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Randomised Controlled Trial

Effect of combined locomotor training and aerobic exercise on increasing handgrip strength in elderly with locomotive syndrome: A randomised controlled trial

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ABSTRACT

Background: Elderly with the locomotive syndrome is at high risk for fall and fractures. Thus multimodal therapy is needed to minimize the risk.
Objective: Analyzing the effect of combined locomotor training and aerobic exercise on muscle strength in elderly with locomotive syndrome stage 1.
Methods: This study used a pre-test and post-test design with 20 participants (treatment group = 10 participants and control group = 10 participants). The treatment group was given combined locomotor training and aerobic exercise, while the control group was only given aerobic exercise for eight weeks. Locomotor training was provided three times/week with progressive increase of set and repetition at each activity. Meanwhile, aerobic exercise was given seven times/week for 30 min per session. Participants were examined for muscle strength (handgrip strength) before and after the intervention. The analysis included paired *t*-test and an independent *t*-test with a *p*-value <0.05.
Results: The participants' mean age was 73.85 ± 4.75 years, with treatment group = 75.4 ± 4.88 years and control group = 72.3 ± 4.30 years (t = 1.508; 95% CI = −1.220 – 7420; p = 0.149). The HGS values in the treatment group were 13.89 ± 5.27 (pre-test) and 19.06 ± 4.54 (post-test; t = 11.765; 95% CI = −6.164 to −4.176; $p < 0.001$). Meanwhile, the HGS values in the control group at pre-test and post-test were 11.27 ± 2.17 and 13.03 ± 2.54, respectively (t = 2.057; 95% CI = −1.600 – 0.076; p = 0.070). The ΔHGS values of treatment and control group were 5.17 ± 1.39 and 1.76 ± 2.07, respectively (t = 4.329; 95% CI = 1.755–5.065; $p < 0.001$).
Conclusion: Combined locomotor training and aerobic exercise have increased muscle strength, as proven by increased handgrip strength.

1. Introduction

Population aging in the 21st century is an inevitable phenomenon faced by developed and developing countries. Like any other country globally, Indonesia is also experiencing population aging. Indonesia's elderly population is 21.7 million, or 8.5% of the total population, consisting of 11.6 million older women (52.8%) and 10.2 million older men (47.2%). This shows that Indonesia will enter the era of an aging population because the number of people aged 60 years and over has exceeded 7.0% [1]. One of the problems experienced by the elderly is the high prevalence of falls. The majority of falls in the elderly reach 30–50% and 40% for the incidence of repeated falls, and it will increase to 20% in 2050. This, according to the WHO Global report, will occur if the balance problem that causes falls is not taken seriously. The incidence of falls seems to vary between countries. For example, a study in Southeast Asia found 6–31% cases in China and 20% in Japan [2].

The elderly experience a degenerative process that takes place progressively in all organs of the body, one of which is decreased muscle

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strength. Decreased muscle strength can be caused by a decrease in the interaction of the peripheral nervous system, central hormonal, nutritional status, and lack of physical activity [3]. Reduced muscle strength can be related to morbidity in the elderly, including the incidence of falls. Muscle strength in the elderly is assessed using a handgrip dynamometer. Grip muscle strength is significantly correlated with lower leg muscle strength in the elderly and is usedto indicate of muscle strength in the elderly [4].

The Japanese Orthopedic Association (JOA) 2007 found a symptom of decreased mobility in the elderly called locomotive syndrome. This syndrome is the most common cause of chronic disability in the elderly. Around 59.8% of patients with the locomotive syndrome had a non-traumatic etiology. This syndrome can be caused by chronic disease, joint degeneration (lumbar spondylosis, cervical spondylosis, lumbar disc hernia, cervical disc hernia, and cartilage degeneration in the lower extremities) [5]. Several factors such as lack of exercise habits, inactive lifestyle, inadequate nutritional intake, and chronic diseases in the elderly population can increase the progression of the locomotive syndrome [6]. According to its severity, the locomotive syndrome is divided into stage 1 and stage 2. Locomotor training is a recommended exercise therapy for locomotive syndrome stage 1 that aims to improve mobility function to increase independence in the elderly with components of muscle strengthening and balance [5,7]. Aerobic exercise can affect the body [8]. The recommended therapeutic exercise program for the elderly in general is multimodal exercise therapy that can improve the function of muscle strengthening, balance, flexibility, and cardiorespiratory fitness obtained by combining locomotor training and aerobic exercise.

Currently, there is no research on the effect of combined locomotor training and aerobic exercise on increasing muscle strength in the elderly population in Indonesia. It influenced researchers to include locomotor training that consisted of resistance and balance components to aerobic exercise with joint resistance and flexibility components. The study aimed to analyse the effect of combined locomotor training and aerobic exercise on muscle strength in the elderly with locomotive syndrome stage 1.

2. Methods

2.1. Participants

Participants in the study were elderly diagnosed with locomotive

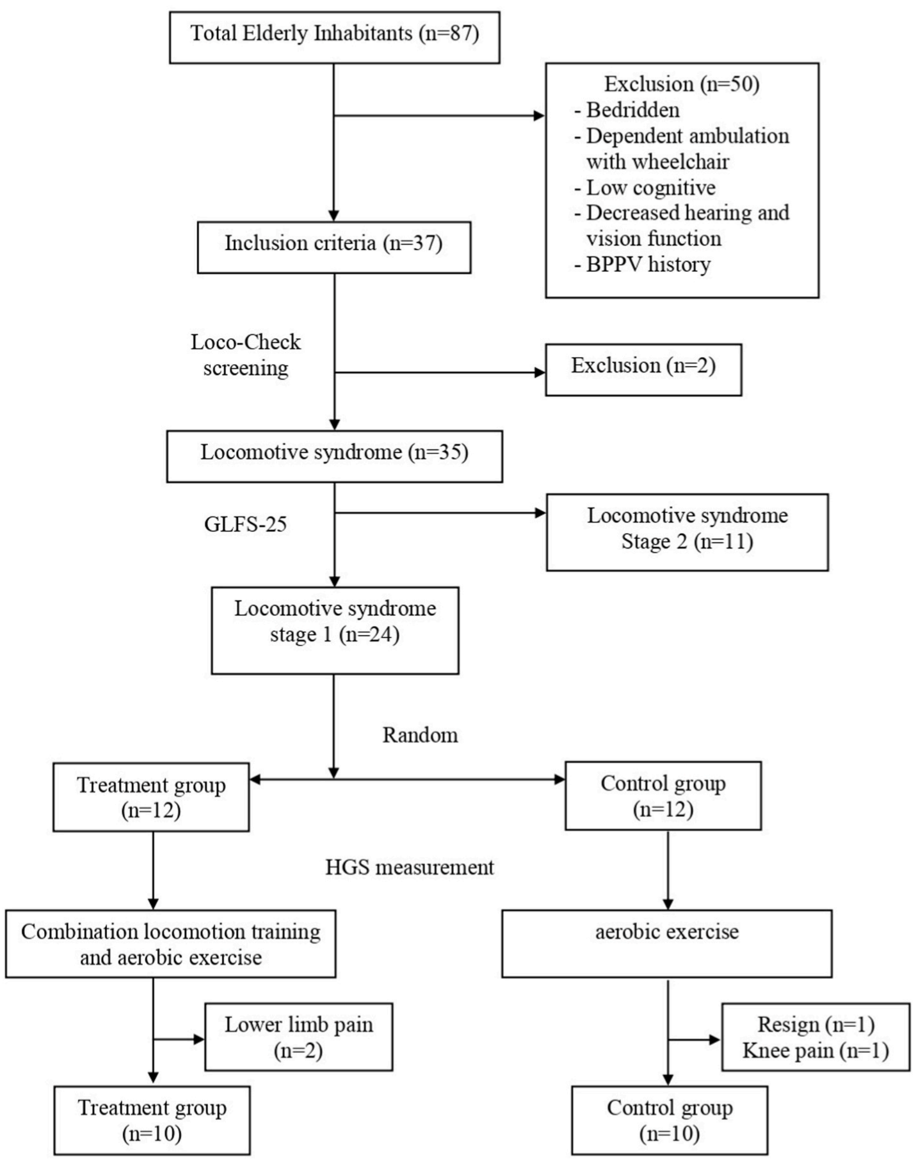

Fig. 1. CONSORT flow diagram.

syndrome stage 1 [9,10]. Participants' inclusion criteria included the elderly (>60 years old) with a positive for Loco-check [11] and a score of 25-questioner Geriatric Locomotive Function Scale (GLFS) with a range of 7–15 [12], good vision and hearing function, without decreased cognitive function with a score of Montreal Cognitive Assessment-Indonesian Version (MoCa-Ina) ≥26 [13,14], stable hemodynamic, and independent ambulation without a walker. Participants' exclusion criteria included patients having a cardiorespiratory disease that affects physical performance during exercise (heart failure and COPD), experiencing muscle and joint pain in the lower extremity (Wong-Baker Face Scale ≥4), and having a chronic disease that interfered with mobility function of the elderly (impaired ambulation due to stroke, uncontrolled diabetes and balance disorders due to intracranial and extracranial processes).

2.2. Study design

This study used a pre-test and post-test group design study, which was reported based on The Consolidated Standards of Reporting Trials (CONSORT) 2010 guidelines [15,16]. The number of samples in this study was 20 participants divided into treatment and control groups, with 10 participants in each group (Fig. 1). Participants in the treatment group were given combined locomotor training and aerobic exercise, while the control group was only given aerobic exercise. The locomotor training and aerobic exercise duration was 30 min per session and carried out for eight weeks. Moreover, locomotor training was carried out three times/week, while aerobic exercise was seven times/week. Locomotor training consisted of strengthening and balance, while aerobic exercise included endurance and flexibility. The combined exercise then could complement each other and are called multimodal exercises. Evaluation of the participants' locomotor training and aerobic exercise was carried out before and after the activity by comparing the participant's muscle strength.

2.3. Locomotor training

Locomotor training (Locotra) is a balance and resistance exercise with high safety, so it can be applied to young adults to the elderly as long as the person can stand alone [5]. Locomotor training aims to increase participants' mobility [6]. Locomotor training consists of 4 types of exercises: one-leg stand, squatting, heel raise, and front lunge exercises. One leg stand exercise is carried out for 1 min, any you can hold on to a chair if you feel unbalanced and fall. Squatting exercise is performed by bending knees 90° while holding a chair and doing three sets of 6 repetitions. The heel raise exercise is conducted for three sets of 10 repetitions with four counts up and four counts down. The front lunges exercise is carried out by stepping one leg forward as far as possible while maintaining an upright posture for three sets of 5 repetitions [5,17]. Locomotor training in this study started with 1 location and increased progressively until three groups at the final exercise. During locomotor training, participants can view the provided instructors and DVD video of exercise demonstration [18]. It was carried out during the COVID-19 pandemic, so participants and instructors used masks during activities.

2.4. Aerobic exercise

Aerobic exercise for the elderly includes exercises to improve cardiorespiratory and muscle endurance and maintain joint flexibility, with mild-moderate intensity (40–70% maximal heart rate). Based on some literature, the duration of aerobic exercise for the elderly is 30 min [19–21]. The practice includes 5 min of warming up, 20 min of aerobic activity (training for the arms and legs while walking and orthostatic exercise), and a 5-min recovery period [22]. During the aerobic exercise, participants and instructors were also required to use masks during the activity.

2.5. Measurement of muscle strength

The participants' muscle strength measurement used handgrip strength (HGS) as measured by a Camry EH101 electronic hand dynamometer (EH101; Zhongshan Camry Electronic Co. Ltd., Zhongshan, China). The HGS measurement procedure was outstanding on the non-dominant hand and elbow flexed to 90°. Participants were instructed to grip the handlebar as hard as possible for 3 s and performed it three times. The distance between trials was about 1-min, and the measurement results were taken from the one with the best value trial [23,24].

2.6. Statistical analysis

Data were analyzed using SPSS version 23.0 (IBM Corp., Armonk, NY, USA). Descriptive presentation of data was carried out to determine the characteristics of all data. The normality test of the data was measured using the Shapiro-Wilk test. The statistical tests used in this study included paired *t*-test and an independent *t*-test. The statistical test results were declared significant if the p-value <0.05.

3. Results

3.1. Characteristic of participant

The participants' average age was 73.85 ± 4.75 years, with a median of 74.5 (70–78) years. The youngest and oldest participant was 65 years old and 80 years old, respectively. There was no significant difference in participants' age between treatment group (75.4 ± 4.88 years) and control group (72.3 ± 4.30 years; $t = 1.508$; 95% CI = −1.220 – 7420; $p = 0.149$). The participant's body mass index (BMI) value was 20.52 ± 3.73 kg/m^2, with a median of 20.60 (18.34–23.16) kg/m^2. The lowest and highest participant's BMI was 13.11 kg/m^2 and 28.09 kg/m^2, respectively. The mean BMI value for treatment and control group was 20.56 ± 3.19 kg/m^2 and 20.49 ± 4.38 kg/m^2, respectively, which both had no significant difference ($t = 0.040$; 95% CI = −3.528 – 3.667; $p = 0.968$). The result of participants' GLFS measurement was 8.35 ± 1.73, with a median value of 8 (7–9). The range of participants' GLFS scores was 6 (min) – 12 (max). Similar to participants' age and BMI, the GLFS scores in the treatment group (8.20 ± 1.93) and control group (8.50 ± 1.58) did not have a significant difference ($t = 0.380$; 95% CI = −1.959 – 1.359; $p = 0.708$; Table 1).

3.2. Effect of combined locomotor training and aerobic exercise on handgrip strength

At the pre-test, the participants' HGS value was 12.58 ± 4.15, with a median of 11.35 (9.88–14.30). The lowest and highest HGS values were 7 and 25, respectively. Meanwhile, the HGS value at the post-test was 16.05 ± 4.73, with a median value of 15.50 (13.08–17.28). There was a significant difference in the HGS value between pre-test and post-test in the treatment group (13.89 ± 5.27 vs 19.06 ± 4.54; $t = 11.765$; 95% CI = −6.164 to −4.176; $p < 0.001$). Meanwhile, in the control group, there was no significant difference in the HGS value at pre-test (11.27 ± 2.17) and post-test (13.03 ± 2.54; $t = 2.057$; 95% CI = −1.600 – 0.076; $p = 0.070$). The ΔHGS values in the treatment and control groups had a

Table 1
Characteristic of participant.

Variable	Group		*p*
	Treatment	Control	
Age	75.4 ± 4.88	72.3 ± 4.30	0.149
Weight	45.41 ± 8.08	48.94 ± 13.32	0.008*
Body Mass Index	20.56 ± 3.19	20.49 ± 4.38	0.957
GLFS-25	8.20 ± 1.93	8.50 ± 1.58	0.708

Note: GLFS-25 = geriatric locomotive functional scale-25; *significant of <0.05.

mean of 5.17 ± 1.39 and 1.76 ± 2.07, respectively, which showed a significant difference in the HGS value in the two groups ($t = 4.329$; 95% CI = 1.755–5.065; $p < 0.001$; Table 2).

Similar findings were also obtained for the measurement of participants' GLFS. The GLFS values in the treatment group at pre-test and post-test were 8.20 ± 1.93 and 6.30 ± 1.64, respectively ($t = 2.578$; 95% CI = 0.233–3.567; $p = 0.030$). Meanwhile in the control group, the GLFS values of participants at pre-test and post-test were 8.50 ± 1.58 and 10.80 ± 3.19, respectively ($t = 3.214$; 95% CI = −3.919 to −0.681; $p = 0.011$). There was a significant difference in GLFS values between treatment group (−1.90 ± 2.33) and control group (2.30 ± 2.26; $t = 4.088$; 95% CI = −6.358 to −2.042; $p = 0.001$), which the mean value of GLFS was 0.20 ± 3.11 with a median of 4.35 (0.88–5.50; Table 2).

4. Discussion

The results of this study are consistent with previous studies, stating that the effect of regular exercise for eight weeks can increase muscle strength [25]. Another study also indicated that endurance and resistance training in the elderly can be carried out at week 8 [26]. Another study showed that exercise for eight weeks could prevent atrophy and increase muscle mass in the elderly [27]. Another study stated that eight weeks of practice significantly increased muscle strength and muscle fiber diameters [28]. Based on the existing literature, combined locomotor training and aerobic exercise are carried out for 8 weeks in the elderly because frailty elderly need a long time of movement (>6 weeks) to get maximum results [29].

Locomotor training was given three times/week, referring to a previous study which stated that giving exercise to the frailty elderly was recommended three times/week [29]. In addition, the analysis results said that in some instances, such as locomotive syndrome disease, it was recommended to carry out the exercise as much as three times/week to be more effective in increasing muscle strength [30]. Meanwhile, research discussing the correlation between exercise frequency and muscle strength cannot be described in detail [31,32]. Therefore, the exercise frequency used in this study referred to a previous study that recommended the implementation of exercise as much as three times/week according to the ability of the frailty elderly because the frequency was considered moderate and could be tolerated [29,33].

The combination of locomotor training and aerobic exercise is increases muscle strength because the given activity stimulates the production of brain-derived neurotrophic factor (BDNF), which plays an essential role in energy metabolism. BDNF plays a role in the metabolism of fat in the body and converts it into energy [34]. In addition, BDNF has been reported to stimulate the release of acetylcholine at the neuromuscular synapse in myocytes, thereby triggering muscle contraction [35,36]. Based on previous studies, BDNF production increases 3–7 days after training, so combined locomotor training and aerobic exercise for eight weeks can increase muscle strength [37]. BDNF has also been shown to be involved in muscle satellite cell regulation. In addition to its role in fat burning and muscle contraction, BDNF is interested in increasing muscle fiber diameter [38].

Table 2
The effect of combined locomotor training and aerobic exercise on handgrip strength.

Group	Locomotor training + aerobic exercise			95% CI	p
	Pre-test	Post-test	Δ		
HGS	12.58 ± 4.15	16.05 ± 4.73	3.47 ± 2.45	1.755–5.065	<0.001**
Treatment	13.89 ± 5.27	19.06 ± 4.54	5.17 ± 1.39	−6.164–−4.176	<0.001**
Control	11.27 ± 2.17	13.03 ± 2.54	1.76 ± 2.07	−1.600 – 0.076	0.070
GLFS-25	8.35 ± 1.73	8.55 ± 3.38	0.20 ± 3.11	−6.358–−2.042	0.001*
Treatment	8.20 ± 1.93	6.30 ± 1.64	−1.90 ± 2.33	0.233–3.567	0.030*
Control	8.50 ± 1.58	10.80 ± 3.19	2.30 ± 2.26	−3.919–−0.681	0.011*

Note: GLFS-25 = geriatric locomotive function scale-25; HGS = handgrip strength; *significant <0.05; **significant <0.001.

Combined locomotor training and aerobic exercise can increase muscle strength in the elderly with locomotion syndrome stage 1 and are more effective than aerobic exercise alone. Locomotor training is specifically designed for patients with locomotive syndrome [5], while aerobic trains endurance and joint flexibility [8]. Locomotor training has been shown to reduce the risk of falls and fractures in locomotive syndrome patients. It also can decrease GLFS scores. In addition, locomotor training includes exercises that can be used to increase muscle mass in locomotive syndrome patients [39]. Likewise, aerobic exercise can also train endurance and increase muscle strength [20]. Based on previous studies, locomotor training and other exercise intervention reports recorded significant improvements in the participants' physical function after each intervention [7].

The limitation of this research in the era of the COVID-19 pandemic was the small number of participants because the participants in the study were an age group that was vulnerable to COVID-19 infection. Previous studies stated that the elderly with COVID-19 had a high probability of experiencing COVID-19 severity or dying [40,41]. In addition, it is hoped that the single intervention (locotra only) in future studies can be compared with another intervention (for example, aerobic exercise, Otago exercise, etc.) to support our investigation.

5. Conclusion

Combined locomotor training and aerobic exercise for eight weeks have increased muscle strength in the elderly with locomotive syndrome grade 1. Locomotor training, carried out three times/week for eight weeks, can reduce GLFS. The results obtained from locomotor training and aerobic exercise are more leverage than to aerobic exercise alone.

Ethical approval

We have conducted an ethical approval base on the Declaration of Helsinki with registration research at the Health Research Ethics Committee in Universitas Airlangga School Medicine, Surabaya, Indonesia.

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None.

Author contribution

All authors contributed toward data analysis, drafting and revising the paper, gave final approval of the version to be published and agree to be accountable for all aspects of the work.

Trial registry number

1. Name of the registry: Health Research Ethics Committee in Universitas Airlangga School Medicine, Surabaya, Indonesia.
2. Unique Identifying number or registration ID: 302/EC/KEPK/FKUA/2020.
3. Hyperlink to your specific registration (must be publicly accessible and will be checked): -.

Guarantor

I Putu Alit Pawana is the person in charge of the publication of our manuscript.

Consent

All participants are required to fill out an informed consent.

Provenance and peer review

Not commissioned, externally peer-reviewed.

Declaration of competing interest

Ajeng Hayu Nayasista, Damayanti Tinduh, I Putu Alit Pawana, Sri Mardjiati Mei Wulan, Dwikora Novembri Utomo, and Melaniani Soenarnatalina declare that they have no conflict of interest.

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