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Improving Capacity of Older Adults with Locomotive Syndrome Stage 1 Living in Nursing Home: A Pilot Clinical Trial

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Background: Aging causes locomotive syndrome (LS), which is characterized by difficulty in walking. The present study determined the effects of locomotion training and regular aerobic exercise programs on the aerobic capacity of older nursing home residents with LS stage 1. **Methods:** This randomized controlled trial included 24 participants aged 60–80 years with LS stage 1 residing in a single nursing home in Surabaya, Indonesia. The participants were randomly assigned to either the locomotion training group (LTG) or the control group (CG). Both the groups performed 30 minutes of a daily group-based aerobic exercise program for 8 weeks. The LTG performed additional locomotion training three times weekly, with three sets per session, gradually increasing to five sets per session according to the participant's tolerance. Two-minute walking test (2MWT) values before and after the 8-week intervention were determined in both the groups and converted to maximum oxygen consumption (VO_{2max}) values. **Results:** After 8 weeks of intervention, a significant increase in VO_{2max} was observed in both the groups (both $p<0.05$). The LTG showed a more significant improvement in VO_{2max} ($p<0.05$) compared to the CG. **Conclusion:** The study results demonstrated the positive effect of 8 weeks of locomotion training and regular aerobic exercise programs in improving the aerobic capacity of older adult nursing home residents with LS stage 1.

Key Words: Older adult, Locomotion, Mobility limitation, Aerobic exercise, Physical Fitness, Nursing home

INTRODUCTION

Indonesia is an aging society. According to Indonesian Central Bureau of Statistics (BPS) data in 2020, the number of citizens aged 60 years or older in Indonesia reached 26.82 million, or approximately 9.92% of the total population. This number is predicted to increase to around 20% in 2045.[1)] Aging causes the deterioration of various organs, including locomotor organs such as the bones, joints, muscles, and nerves.[2)] Locomotive syndrome (LS) is a state of degraded mobility due to impaired locomotive organs, which results in an increased risk of disability.[3)] This syndrome, characterized by decreased physical function in older adults, leads to limitations 1st in activities of daily living (ADL) and reduced quality of life.[2,3)] Locomotion syndrome is classified into three stages depending on the severity of locomotion dysfunction. Locomotion stage 1 indicates the beginning of the mobility function decline and is recommended to perform exercise training (locomotion training). Locomotion stages 2 and 3 need further physician evaluation before any intervention is taken.[2,3)]

The decrease in physical function with increasing age can be assessed by measuring exercise capacity using maximal and submaximal exercise tests to measure maximum oxygen consumption (VO_{2max}).[4] The 2-minute walk test (2MWT) is a shorter and relatively safer submaximal training test, especially for frail older adults. These tests are safe and simple, provide the same information on mobility, and are valid and reliable for the measurement of aerobic capacity in older adults.[5,6]

Physical exercise can improve physical function, reduce inflammation, and delay dependence in older adults.[7-9] The recommended physical exercise program for older adults is multicomponent exercises that include strength, flexibility, balance, and aerobic exercise.[10] The locomotion training developed by the Japanese Orthopedic Association is a combination of strengthening and balance exercises that are proven safe, simple, and effective for improving the physical function of older adults.[2,3]

Nursing homes in Indonesia are funded mainly by the government, private companies, and charity organizations. Usually, only older adults with comorbidities and poor financial support move to nursing homes.[11] Due to the lack of funds and staff, many of these nursing homes cannot provide comprehensive and multimodal exercise programs to their residents. Thus, short-duration, low-to-moderate-intensity aerobic exercise has become a staple in most nursing homes in Indonesia.

The present study aimed to assess the effect of locomotion training and regular aerobic exercise programs on the aerobic capacity of older adults with LS stage 1 living in nursing homes. We hypothesized that older adults who participated in the intervention groups would show significantly improved outcomes compared to their peers in the control group (CG).

MATERIALS AND METHODS

Study Design and Study Population

This randomized clinical trial was conducted at Jambangan Nursing Home from December 2020 to February 2021. The study population consisted of older adults residing in the nursing home. The inclusion criteria were older adults aged 60–80 years with LS stage 1—a positive Indonesian version of the loco-check[12] and a 25-question Geriatric Locomotive Function Scale (GLFS-25) score of 7–15.[13] The exclusion criteria were loss of sight, hearing, and other senses that affected communication; previous diagnosis of dementia or cognitive impairment; unstable hemodynamics; any acute metabolic disorder; heart failure (New York Heart Association [NYHA] class II, III, and IV); uncontrolled hypertension (systolic blood pressure >180 mmHg, diastolic blood pressure >100 mmHg); uncontrolled arrhythmia; stable or unstable angina pectoris; and any pain or physical disability that prevented exercise. Fig. 1 shows a flowchart of the study participants. This study was approved by the Research Ethics Committee of Airlangga University School of Medicine Health (No. 207/EC/KEPK/FKUA/2020). All procedures followed the principles of the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards. The patients were informed about the study protocol, and they provided their written informed consent. This study complied the ethical guidelines for authorship and publishing in the *Annals of Geriatric Medicine and Research*.[14]

Randomization

This randomized controlled trial included 24 older adults aged

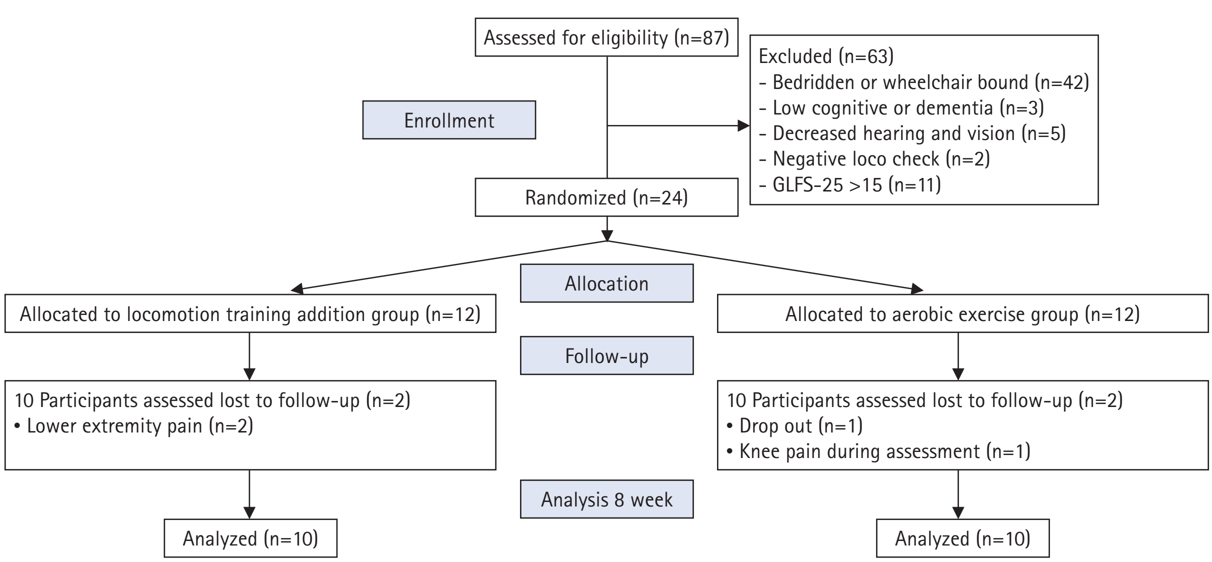

Fig. 1. Flowchart of the study procedure. GLFS-25, 25-question Geriatric Locomotive Function Scale.

60–80 years residing in a single nursing home in Surabaya, Indonesia. The participants were randomly assigned to the intervention/locomotion training group (LTG) or CG. This trial was not blinded for participants and investigators because the intervention could not be blinded. The sample size for the present study was calculated[15)] based on a previous study examining the effects of a multicomponent exercise intervention on frail older adults,[16)] with alpha error rate (α) = 5% and beta error rate (β) = 20%. The research sample comprised 10 older adults in each group. The sample size was increased by 20% to account for participant dropout during follow-up. The final sample size was 24 older adults, who were equally distributed between the two groups (12 participants in each group).

Interventions

The participants in both the groups performed mild-to-moderate aerobic exercise daily (40%–70% maximal heart rate) for 30 minutes per session. The aerobic exercise included movements to improve cardiorespiratory and muscle endurance and maintain joint flexibility. The LTG received additional locomotion training three times per week; the three sets per session were gradually increased to five sets per session according to the participants' tolerance. In both LTG and CG, measurements were performed before and after 8 weeks of intervention and compared statistically.

Locomotion Training

The locomotion training included strengthening and balancing exercises. The four exercises included one-leg stand, half-squat, heel raise, and forward lunge. All exercises were performed in six-member groups under the supervision of a physician, two physiotherapists, and nursing home medical staff on pre-programmed days and hours in the Jambangan Nursing Home multipurpose room. A physiotherapist provided examples of the movements to ensure the correctness of the movements during locomotion training. The participants were also provided with a booklet and video describing the locomotion training. The details of each set of locomotion training exercises and instructions were as follows: single-leg standing with eyes open (1 minute for each leg), squats (six repetitions), heel raises (10 repetitions), and forward lunges (five repetitions for each leg). Further details are available from the Japanese Orthopedic Association (https://locomo-joa.jp/assets/pdf/index_english.pdf).

Control Group

The CG received routine health care at Jambangan Nursing Home, including monthly physician visits, tests, prescription medications, and daily activities. The CG participants were asked not to participate in any other intervention-based training program during the 8-week study period. To meet the ethical principles, the CG was provided knowledge of the concepts of the locomotion training program and its applications after completing the research data.

Assessments

We obtained written informed consent from all participants after providing them with necessary information about the study. The participants then completed the research forms, which allowed the collection of data on sociodemographic characteristics including age, sex, education, and use of walking aids. The participants recorded their body weight, body height, body mass index (BMI), and submaximal exercise testing with 2MWT in 30-m courses. The distance was recorded and converted to VO_{2max} using equation[6)]:

$$VO_{2max}\ (\text{mL/kg BB/min}) = 2.809 + (0.868 \times \text{age}) - (0.0412 \times \text{body weight}) - (0.382 \times \text{body height}) - (0.474 \times \text{walking speed})$$

Note: Age (y), body weight (kg), body height (cm), walking speed (m/min), estimation of error standard = 0.119.

This equation was developed by Pratiwi et al.[6)] in 2019 for older adults with frailty. The VO_{2max} value obtained from this equation was calculated using confirmatory factor analysis. The calculation of the Pearson correlation coefficient revealed a strong correlation ($r = 0.791$; $p < 0.001$) with the 2MWT and a significant correlation with VO_{2max} values during the 6-minute walking test (6MWT) submaximal training test. The 2MWT has shown very good test-retest reliability (intraclass correlation coefficient [ICC] = 92.5%). This result demonstrated that the 2MWT submaximal training test was reliable for the assessment of aerobic capacity.[6)]

Statistical Analyses

IBM SPSS Statistics for Windows, version 26.0 (IBM Corp., Armonk, NY, USA) was used to analyze the data. Categorical variables are expressed as numbers and percentages, while continuous variables are expressed as means and standard deviation (SD). In the statistical evaluations of the variables, we assessed the normality of the variable measurements using Shapiro-Wilk tests. Independent- and paired-sample t-tests were used in pairwise comparisons and within- and between-group evaluations because they were consistent with the normal distribution. Statistical significance was set at $p < 0.05$.

RESULTS

The mean ages of the LTG and CG (75.40 ± 4.88 and 72.30 ± 4.30

Table 1. Baseline demographic characteristics of the participant groups

Characteristic	Locomotion training group (n = 10)	Control group (n = 10)	p-value
Age (y)	75.40 ± 4.88	72.30 ± 4.30	0.15
Sex			
Female	7 (70)	7 (70)	
Male	3 (30)	3 (30)	
Education level			
Elementary school or lower	7 (70)	8 (80)	
Middle school	1 (10)	1 (10)	
High school	1 (10)	1 (10)	
University	1 (10)	0 (0)	
Ambulatory Aid			
Yes	1 (10)	0 (0)	
No	9 (90)	10 (100)	
Body height (cm)	148.5 ± 8.51	153.7 ± 7.97	0.18
Body weight (kg)	45.41 ± 8.08	48.96 ± 13.30	0.48
BMI (kg/m^2)	20.56 ± 3.19	20.50 ± 4.38	0.97
GLFS-25 score	8.20 ± 1.93	8.50 ± 1.58	0.71
Baseline 2MWT (m)	91.7 ± 20.9	90.0 ± 14.5	0.84
Baseline VO_{2max} (mL/kg/min)	28.9 ± 6.9	34.6 ± 8.6	0.12

Values are presented as mean±standard deviation or number (%).
BMI, body mass index; GLFS-25, 25-question Geriatric Locomotive Function Scale; 2MWT, 2-minute walk test; VO_{2max}, maximum oxygen consumption.

years, respectively) were similar, and most participants in both the groups were female (70% in both the groups). The other demographic characteristics of the two groups were also similar (Table 1). We observed no significant differences in the mean and SD of baseline body weight, height, BMI, GLFS-25, 2MWT, and VO_{2max} between the LTG and CG (Table 1). Two participants each in the LTG and CG dropped out of the study. Hence, the study was completed by 10 participants each in the LTG and CG. The outcomes of within- and between-group assessments after calculating the median and mean values for each scale before and after the 8-week intervention were also performed. The mean 2MWT score before and after the 8-week intervention differed significantly in the LTG ($p = 0.001$). The mean and SD of 2MWT before the intervention, 91.70 ± 20.90, increased to 107.00 ± 21.38 after the intervention, indicating the effectiveness of the additional locomotion training on improving mobility in older adults with LS. However, we observed no significant changes in the CG ($p = 0.249$). The mean 2MWT values differed significantly between the two groups after the 8-week intervention ($p = 0.004$) (Table 2). The mean VO_{2max} differed significantly before and after the 8-week intervention in the LTG and CG ($p < 0.001$ and $p = 0.022$, respectively). The mean and standard deviation of VO_{2max} before the intervention, 28.9 ± 6.9, increased to 33.4 ± 8.3 after the intervention in the LTG. Moreover, the mean and SD of the VO_{2max} before the intervention, 34.6 ± 8.6, increased to 36.6 ± 8.8 after the intervention. The two groups also showed a significant difference in the mean VO_{2max} values after the 8-week intervention ($p = 0.016$) (Table 3).

DISCUSSION

The present study assessed the effect of locomotion training and regular aerobic exercise programs on older adults with LS stage 1 who were nursing home residents. LS is a condition of reduced mobility due to impairment of the locomotive organs. Because upright bipedal walking involves minutely controlled movement patterns, it can be adversely affected by the impairment of any aspect of the locomotive organs. The progression of these impairments eventually results in limitations in ADL, reduction in quality of life, and the necessity for care support. Based on the 2020 LS criteria, LS can be classified into three stages based on the total GLFS-25 score, with scores ≥ 7 to < 16, ≥ 16 to < 24, and ≤ 24 categorized as LS stages 1, 2, and 3, respectively. A higher score indicates lower locomotive function, and physical performance test results differ significantly between LS stages 2 and 3, while muscle strength differs significantly between LS stages 1 and 2.[2,3,13)]

Functional mobility and independence are the main objectives of rehabilitation programs. Functional capacity reflects an individual's aerobic capacity.[6)] The current concept of LS focuses on strength and balance impairments in determining decreased functional capacity and mobility in older adults.[2,3)] The lower limb

Table 2. Within-group and between-group comparisons of 2MWT scores before and 8 weeks after the intervention

	Locomotion training group		Control group		p-value (between-group)
	Score	p-value (within-group)	Score	p-value (within-group)	
Pre-intervention	91.7±20.90	0.001*	90.0±14.50	0.249	0.004*
Post-intervention	107.0±21.38		92.7±10.84		

Values are presented as mean±standard deviation.
2MWT, 2-minute walking test.
*p<0.05.

Table 3. Within-group and between-group comparisons of VO_{2max} scores before and 8 weeks after the intervention

	Locomotion training group		Control group		p-value (between-group)
	Score	p-value (within-group)	Score	p-value (within-group)	
Pre-intervention	28.9±6.9	<0.001*	34.6±8.6	0.022*	0.016*
Post-intervention	33.4±8.3		36.6±8.8		

Values are presented as mean±standard deviation.
VO_{2max}, maximum oxygen consumption.
*p<0.05.

muscle strength is strongly positively correlated with body balance in older adults.[17)] Strength and balance are often significant contributors to mobility limitations, and aerobic capacity, often measured as maximal oxygen uptake (VO_{2max}) or peak oxygen uptake (VO_{2peak}), also correlates with self-reported difficulty and disability and timed functional performance in older adults.[18)]

Aerobic capacity is generally assessed by measuring VO_{2max}. However, this measurement requires complex equipment and laboratories, specific and expensive equipment, supervision of a professional medical team, and consideration of the motivation and physical effort of the subject to undergo the training test. Therefore, an alternative test is required to estimate VO_{2max} using a submaximal training test.[6,19)]

The 6MWT is a standardized test developed by the American Thoracic Society in 2002 to measure VO_{2max}. However, this test has limitations in older adults, especially those with frailty. The 6MWT is too tiring, takes longer, and increases the risk of falling in frail older adults; therefore, the 2MWT may be an alternative in this population. The 2MWT has good validity, as anthropometric parameters of weight, height, age, sex, and walking speed in the 2MWT were significantly correlated with VO_{2max} during the 6MWT submaximal training test. The 2MWT also has excellent test-retest reliability in frail older adults.[6)]

In older adults, physical activity is associated with many health benefits and functional abilities, including ADL mobility and independence. Physical activity also promotes better outcomes in older adults with chronic diseases. Physical exercise reduces the risk of falls and improves physical function, particularly in frail older adults with limited mobility.[7,20)]

In this study, locomotion training and a regular aerobic exercise program for 8 weeks resulted in a significant increase in 2MWT in the LTG (15.3±9.8 m). In contrast, we observed no significant change between the baseline and post-exercise periods in the CG. Connelly et al.[5)] reported that the minimum change value for the 2MWT to show the effect of exercise on the aerobic capacity of older adults in nursing homes was 15 m, with a time between measurements of at least 1 week.

The walking test for measuring aerobic capacity indicates the capacity for independent mobility, defined as the ability to adjust body position independently, strength for vertical and horizontal transitions, and aerobic fitness. Tests based on runs have limitations for use in older individuals with multisystem disorders.[5)] Walking test results are also highly correlated with other mobility measures, including balance and strength.[21)] LS is characterized by decreased balance and strength. Locomotion training combines strengthening and balance exercises; therefore, regular locomotion training can improve these factors, including the mobility ability of patients with LS.[2,3)] This improved mobility capability is evident in the 2MWT results.

Comparisons of mean VO_{2max} values before and after the 8-week intervention showed a significant difference between the LTG and CG ($p = 0.016$). Both the groups showed significantly increased VO_{2max}; however, the difference was greater in the LTG than in the CG. A meta-analysis by Hurst et al.[22)] concluded that for the same duration, a combination of aerobic and strengthening exercises provided a better benefit in increasing VO_{2max} compared to aerobic exercise alone in a population aged >50 years. This is because aging simultaneously affects several physiological systems. Therefore, physical exercise in older adults should include resistance training, aerobics, balance, and flexibility exercises.[23)]

This study had several limitations. First, this study was performed during the coronavirus disease 2019 pandemic and included a relatively small number of participants in a single study area. Owing to the small number of participants, we could not assess the effect of locomotion training addition based on participant sex; therefore, sex differences in locomotive performance could be possible. Moreover, most participants were women; therefore, the results could not completely reflect the older population. Follow-up studies with larger sample sizes and geographical areas are warranted. Second, long-term effects of locomotion training were not monitored and the total exercise duration was longer in the LTG than in the CG. These differences in exercise durations also affected the results of the locomotion training. The evaluation of the long-term effects and an increased duration of the CG is recommended in follow-up studies.

In conclusion, the addition of locomotion training to a regular aerobic exercise program in nursing homes showed positive effects on improving mobility and aerobic capacity in older adults with LS stage 1. Locomotive training may be an effective intervention to prevent and slow LS progression in older adults living in nursing homes.

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CONFLICT OF INTEREST
The researchers claim no conflicts of interest.

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AUTHOR CONTRIBUTIONS
Conceptualization: MP, DT, RS, DP, SMMW, YM; Data curation and Formal analysis: MP, DT, SM; Investigation and Methodology: MP, DT, DP, RS, SMMW, YM; Project administration: MP; Supervision: DP, MP, RS, DT, SMMW, YM; Writing-original draft: MP; Writing-review and editing: DP, RS, SMMW, DT, YM, SM.

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