s.: not significant; #: covariate: age.

Table 2. Relationship between fall risk and coexistence of locomotive syndrome and sarcopenia using χ^2 test

	CON	L	L+S	χ^2 test
	n=72	n=30	n=10	
High risk (≥13.5 sec)	0	3	9	p<0.01
Low risk (<13.5 sec)	72	26	1	

TUG: Timed Up and Go Test; CON: control group; L: locomotive syndrome group; L+S: coexistence of locomotive syndrome and sarcopenia group.

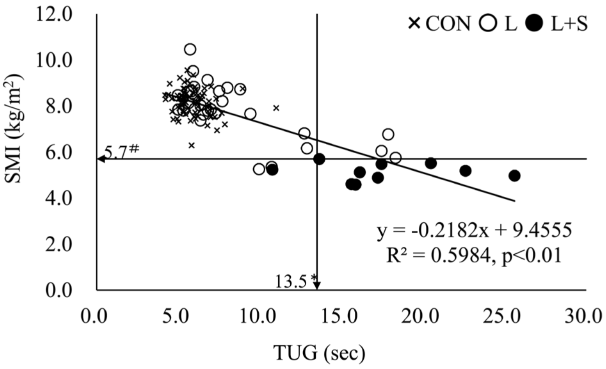

Fig. 1. SMI and TUG of the three groups.
Relationship between SMI (skeletal muscle mass) and TUG (Timed up and Go test), and control group (CON), Locomotive syndrome group (L), or coexistence of locomotive syndrome and sarcopenia-group (L+S). †: The vertical line on the x-axis shows 13.5 sec of the cut-off value of TUG. ‡: Horizontal lines on the y-axis show SMI's Asian standard of 5.7 kg/m^2.

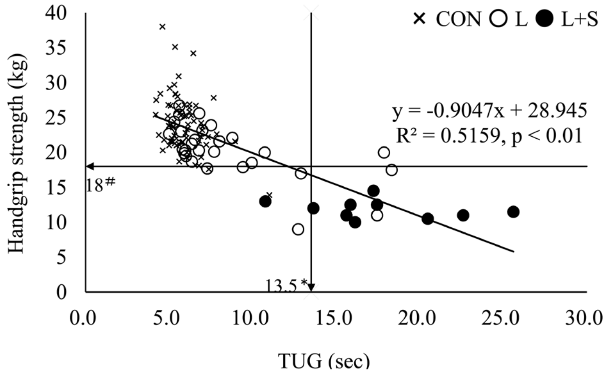

Fig. 2. Handgrip and TUG of the three groups.
Relationship between Handgrip strength and TUG (Timed up and Go test), and control group (CON), Locomotive syndrome group (L), or coexistence of locomotive syndrome and sarcopenia-group (L+S). †: The vertical line on the x-axis shows 13.5 sec of the cut-off value of TUG. ‡: Horizontal lines on the y-axis show Handgrip-strength's Asian standard of 18 kg.

Total TMIG-IC scores showed significant differences between groups (CON, L, and L+S groups; p<0.01; Table 1). There were significant differences between groups in IADLs and intellectual activity, but not social roles, by one-way ANCOVA adjusted for age (p<0.01; Table 1).

DISCUSSION

This cross-sectional study aimed to investigate if the coexistence of locomotive syndrome and sarcopenia are associated with increased fall of risk and worse ADL performance. The main findings of the present study were as follows: (1) TUG times in the L+S group were significantly longer than those in CON and L groups; (2) TUG times were closely correlated with muscle mass, muscle strength, and usual gait speed; (3) more than 90% of participants in the L+S group were classified as having high fall risk; and (4) the ADL performance in the L+S group was a significant decrease than those in CON and L groups. These main findings are in line with our hypothesis that the coexistence of locomotive syndrome and sarcopenia further increases fall risk and worse ADL performance among elderly Japanese females.

In general, fall risk is assessed by usual gait speed, TUG time, and balance. A previous study reported that participants who have fallen or who have gait or balance problems are at higher risk of future falls[17)]. Both locomotive syndrome and sarcopenia are associated with fall risk[9, 10)]. In the present study, TUG time in the L+S group was significantly longer than those in CON and L groups. Moreover, TUG time was closely correlated with muscle mass, and muscle strength (p<0.01; Figs. 1, 2). And gait speed also was significant correlations TUG similarly (R^2=0.6435, p<0.01). More than 90% of participants in the L+S group were classified as having a high fall risk by the 13.5 sec cut-off for TUG performance (p<0.01; Table 2). A high fall risk that defined by 13.5 sec cut-off are described in previous study[16, 17)], and showed relationship fall risk and lower extremity osteoarthritis[18)]. TUG times in the present study were 5.9 ± 1.1 sec in the CON group, 8.4 ± 3.9 sec in the L group, and 17.5 ± 4.3 sec in the L+S group. Mean TUG times reported in previous studies are similar to that of the L+S group in the present studyc. Therefor result of TUG time in the present study suggests that participants in the L+S group had a higher fall risk (90%) than participants in CON and L group.

Muscle function has been shown to be an important factor in balance, gait, and the occurrence of falls[19)]. Hayashida et al. reported relationships between muscle strength, muscle mass, and gait speed in community-dwelling elderly Japanese individuals aged ≥65 years[21)]. In that study, muscle strength was significantly positively correlated with maximum walking speed, whereas muscle mass was not. In the present study, a significant difference was observed between the three groups in SMI, handgrip strength, and gait speed by one-way ANCOVA adjusted for age. Results for these parameters were similar to those reported in a previous study[20].

Usual gait speed in the present study showed significant differences between all three groups. The usual gait speed determined for the CON group (1.4 ± 0.2 sec) is similar to that reported in a previous study targeting females aged ≥75 years (1.4 ± 0.14 sec)[7]. Results of the present study for ASM and SMI adjusted for age showed significant differences between CON and L+S groups, and between L and L+S groups. Handgrip strength measurements showed significant differences between all groups. Our findings also demonstrate that fall risk is clearly associated with muscle mass, muscle strength, and gait speed. Thus, usual gait speed, muscle mass, and muscle strength are closely connected with fall risk.

In activities of daily living, previous studies have reported that locomotive syndrome and sarcopenia are associated with ADL performance[9, 10]. For example, one study found that decreased rapid walking speed for females aged ≥65 years was associated with incident ADL disability[21]. In addition, walking speed for Japanese individuals aged ≥75 years has been found to be the best physical measurement for predicting the onset of ADL impairment[22]. Consistent with these relationships, we found significant differences between all groups in IADL and ADL, as reflected in total TMIG-IC scores. Moreover, the significant differences among all three groups for usual gait speed may suggest its relationship with IADL performance and total TMIG-IC scores.

Yoshimura et al. reported that prevalence of locomotive syndrome and sarcopenia, and co-existence of locomotive syndrome and sarcopenia was 70.2%, 0.0% and 5.8%, respectively, and 18.9% had none locomotive syndrome and sarcopenia[9]. In this study, prevalence of locomotive syndrome and sarcopenia, and co-existence of locomotive syndrome and sarcopenia was 26.8%, 0.0% and 8.9%, respectively, 70.2% have none locomotive syndrome and sarcopenia. In this study, prevalence of locomotive syndrome and sarcopenia, and co-existence of locomotive syndrome and sarcopenia was 26.8%, 0.0% and 8.9%, respectively. Prevalence of sarcopenia is equivalent result the previous study[23]. Therefore, it seems likely that locomotive syndrome is a more sensitive assessment of the lower limb dysfunction compare to sarcopenia. One of the reasons for this is that sarcopenia has more severe criteria than locomotive syndrome. AWGS 2019 revised the diagnostic algorithm, protocols and some criteria; low muscle strength is defined as handgrip strength <28 kg for males and 18 kg for females; criteria for low physical performance are 6-m walk <1.0 m/sec, five-time chair stand ≥12 sec[24].

The present study has some limitations. First, only elderly females aged ≥75 years were included in this study. Elderly males and a sarcopenia group were not included. Second, the present study had a small sample size. Finally, the present study adopted a cross-sectional design. Thus, our findings should be validated in a future prospective study with more participants.

In conclusion, we found that the coexistence of locomotive syndrome and sarcopenia are associated with increased risk of falls and worse activities of daily living in elderly females. Fall risk is clearly associated with muscle mass, muscle strength, and gait speed. Similarly, ADLs are associated with gait speed. It seems likely that locomotive syndrome is a more sensitive assessment of the lower limb dysfunction compare to sarcopenia. These findings may contribute to the treatment of elderly individuals by identifying reasons for increased fall risk and worse ADL performance.

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Conflict of interest

The authors declare no conflicts of interest associated with this manuscript.

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