Exercise improving balance function in the older adult with locomotive syndrome stage 1: a randomized clinical trial

Ajeng Hayu Nayasista1, Rwahita Satyawati Dharmanta1, Yudith Dian Prawitri2*, Sri Mardjiati Mei Wulan1, Yukio Mikami3, Soenarnatalina Melaniani4

ABSTRACT

Introduction: Fall risk is generally increased in older adults. The aging process is linked to several balance issues and gait abnormalities in the elderly. A multicomponent exercise program for older persons that combines locomotor training and cardiovascular exercise may help the aged population's balance and strength. This study aims to investigate the effects of aerobic exercise and locomotor training on the elderly’s capacity to balance.

Methods: This study is a randomized clinical trial with a pre-test and post-test group design. 24 older adults were divided into an intervention group (locomotor training combined with aerobic exercise) and a control group (aerobic exercise only). They underwent locomotor training 3 times a week for 8 weeks under supervision and aerobic exercise 7 times a week 40-70% HR maximal. The pairwise comparisons within-group evaluations, and between-group evaluations used independent- and paired-sample t-tests.

Results: One Leg Stance (OLS) and Timed Up and Go (TUG) test intra-group and inter-group differences were significantly higher (p< 0.05).

Conclusion: The combination of locomotor exercise and aerobic exercise improves static and dynamic balance in older adults with locomotive syndrome stage 1.

INTRODUCTION

The aging of the population has become a global phenomenon. Additionally, Indonesia is where this incident takes place. Indonesia’s population structure is characterized by an aging demographic, with more than 10% of the country’s population expected to be over 65 in 2020. In Indonesia, it was predicted that by 2045, the elderly would make up around one-fifth of the entire population. 28 million Indonesians, or 10.7% of the entire population, are projected to be 60 or older in 2020. The increased incidence of falls among the elderly is one of their issues. Aging is a factor in many older adult’s balance and gait issues. Decreased lower limb muscle strength in older adults and aging of the nervous system will cause a decrease in older adults’ ability to perform daily tasks. This causes an older to become increasingly dependent and can increase the risk of falling. The term “Locomotive Syndrome” refers to the idea of musculoskeletal diseases in the elderly that are characterized by loss of balance and difficulties walking and result in incapacity. The locomotive syndrome is one of the most typical types of persistent impairment in the elderly, which affects 59.8% due to non-traumatic causes such as joint degradation and chronic illness. Types of exercise used as interventions for decreasing locomotor function in the elderly include multicomponent exercises consisting of strengthening, flexibility, balance, and aerobic exercises. The Japanese Orthopedic Association (JOA) developed Locotra (Locomotion Training), a series of low-to moderate-intensity exercises with a focus on building balance and muscle strength to improve standing function and mobility in the elderly. The exercise has aerobic components. Aerobic exercise can have benefits in the elderly by decreasing body fat mass, boosting cardiopulmonary and endothelial function, and increasing mitochondrial biogenesis, which will result in improved cardiopulmonary performance in the patient. Aerobic exercise will also boost blood flow, particularly to the muscles, hence increasing myofibril oxygenation.
can result in increased resistance in the big trained muscles. Aerobic exercise can raise the strength, function, and capacity of muscle training, which correlates to an individual’s ability to carry out daily tasks.8-10 This study aimed to investigate how aerobic exercise and locomotor training affected balance in older adults.

**METHODS**

**Participant**

The elderly population aged 60-80 years at the Jambangan Nursing Home with a diagnosis of stage 1 Locomotive Syndrome is characterized by a positive score on the Indonesian version of the loco-check questionnaire11 and a score of 7-15 on the 25-question Geriatric Locomotive Function Scale (GLFS-25)12 vision and hearing function were normal, there was no decrease in cognitive function so that the subject could understand and follow instructions, as determined by a score ≥26 on the Montreal Cognitive Assessment-Indonesian Version (MoC-Ina)13, hemodynamics stable, and the patient was willing to fill out the consent form. Exclusion criteria where the elderly have a cardiopulmonary disease that impairs physical performance during exercise (resting blood pressure 180/100 mmHg, sufferers of NYHA Class III and IV uncompensated heart failure, and Chronic Obstructive Pulmonary Disease), have muscle or lower limb joint pain (Wong-Baker Face Scale score > 4) and clinical signs of inflammation and are affected by BPPV (Benign Paroxysmal Position (eg, patients with peripheral neuropathy or decreased balance function after stroke).

**Study Design**

Between December 2020 and February 2021, a randomized clinical trial with a pre-test and post-test group design will be conducted. Twenty senior citizens were randomly split into two groups: the treatment group and the control group (figure 1). While the control group only received aerobic exercise, the treatment group received both locomotor training and exercise. This study was authorized by the research ethics committee of the school of medicine at Airlangga University (No. 302/EC/KEPK/FKUA/2020).

**Exercise Intervention**

Balance and resistance exercises are incorporated into a sequence of locomotor activities. The four main exercises of locomotor training include the one-legged stance, which is performed three times for one minute on each leg. The second exercise is the squat, which is performed six times. It is advised to perform inspiration when standing and exhalation while lying down. Ten repetitions of the heel raise exercise are performed as the third exercise. The fourth exercise is front lunges, which are performed five times.14 The number of sets gradually increases until the final treatment consists of three. Both the control and treatment groups participated in aerobic activity to improve cardiorespiratory endurance and muscular endurance. The control group performs daily (40-70% maximum HR) exercise for thirty minutes. The intervention lasted for eight weeks. The training was overseen by two physiotherapists, two social workers from an orphanage, and two physicians. The final measurement will be performed one week following the patient’s final workout.

**Balance Assessment**

This study evaluated the balance function using the One Leg Stand Test and the Timed Up and Go Test. The one-leg stance (OLS) test has been utilized as a predictor...
of balancing function when conducted statically with eyes open for one minute. This Timed Up and Go (TUG) test can simultaneously assess functional mobility in the elderly. Sitting to standing and standing to sitting activities are functional activities that are often done on a daily basis. The ability to stand is important for independence and prerequisite for upright mobility. Less than five minutes are needed to complete the TUG test, and no special tools are needed. The subject sits with his back against the chair in a typical chair (height range: 44–47 cm) to do the TUG test. In response to cues, the patient stands (without using the armrests), moves three meters at a regular pace, then circles back and returns to the chair to sit down. A longer test completion time of 13.5 seconds indicates a higher risk of falling among the elderly.

### Statistical Analysis

Version 26.0 of IBM SPSS Statistics for Windows was used to analyze the data (IBM Corp., Armonk, NY, USA). The sample size was determined. Since they were compatible with the normal distribution, pairwise comparisons, within-group evaluations, and between-group evaluations used independent- and paired-sample t-tests. p value < 0.05 was used as the significant level.

### RESULTS

#### Participant characteristics

In the treatment group, the average age was 75.4 + 4.88 years, while in the control group, it was 72.3 + 4.3 years. The mean body mass index (BMI) in the treatment group was 20.56 + 3.19 kg/m², whereas it was 20.49 + 4.38 kg/m² in the control group; there was no significant difference between the BMI of the control and treatment groups (p= 0.25). The mean GLFS-25 score in the treatment group was 4.74 + 1.65, whereas it was 8.5 + 1.58 in the control group; therefore, there was no significant difference between the treatment and control groups (p=0.63). The 2-minute walk test revealed that the mean value of cardiorespiratory fitness assessed by VO2max before treatment was 28.9 + 6.9 ml/kg/min in the treatment group and 34.6 + 8.6 ml/kg/min in the control group with p= 0.34; therefore, there was no significant difference between the fitness status of the treatment and control groups prior to receiving treatment. Before treatment, there was no significant difference between the static balancing function of the treatment group and the control group (p = 0.75), as the mean OLS value for the treatment group was 4.74 + 1.65 seconds, and for the control group, it was 2.7 + 1.47 seconds. The mean value of TUG in the treatment group was 13.17 + 2.75 seconds, whereas it was 12.04 + 2.89 seconds in the control group, with no significant difference in the context of the dynamic balancing function between the two groups (p=0.54) (Table 1). In the OLS calculation In the treatment group, there was a significant difference in the OLS before and after 8 weeks of practice (p-value <0.001), whereas there was no significant difference in the control group (p-value 0.345). The OLS comparison between the intervention and control groups revealed a significant difference (p-value <0.001). (Table 2). In the TUG calculation In the treatment group, there was a significant difference in the TUG before and after 8 weeks of practice (p-value 0.001), whereas there was no significant difference in the control group (p-value 0.345). The TUG comparison between the intervention and control groups revealed a significant difference (p-value = 0.001). (Table 3).

#### Table 1. Basic characteristics of participants.

<table>
<thead>
<tr>
<th>No</th>
<th>Characteristic</th>
<th>Intervention Group Mean ± SD</th>
<th>N</th>
<th>Control Group Mean ± SD</th>
<th>N</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Age</td>
<td>75.40 ± 4.88</td>
<td>10</td>
<td>72.30 ± 4.30</td>
<td>10</td>
<td>0.63</td>
</tr>
<tr>
<td>2</td>
<td>Body Mass Index (kg/m²)</td>
<td>20.56 ± 3.19</td>
<td>10</td>
<td>20.49 ± 4.38</td>
<td>10</td>
<td>0.25</td>
</tr>
<tr>
<td>3</td>
<td>GLFS-25</td>
<td>8.3 ± 1.83</td>
<td>10</td>
<td>8.5 ± 1.58</td>
<td>10</td>
<td>0.63</td>
</tr>
<tr>
<td>4</td>
<td>VO2max</td>
<td>28.9 ± 6.9</td>
<td>10</td>
<td>34.6 ± 8.6</td>
<td>10</td>
<td>0.34</td>
</tr>
<tr>
<td>5</td>
<td>OLS (s)</td>
<td>4.74 ± 1.65</td>
<td>10</td>
<td>2.7 ± 1.47</td>
<td>10</td>
<td>0.75</td>
</tr>
<tr>
<td>6</td>
<td>TUG (s)</td>
<td>13.17 ± 2.75</td>
<td>10</td>
<td>12.04 ± 2.89</td>
<td>10</td>
<td>0.54</td>
</tr>
</tbody>
</table>

Significance value(p<0.05)

#### Table 2. Comparisons within-group and between-group of One Leg Stance score.

<table>
<thead>
<tr>
<th></th>
<th>Intervention (n=10)</th>
<th></th>
<th>Control (n=10)</th>
<th></th>
<th>p-value between group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Before</td>
<td>After</td>
<td>p-value</td>
<td>Before</td>
<td>After</td>
</tr>
<tr>
<td>OLS (s)</td>
<td>3.43±1.73</td>
<td>14.85±2.73</td>
<td>0.000*</td>
<td>2.70±1.48</td>
<td>3.16±0.94</td>
</tr>
</tbody>
</table>

Significance value(p<0.05)

#### Table 3. Comparisons within-group and between-group of Timed Up and Go score.

<table>
<thead>
<tr>
<th></th>
<th>Intervention (n=10)</th>
<th></th>
<th>Control (n=10)</th>
<th></th>
<th>p-value between group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Before</td>
<td>After</td>
<td>p-value</td>
<td>Before</td>
<td>After</td>
</tr>
<tr>
<td>TUG (s)</td>
<td>13.16±2.74</td>
<td>9.38±0.76</td>
<td>0.001*</td>
<td>12.59±1.55</td>
<td>14.89±3.91</td>
</tr>
</tbody>
</table>

Significance value(p<0.05)
DISCUSSION

The body’s ability to adapt in order to maintain a position either statically or dynamically is known as balance. The purpose of this is to keep the body’s center of mass at the fulcrum.\textsuperscript{17} Static balance refers to the body’s capacity to maintain equilibrium in a steady position with a constant center of gravity (COG), such as when standing on one leg or on a balancing board. Static balance is crucial to maintaining stability throughout the movement in order to prevent falls when the human body is in a different position.\textsuperscript{19} Dynamic balance refers to the capacity to hold a body position where the Center of Gravity (COG) is constantly fluctuating or the capacity to maintain balance while moving on a motion base that renders the body inherently unstable. The ability to stand is essential for independence and is a requirement for upright movement. The pattern of muscle activation during the transition from sitting to standing starts with the activation of the anterior tibialis muscle and forward rotation of the leg, then the quadriceps, which helps to stabilize the knee before knee extension, the hamstrings, which also serve as a knee stabilizer, and finally the soleus muscle.\textsuperscript{18,20}

The elderly’s physical performance can be significantly improved with exercise therapy. Strengthening activities, flexibility exercises, balancing exercises, aerobic workouts, or a mix of these exercises known as multimodal exercises are the sorts of exercises utilized as therapies for decreased locomotor function in the elderly.\textsuperscript{4} The results of this study support previous research on the benefits of multimodal exercise, which included exercising the elderly for 12 weeks, but the effect of raising OLS values can already be seen in 8 weeks. Locomotor exercises were added to aerobic exercise for 8 weeks, increasing OLS values in the elderly.\textsuperscript{21} It is suspected that there is an increase in the serum Brain Derived Nerve-growth Factor (BDNF) in the elderly who undergo multimodal exercise. Exercise-induced increase in serum protein BDNF is closely related to the process of neuroplasticity. The emergence of BDNF when the elderly do exercises can stimulate motor responses so that they can stimulate the excitability of motor networks in the spinal cord, modulate the release of acetylcholine at neuromuscular synapses, maintain the level of neuron resistance so that it can potentially increase neuron growth and trigger neuroplasticity, to improve static balance function.\textsuperscript{22-23} In this study, when the combination of multimodal exercise was compared with aerobic exercise therapy alone, there was no improvement in static balance. This was because one of the factors of lower extremity muscle strength, such as the soleus, gastrocnemius, and hamstring muscles, played an important role in maintaining static balance, whereas the aerobic exercise protocol does not include a strengthening component for these muscles.\textsuperscript{24} The results of this study suggest that eight weeks of locomotor training combined with aerobic exercise can improve dynamic balance function. In accordance with prior studies, there was an increase in TUG values among the elderly after 9 weeks of multimodal training.\textsuperscript{25-26} TUG measures dynamic balancing function and has the potential to predict elderly mobility.\textsuperscript{27} The elderly in this study engaged in routine physical activity with multimodal exercises that involved mechanical stimulation from the body, increasing the production of neurotrophic factor (BDNF), which is closely related to the process of neurogenesis and where an increase in BDNF levels in the body is triggered by routine physical exercise in healthy elderly people. This led to an increase in the TUG value.\textsuperscript{28-30} Physical exercise in the elderly can reduce the process of oxidative stress that hinders the improvement of the elderly’s mobility function, where balance, muscle strength, and good sensory factors are closely related to the increase in the elderly’s functional dynamic balance as measured by the TUG test. The body can retain the dynamic balance function specific to aging and is directly correlated with neurodegenerative processes thanks to neurogenesis, which boosts the number of nerve fibers as well as afferent and efferent impulses.\textsuperscript{8} The components of balance and muscle strengthening in locomotor training also increase as evidenced by the increase in TUG values before and after exercise. In the control group, which only did aerobic exercise without the addition of locomotor exercises, there was no difference in the TUG assessment because the intensity could not be closely supervised, so it could not have a positive effect on balance function. Aerobic exercise carried out with an intensity of 60-85% HRR can improve balance function as measured by the TUG test.\textsuperscript{29}

CONCLUSION

The combination of locomotor and aerobic exercise for eight weeks has significantly improved static and dynamic balance function compared to aerobic exercise alone in older adults with locomotive syndrome stage 1. It is important to assess the supervision dose of aerobic exercise intensity and a larger sample size in order to generalize the research findings.

ACKNOWLEDGMENTS

We would like to express our deepest gratitude to the heads of the institution, board members, and staff of Dr. Soetomo General Academic Hospital and Universitas Airlangga for their cooperation and encouragement. We are also immensely grateful to all the participants participating in this study and their families.

CONFLICT OF INTEREST

The author reports no conflicts of interest in this work.

AUTHOR CONTRIBUTION

All authors have contributed equally from the conceptual framework, data acquisition, and data analysis until the study results are reported through publication.

FUNDING

This research did not receive any specific grant from funding agencies in public, commercial, or not-for-profit-sectors.

REFERENCES

ORIGINAL ARTICLE


