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The effect of low impact aerobic exercise on increasing physical fitness for the elderly

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Abstract: This study aimed to investigate the effect of low-impact aerobic exercise on increasing physical fitness for the elderly. This one group of pretest-posttest quasi-experimental research recruited elderly subjects from Sumber Waras Elderly Association in Yogyakarta, Indonesia. Twenty-four elderly subjects aged 60-70 years old participated in the 16 sessions of aerobic exercise intervention. All subjects completed pre-and post-intervention physical fitness tests comprising the aerobic/cardiovascular (CV) endurance (2 minutes step test), upper body strength (arm curl test), lower body strength (chair stand test), upper body flexibility (back scratch test), core and lower body flexibility (sit and reach test) and balance (8 foot up and go test). Changes in physical fitness (post- versus pre-intervention) of the subjects were analyzed using paired T-test. The normality and homogeneity tests were performed using the Kolmogorov Smirnov and Levene's tests, respectively. Statistical significance was set to $p < 0.05$. This study showed that all physical fitness components, including aerobic endurance, upper and lower body strength, upper and lower body flexibility, and balance, were increased significantly in the subjects ($p < 0.05$). The results suggest that low-impact aerobic exercise positively affects physical fitness improvement in the elderly.

Keywords: physical fitness, elderly, aerobic, exercise.

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INTRODUCTION

Population ageing is one of the most significant trends of the 21st century, which has also been called the "century of elderly". This phenomena has an economic impact on families, communities, and the government. An increase in the dependency ratio of the elderly is playing an important role in significant economic effect of expanding the total population (Porcari et al., 2015). As a result, the elderly must be considered in the national development program. Aging is a natural process that occurs in human life as their biological systems change with age. According to the new classification from World Health Organization (WHO), the middle age is from 45-59, elderly age is 60-74, senile age is 75-90 and long-livers are after 90 years old. The ageing process can increase the physical, mental, spiritual, and social problems as a result of the degenerative process (Naomi&Wiwit., 2021). The elderly phase can be recognized by the declines in body functions, including physical fitness decreases, such as cardiovascular endurance, strength, balance, and body flexibility, resulting in independence declines in daily life (Eckstrom et al., 2020). Another decrease also happens in muscle strength and endurance, resulting in changes in muscle function, such as decreases in muscle strength, muscle elasticity and flexibility, reaction time and relaxation speed, and functional performance. The other effect can result in a decrease in body balance, slightly hampered movement/sitting/standing, increased risk of falls, and

changes in posture (Gao et al., 2019). Various changes associated with increasing age can affect the incidence of falls in the elderly, mainly when these changes affect functional abilities and impair sensory or gait and balance instability (Porcari et al., 2015). Physical fitness itself was the ability to carry out activities without feeling significant fatigue (Cadenas-Sanchez et al., 2019).

Declines and physical changes will affect physical activities. The elderly will experience changes in body composition, muscles, bones and joints, cardiovascular system, respiration, and cognitive, affecting body flexibility. The influence of functional ability was related to the most significant risk of falling in the elderly with weakness and limited physical function, resulting in locomotion stiffness and causing an imbalance when walking. The decreased muscle strength affects independence, especially in the extremities (legs) muscles. For the elderly, limb dysfunction and impaired physical activity can be noticed when walking or getting up from a seat. A decrease in strength and power will be followed by an increased risk of falling and fractures. As Mithal et al. (2013) said, muscle strength plays a vital role in determining the risk of falls.

Physical exercise can be one way to solve the problem of declining fitness in the elderly. Exercise becomes a form of a physical stressor, so when an exercise does not use the basic principles can trigger health problems, while exercise that uses one will lead to a suitable adjustment process. The exercise was a physical stressor that can cause disturbances in homeostatic balance. The application of exercise in the form of physical exercise needs to be measured with an appropriate dose to make it possible to create disease mechanisms that can change the stressor into a stimulator form. If the exercise dose is not correct, then the stressor concerned can cause disturbances in physical balance (homeostasis) and can trigger problems with biological/pathological disorders (Nurlina & Keb, 2021). A series of physical exercise processes can improve walking posture, balance, general physical functional capacity, and bone health in the elderly (Sampaio et al., 2020).

Physical exercise was divided into two energy systems, namely aerobic and anaerobic capacities. The aerobic capacity activity requires oxygen, while anaerobic capacity does not require oxygen. Aerobic exercise was more related to our body's endurance when carrying out sports activities. Bompa (2012) explains that aerobic exercise uses aerobic energy capacity to move for a long time. The principle of exercise in aerobic exercise is to provide a light load and carry it out for a long time and the energy used comes from the meet oxygen demand. Aerobic exercise can be one way to improve physical fitness in the elderly as long as it has the right exercise dose and the correct design for the elderly. Thus aerobic exercise to improve elderly physical fitness uses low impact aerobic exercise. Low impact aerobic exercise was carried out without jumping, and one foot remained on the floor (Espí-López et al., 2016). Therefore, this exercise was safe from risks and appropriate for the elderly (McPhee et al., 2016; Nied & Franklin, 2002). According to Sidiq (2019), 16 sessions of aerobic exercise could affect the physiological changes, from "sedentary" to the "trained."

This study aimed to investigate the effects of low-impact aerobic exercise on increasing physical fitness components, namely aerobic (CV) endurance, upper and lower body strength, upper and lower body flexibility, and balance. The results of this study may provide additional consideration to the elderly in implementing routine, low-impact aerobic exercise.

METHOD

This Quasi-experimental study with One Group Pretest-Posttest design consisted of 16 intervention sessions. The study recruited 24 subjects from the *Sumber Waras* Gondanglegi elderly association in Sleman regency, Yogyakarta, Indonesia. The inclusion criteria were (1) male and female aged 60-70 years old and (2) normal walking without any assistance device. The exclusion criteria were (1) serious injury resulting from falls, (2) active elderly, (3) history of falls caused by iron deficiency anemia within one year, (4) serious diseases or medical conditions, i.e., hypertension, coronary heart disease, and stroke. Subjects who were absent for three sessions or more and subjects who refused to continue the study were dropped out from this study.

Subjects performed the low-impact aerobic exercise, which trained physical fitness components: cardiovascular exercise, muscle strength and endurance, flexibility, and balance exercise. The exercise was performed to music in a group setting. Each session consists of warm-up and stretching, aerobics (main exercise), and cool-down. Three types of aerobics (main exercise) were designed by the researcher in this study, namely (1) aerobics 1, performed in a sitting position, focusing on cardiovascular

endurance, strength, and balance exercise, (2) aerobics 2, performed in a standing position, focusing on muscle strength and endurance and (3) aerobics 3, performed in laying position, focusing on muscle strength, endurance, and flexibility. The exercise dosage in this study showed in table 1.

Table 1. Low Impact Aerobic Exercise Dosage

Number	Components	Explanation
1.	Frequency	Three times per week (Tuesday, Thursday, and Sunday)
2.	Intensity	Moderate (40-60% of HR-Max)
3.	*Time*	30 to 40 minutes.
4.	*Type*	Low impact aerobic exercise

Baseline data, including name, sex, age, height, weight, and BMI, were collected from the subjects. The physical fitness test was conducted twice, before and after the 16th session of intervention. Six types of physical fitness were measured in this study. The tests consist of (1) a 2-minutes step test for aerobic endurance, (2) Arm curl test for upper body strength (3) 30-seconds chair stand for lower body strength, (4) Back scratch test for upper body flexibility (5) Chair sit and reach test for lower body flexibility and (6) 8-Foot (ft) up and go test for balance and coordination. The results were compared to standard norms of senior fitness tests (C. Jessie Jones and Roberta: 2002). The physical fitness norms showed in table 2.

Table 2. Physical Fitness Norms for Elderly

Test and Measurements	Age and Categories					
	60-74 years old			75-94 years old		
	Under Average	Normal	Above Average	Under Average	Normal	Above Average
	Male					
Body Mass Index	≤18.5 (underweight)	18.5 – 24.9	≥25 (over weight)	≤18.5 (underweight)	18.5 – 24.9	≥25 (over weight)
Aerobic endurance (2 Mins Step)	<62.18	62.18 – 97.84	>97.84	<40.23	40.23 – 91.44	>91.44
Lower Body Strength (Chair Stand)	<10	10 – 17	>17	<4	4 -15	>15
Upper Body Strength (Arm Curl)	<12	12 – 19	>19	<8	8 – 17	>17
Lower Body Flexibility (Chair Sit & Reach)	<-0.5	-0.5 - +5	>5	<-4.5	-4.5 -3.5	>3.5
Lower Body Flexibility (Back Scratch)	<-3.0	-3.0 - 1.5	>1.5	<-8.0	-8.0 - + 0.5	>0.5
Balance (8 Ft Up & Go)	>7.1	7.1 – 4.4	<4.4	>11.5	11.5 – 5.2	<5.2
	Female					
Body Mass Index	≤18.5 (underweight)	18.5 – 24.9	≥25 (over weight)	≤18.5 (underweight)	18.5 – 24.9	≥25 (over weight)
Aerobic Endurance (2 Mins Step)	< 73.15	73.15 - 106.07	> 106.07	< 47.54	47.54 – 99.67	> 99.67
Lower Body Strength (Chair Stand)	< 12	12-19	>19	< 7	7-17	>17
Upper Body Strength (Arm Curl)	<14	14-22	>22	< 10	10-19	>19
Lower Body Flexibility (Chair Sit & Reach)	< -2.5	-2.5 - +4	>4	< -6.5	-6.5 - +2	>2
Lower Body Flexibility (Back Scratch)	< -8.0	-8.0 - +0.0	>0.0	< -10.5	-10.5 - -2.0	>2.0
Balance (8 Ft Up & Go)	> 6.0	6.0 - 3.8	<3.8	> 10.00	10.00 – 4.6	< 4.6

Statistical analysis was conducted using SPSS version 25.0 (SPSS Inc., Chicago, IL, USA). Descriptive statistics were used to calculate the mean and standard deviation (SD). The normality test was performed using the Kolmogorov Smirnov test, and the Homogeneity test was performed using Levene's test.

The paired T-test was conducted to compare the differences between pre and post-intervention results in the subjects. A significance level was set to $p < 0.05$.

RESULTS

A total of 24 subjects (22 female and two male) participated in this study. No subjects dropped out, resulting in all 24 subjects for the final analysis. More than half (n=13) of subjects had ideal body mass index (BMI), while 33% (n=8) of the subjects were overweight and 13% (n=3) of the subjects were obese grade II and extreme obesity.

The normality test using Kolmogorov Smirnov was conducted in the pre-and post-intervention data. The result showed that all variables were normally distributed ($p > 0.05$). The analysis presented in Table 3.

Table 3. Normality Test Results

Variables	*p*	Interpretation
Aerobic Endurance	0,065	Normal
Lower Body Strength	0,055	Normal
Upper Body Strength	0,200	Normal
Lower Body Flexibility	0,127	Normal
Upper Body Flexibility	0,058	Normal
Balance	0,200	Normal

Note: *significant if p<0.05

The homogeneity test using Levene's test showed that the data variances were not homogeneous (unequal/heterogeneous) on upper body strength lower body flexibility and balance ($p < 0.05$) while other variables were homogenous. The analysis showed in Table 4.

Table 4. Homogeneity Test Results

Variables	*p*	Interpretation
Aerobic Endurance	0,052	Homogeneous
Lower Body Strength	0,477	Homogeneous
Upper Body Strength	0,001*	Heterogeneous
Lower Body Flexibility	0,002*	Heterogeneous
Upper Body Flexibility	0,801	Homogeneous
Balance	0,001*	Heterogeneous

Note: *significant if p<0.05

The paired T-test was conducted to compare pre-and post-intervention results in the subjects. The test result showed a significant improvement in aerobic endurance (p =0.026), upper body strength (0.001), lower body strength (0.003), upper body flexibility (0.002), lower body flexibility (0.000), and balance (0.000) in the subjects. The results are presented in Table 5.

Table 5. Changes in physical fitness components, pre-and post-intervention

Components	Subjects (n= 24)		
	Pre test (mean ± SD)	*Post test (mean ± SD)*	*p*
CV/Aerobic endurance (2 Mins step test)	255,75 ± 25,64	438,93 ± 15,75	0.000*
Upper body strength (Arm curl test)	17,04 ± 2,44	22,17 ±7,04	0.001*
Lower body strength (Chair stand test)	14,13 ± 2,49	16,58± 2,02	0.003*
Upper Body Flexibility (Back scratch test)	-4,95± 5,12	-0,83 ± 3,63	0.002*
Lower Body Flexibility (Chair sit & reach test)	0,50± 2,11	13,31 ±5,62	0.000*
Balance (8 Ft Up & Go test)	13,88 ±1,96	8,73 ±1,03	0.000*

Note: *significant if p<0.05

Descriptive analysis showed that 16 sessions of intervention could improve aerobic endurance, upper body strength, upper body flexibility, and lower body flexibility components compared to the baseline, while there was no improvement in lower body strength and balance components. The descriptive table was showed in Table 6.

Table 6. Physical fitness categories level, pre-, and post-intervention

Components	Pre-test categories (n; (%))			Post-test categories (n; (%))		
	Above Average	*Normal*	*Under Average*	*Above Average*	*Normal*	*Under Average*
CV/Aerobic endurance (2 Mins step test)	4 (16,67%)	19 (79,17%)	1 (4,17%)	16 (66,66%)	7 (29,17 %)	1 (4,17)
Upper body strength (Arm curl test)	4 (16,67%)	19 (79,17%)	1 (4,17%)	10 (41,67%)	14 (58,33%)	0 (0%)
Lower body strength (Chair stand test)	0 (0%)	0 (0%)	24 (100%)	0 (0%)	0 (0%)	24 (100%)
Upper Body Flexibility (Back scratch test)	0; (0%)	11 (45,83%)	13 (54,17%)	5 (20,83%)	14 (58,34%)	5 (20,83%)
Lower Body Flexibility (Chair sit & reach test)	0 (0%)	18 (75%)	6 (25%)	21 (%87,50)	3 (12,50%)	0 (0%)
Balance (8 Ft Up & Go test)	0 (0%)	0 (0%)	24 (100%)	0 (0%)	0 (0%)	24 (100%)

DISCUSSION

The elderly, as the last development stage of a person's life, begins at 60 years old. Regulation of Minister of Public Work No. 30 of 2006; from year to year, the total elderly population increases due to advances in technology and improving health care. The increasing number of the total elderly population makes the community must pay attention to this elderly group. For the elderly, there will be a setback in physical function, such as physical condition decreases in muscle and body strength, bone and joint fragility, inflexibility of body movements, speed in motor activities, and sensory function. This decreases the risk of the elderly having difficulties in mobility and daily activities. The elderly become less alert, unable to run or walk long distances, unable to climb stairs, and slip easily.

Meanwhile, the elderly still have activities to fulfill their needs that require movement, such as buying daily needs and going to a health center for a check-up and other certain purposes or recreation. Activity theory reveals that the elderly must always be active and contribute to the surrounding environment to realize successful aging (Eckstrom et al., 2020; Fox, 1999). However, many elderly stop their activities and live their lives passively for some reason.

The decline in health limits movement, and mobility barriers from environmental conditions complicate their movements. Before having a stroke, many elderly liked to go out of the house. They are often unsteady after getting the disease because their wheelchair cannot run smoothly on uneven areas. For the elderly, having daily activities and moving between places was usually not tricky, but it was not the same for the elderly who have decreased physiological and mental functions.

The decline in cognitive function was associated with increasing age. Increased limitations in the elderly occur in the 50-65 year age range (WHO, 2016). The preventive step that can be chosen is physical activity because it was proven to slow down aging (Ige-Elegbede et al., 2019). Exercise or physical activity was an essential component of healthy aging to prevent falls, pain, sarcopenia, osteoporosis, and cognitive impairment. There needs to be an effort to maintain the consistency of the exercise program, which includes aerobic exercise, strength balance, and flexibility, to match with elderly who do not meet the recommended duration of exercise per week (Eckstrom et al., 2020). Many studies discuss if the elderly follow fitness exercises that benefit the body as aging occurs (Kuo, 2019).

Based on the study results, it was found that low-impact aerobic exercise can be beneficial for the elderly. Facts show that long-term exercise consisting of weight training, balance, and functional training greatly benefits older people (Seco et al., 2013). Combination exercise habits should be introduced from pre-elderly age, around 45-59 years old (Badan Pusat Statistik, 2019). This will be related to the consistency of healthy behavior applied throughout life. First, start with flexibility exercises. It was recommended that anyone stretch after waking up as soon as possible and continue before going to bed at all ages (Kenney et al., 2015). It was well known that the theory of flexibility training has not changed since ancient times. One of the general goals of flexibility training is to maximize joint space (T. Bompa & Haff, 2009; Nasrulloh et al., 2021). For the elderly, falling becomes the most fundamental obstacle experienced in daily activities, especially if you are still doing movements up and downstairs.

The second was strength training. Weight training carried out by the elderly was very useful in maintaining muscle (Granic et al., 2019; Nasrulloh et al., 2020) and muscle strength (Fisher et al., 2014; Miller et al., 2021; Nasrulloh & Wicaksono, 2020). Strength training goals must pay attention to choosing which muscles to focus on during training (Ribeiro et al., 2020). The recommendation for strength training for the elderly was made twice a week and aerobic exercise three times a week (World Health Organization, 2020). Strength training like walking can minimize the risk of falling. Walking was proven to help reduce the risk of falling and train the lower body muscles (Gao et al., 2019). The elderly who are used to going to the gym and are very physically active will tolerate high-intensity weight training once or twice a week without compromising the excitement essence (D.L. et al., 2019). The third form of exercise was balanced, and strength training helps minimize the risk of falling (Cress et al., 2004; Eckstrom et al., 2020; Seco et al., 2013). Balance and strength have an essential role for the elderly in their bio-motoric training goals (Porcari et al., 2015). Without these two things, the elderly experience difficulty carrying out basic daily activities, loss of independence, and decreased self-confidence (Eckstrom et al., 2020). As a solution, regular exercise should be done to help the nervous systems stay awake to streamline movement and reaction time (Jehu et al., 2017; Lin et al., 2019).

Studies show that the elderly who are trained have a faster reaction time than those who are not trained and can continue to improve if they continue to be trained. Research also shows that physical activity has an enormous contribution to the function of the central nervous system. For the active elderly, it was possible to have a routine of being involved in a sports club. Some sports communities do involve trainers to direct and supervise the movement. However, especially active elderly choose to exercise alone because they can still do the movements. Elderly who understand the form of exercise can even be involved in activities such as High-Intensity Interval Training (HIIT). Studies show that there was still a significant increase in the ability to breathe maximal oxygen for the elderly who participate in HIIT training (Mekari et al., 2020). However, it was necessary to consider what kind of elderly criteria may be involved in these training activities. The habit of the elderly doing regular exercise with a long time intervention also helps in increasing VO2max (Villareal et al., 2017).

Regular aerobic exercise positively affects the cardiovascular system by slowing and fighting the decline in effectiveness with aging in the elderly (Eckstrom et al., 2020). Aerobic exercise improves respiratory function, maintains stroke volume (Nasrulloh, 2009), and lowers blood pressure at rest, especially in the elderly (Kenney et al., 2015; Porcari et al., 2015). Regular aerobic exercise has also been shown to reduce blood fat levels concerning weight management (Villareal et al., 2017), improve glucose tolerance (Malin & Kirwan, 2012) and insulin sensitivity (Lithgow & Leggate, 2018; Prior et al., 2012). Studies show a significant reduction in oxygen transfer efficiency in ordinary people compared to people who are active in sports (Van et al., 2016). In addition, exercise can significantly affect aerobic endurance (Mekari et al., 2020; Villareal et al., 2017) in long-term performance.

The problems that occur and are suffered by the elderly lead to diseases related to blood pressure, arthritis, and diabetes, in addition to degenerative and cardiovascular diseases. The gradual increase in blood pressure associated with aging was due to sedentary lifestyles. The elderly are at increased risk of hypotension and falls (Odden et al., 2015). Endurance training has decreasing effects on systolic and diastolic (Hwang & Sim, 2020; Kelley & Kelley, 2018). Aerobic exercise has been proven to treat blood pressure in the elderly and take medication. The study showed that active elderly who did HIIT and IHG (isometric handgrip training) decreased systolic but showed no significant change in diastolic (Herrod et al., 2021). It should be noted that if it was associated with body composition, it turns out that blood pressure will increase with an increase in waist size and body mass index (Zhang et al., 2021).

Osteoarthritis is a degenerative disease of the joints, while rheumatoid arthritis is an inflammatory disease of the immune system that affects joint tissue. Most elderly experienced osteoarthritis in the knee (Ling & Bathon, 1998), and getting more severe every year (Peat et al., 2001; Silverwood et al., 2015; Verweij et al., 2009; Yeh et al., 2020). Regular exercise can maintain joint function, which will promote increased joint healing. For example, the risk of falling when going up and down stairs can occur in the elderly, so it is necessary to strengthen the ankle joint (Gavin et al., 2019) to support the other leg. On the other hand, diagnosis of osteoarthritis was independently associated with age, female gender, a higher number of comorbidities, physical disability, and low level of physical activity (Duarte et al., 2017). It was recommended to do power exercises for various problems experienced by people with osteoarthritis (Corkery et al., 2021).

Physical activity effectively increases the efficiency of the body's response to insulin sensitivity (Lithgow & Leggate, 2018; Prior et al., 2012). Both aerobic and strength training help regulate blood sugar levels (Hwang & Sim, 2020; Qiu et al., 2019), improve insulin sensitivity, and helps maintain weight (Zhang et al., 2021). Although some literature says that some of the elderly experience a decrease in blood sugar levels, they need exercise assistance to increase their blood sugar levels (Lee et al., 2014b, 2014a; Pratley et al., 2020). However, in reality, the elderly whose diet was often >3x/day are three times more likely to have diabetes than those whose eating pattern was rarely <3x/day. So that the elderly are expected to do light exercise, visit health promotions related to diabetes from the medical team, and regularly check to reduce the risk of diabetes (Suprapti, 2019). Walking can also reduce the risk of cardiovascular disease in the elderly with diabetes (Smith et al., 2007).

Overall, fitness training has proven to be beneficial for aging people. Several regions in Indonesia provide a place for the elderly to do activities so that life expectancy and quality of life are better (Dewi, 2018). Forms of degenerative disease, cardiovascular disease, and things that make the elderly more prone to falls can be overcome with moderate-intensity exercise routines (d'Arbeloff, 2020; Odden et al., 2015; Song et al., 2020), balance training (Jehu et al., 2017), strength (Miller et al., 2021), flexibility (Seco et al., 2013), the combination of strength and flexibility training (Gavin et al., 2019), aerobic endurance (Hwang & Sim, 2020) and a combination of aerobic endurance and strength training (Villareal et al., 2017).

Regular, programmed and measured physical exercise was important for maintaining physical fitness, slowing aging, and managing chronic disease. As a matter of consideration, the involvement of the elderly in sports must conform to the principle of individualization (Kenney et al., 2015), where one form or dose of exercise cannot be applied to all. However, there will be different adaptations for each individual, so it has long been reminded that the elderly need an exercise program that is safe, comfortable, and simple (Cress et al., 2004) so that the training goals can be achieved and the benefits can be felt in the long term.

CONCLUSION

This study demonstrated that 16 sessions of low-impact aerobic exercise could improve the physical fitness components (aerobic endurance, muscle strength, flexibility, and balance) in elderly subjects. This improvement is considered beneficial in maintaining the quality of life of the elderly. Further high-quality RCT research is needed to investigate the effectiveness of low-impact aerobic exercise in the geriatric population.

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