Original Article

CLINICAL REHABILITATION

Clinical Rehabilitation
2022, Vol. 36(1) 59–68

DOI: 10.1177/02692155211036956
journals.sagepub.com/home/cre
SAGE

Comparative effectiveness study of low versus high-intensity aerobic training with resistance training in community-dwelling older men with post-COVID 19 sarcopenia: A randomized controlled trial

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Abstract

Objective: To find and compare the clinical and psychological effects of low and high-intensity aerobic training combined with resistance training in community-dwelling older men with post-COVID-19 sarcopenia symptoms.

Design: Randomized control trial.

Setting: University physiotherapy clinic.

Participants: Men in the age range of 60–80 years with post-COVID-19 Sarcopenia.

Intervention: All participants received resistance training for whatever time of the day that they received it, and that in addition they were randomized into two groups like low-intensity aerobic training group ($n = 38$) and high-intensity aerobic training group ($n = 38$) for 30 minutes/session, 1 session/day, 4 days/week for 8 weeks.

Outcomes: Clinical (muscle strength and muscle mass) and psychological (kinesiophobia and quality of life scales) measures were measured at the baseline, fourth week, the eighth week, and at six months follow-up.

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Results: The 2 × 4 group by time repeated measures MANOVA with corrected post-hoc tests for six dependent variables shows a significant difference between the groups ($P < 0.001$). At the end of six months follow up, the handgrip strength, −3.9 (95% CI −4.26 to −3.53), kinesiophobia level 4.7 (95% CI 4.24 to 5.15), and quality of life −10.4 (95% CI −10.81 to −9.9) shows more improvement ($P < 0.001$) in low-intensity aerobic training group than high-intensity aerobic training group, but in muscle mass both groups did not show any significant difference ($P > 0.05$).

Conclusion: Low-intensity aerobic training exercises are more effective in improving the clinical (muscle strength) and psychological (kinesiophobia and quality of life) measures than high-intensity aerobic training in post-COVID 19 Sarcopenia.

Keywords

COVID-19, sarcopenia, aerobic training, muscle strength, quality of life

Received: 13 May 2021; accepted: 9 July 2021

Introduction

The COVID-19 disease has emerged as a major health concern for humans, especially in the age group of 60 years and above.[1] Sarcopenia is one such major health consequence in the COVID-19 scenario that needs to be taken care of by means of physiotherapy. Sarcopenia is defined as a state of deterioration of muscle mass and its function due to aging and physical inactivity, which if untreated leads to poor quality of life and high mortality rate.[2,3] In the present COVID-19 scenario, the requirement of social isolation leads to physical inactivity and a sedentary lifestyle, which in turn accelerates the muscle atrophy and diminishes the muscle function.[4–6] Izquierdo et al.[7] stated that regular physical activities and proper exercise training is required to maintain the muscle mass and prevent atrophy in the older age. Furthermore, recognition of sarcopenia as a important medical complication in the aged population has ignited a question for the researchers to attempt to devise an exercise protocol to overcome these consequences.

Aerobic training plays a major role in changing the clinical status of older adults with sarcopenia symptoms. Sheffield-Moore et al.[8] found that low-intensity aerobic training performed at 40%–60% of maximum heart rate by older adults with sarcopenia improved the protein metabolism. At the same time, Fujita et al.[9] noticed that high-intensity aerobic training performed at 60%–80% of maximum heart rate bypass protein insulin resistance and preserve the muscle protein synthesis through different signaling properties. Therefore, aerobic training can be given to treat sarcopenia in older adults with post-COVID-19 symptoms. Hence, this study was aimed to investigate the effects of different aerobic training protocols combined with resistance training in community-dwelling older adults with post-COVID-19 sarcopenia symptoms. The outcomes of the study can provide new evidence and a clearer idea about the selection of exercise protocols for sarcopenia in clinical practice.

Methods

The trial was executed under the ethical guidelines laid down by the 1964 declaration of Helsinki and was registered retrospectively in the clinical trial registry with clinical trial.gov ID: NCT04796064. The study obtained ethical approval from the Department of the Ethical Committee, Prince Sattam Bin Abdulaziz University, AlKharj, Saudi Arabia with the reference number of RHPT/020/044. This research was funded by the Deanship of scientific research at Princess Nourah Bint Abdulrahman University through the Fast-track research funding program. This was a randomized, single-blinded, prospective, clinical study conducted from March 2020 to April 2021.

Participants for the study were screened by a general physician and recruited from local and government hospitals in Al-Kharj and Riyadh region of Saudi Arabia and the study was conducted at the University physiotherapy clinic, Prince Sattam Bin Abdulaziz University, Al-Kharj, Saudi Arabia. Due to cultural restrictions regarding access to female participants, the study included only male participants. Men within the age range of 60–80 years with post-COVID-19 sarcopenia were included. Sarcopenia (skeletal muscle loss) was identified through appendicular skeletal muscle mass index (kg/m^2). Based on the Asian working group for Sarcopenia criteria, appendicular skeletal muscle mass index score <7.0 kg/m^2 for men were diagnosed as sarcopenia,[3] normal VO_2 max (oxygen consumed in one minute, per kilogram of body weight in milliliters: 17–18 ml/kg/min) and resting heartbeat (70–90 beats per minute) were included in the study. Participants with low muscle mass in observation, handgrip strength less than 24 kg and slow gait speed (<0.7 m/sec) were excluded. Participants with prior exercise training, under medication, history of lower limb surgeries, fractures, cardiac problems, respiratory problems, neurological problems, systemic problems, and any other contraindications for aerobic training were excluded. Figure 1 shows the flowchart of methodology of the study.

The participants' consent form, intervention procedures, and the outcome measures used were also approved by the ethical committee. All the participants selected for the final study were asked to complete the written informed consent form and they had to undergo baseline demographic and clinical measurements. By using a simple two-block random sampling method, the participants were randomized and allocated into two groups. Randomization was performed remotely, and the results placed into opaque envelopes, thereby concealing the sequence of group allocation from the researcher recruiting the participants. The first group received low-intensity aerobic training ($n = 38$) and the second group received high-intensity aerobic training ($n = 38$) for eight weeks.

Participants ($n = 38$) in the low intensity aerobic training group underwent low-intensity aerobic training for eight weeks. All the participants were instructed with the guidelines for performing the low-intensity aerobic training exercises by a trained physiotherapist with proper COVID-19 guidelines. The exercises performed by the participants were maintained in an exercise logbook and were checked every week by a supervisor. Before every session, the vital signs such as temperature, blood pressure, oxygen saturation, heart rate, and physical status were measured. If the vital signs were not suitable, like temperature >38°C, blood pressure >160/100 mmHg, and pulse rate >100 or <50 beats per minute, participants were not allowed to do exercises on that particular day.[10]

The intensity of the given exercises was measured through maximum heart rate and was calculated by subtracting the age of the participant from 220. In low-intensity aerobic exercises, 40%–60% of maximum heart rate was used. Each session started with 15 minutes of warm-up, which includes static stretching of the upper and lower limb muscles. Following the warm-up, the participants were instructed to do 30 minutes of low-intensity aerobic training exercises, which includes 20 minutes of the treadmill (Reebok Fitness, GT50, CA) and 10 minutes of cycle ergometer (JX Fitness, JX-7056, CA), followed with resistance training and 15 minutes of cool down through gentle stretching of all major muscles to release tension and breathe deeply to deliver oxygen to muscles. In high-intensity aerobic training group, the participants followed the similar exercise protocol but the intensity of aerobic exercises was fixed between 60% and 80% of maximum heart rate.[11]

Resistance training was prescribed to all the participants in both the groups with weights based on an individual, personal strength assessment basis. The optimum resistance required for the muscle groups were decided based on ten-repetition maximum (10 RM) and the muscles were trained according to the DeLorme method.[12] A 10 repetition maximum is the greatest amount of weight that a participant can lift through the range of motion for 10 times. The major group muscles such as shoulder flexors, shoulder extensors, shoulder abductors, elbow flexors, elbow extensors, hip flexors, hip extensors, knee flexors, knee

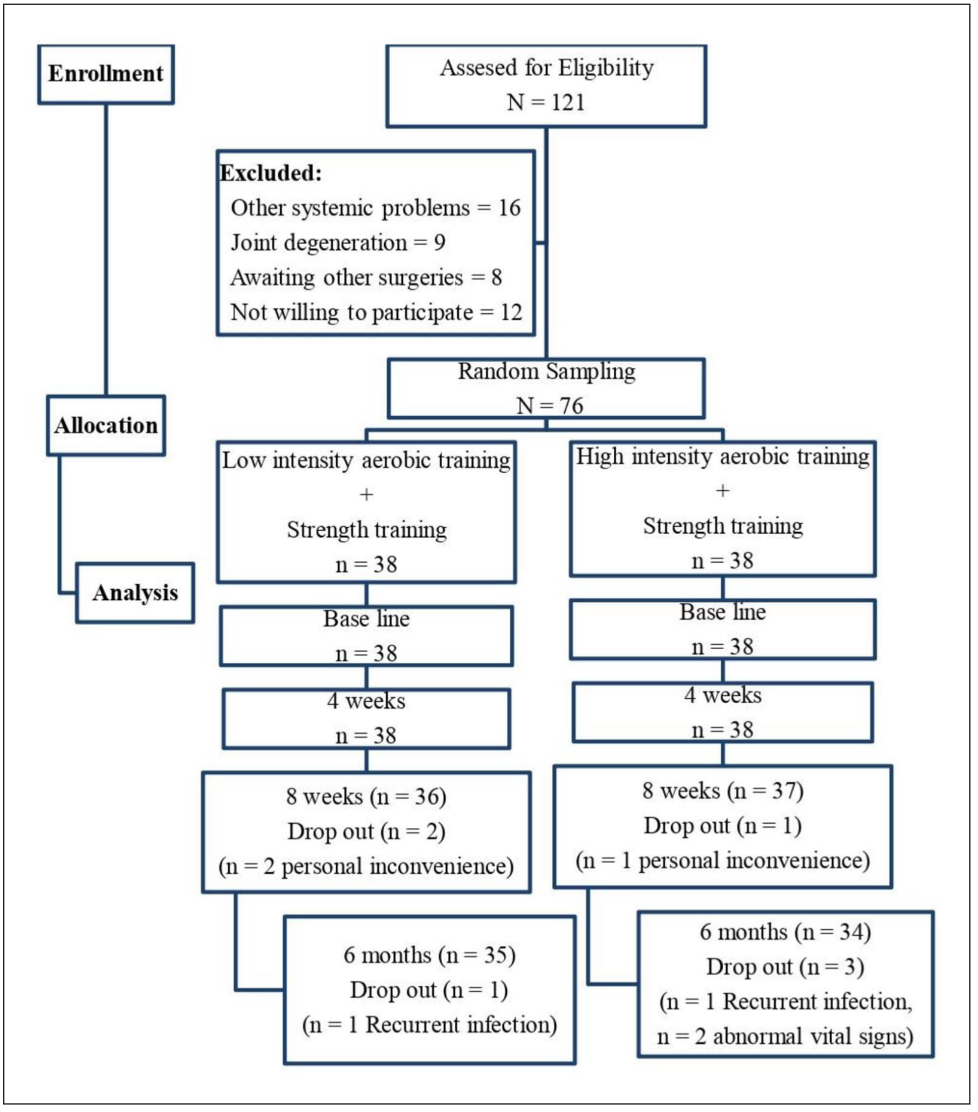

Figure 1. Flow chart showing the study details.

extensors, abdominal, and back muscles were trained. Each group of muscles was trained for 10 repetitions for three sets with a rest period of 60 seconds. The resistance was increased gradually as per the individual requirements and the training was given four days a week, for eight weeks. This training was conducted by a trained physiotherapist on an individual basis at the physiotherapy department. The detail description of intervention procedures was shown in Supplemental Appendix A.

Participants in both the groups were instructed not to participate in any other training programs and were allowed to take a regular diet. All measures were completed by a trained physiotherapist who was blinded to group allocation. Measurements were collected during and after the participants' training sessions.

Handgrip strength: It is a simple and cost-effective test to measure the upper limb strength and it was measured with a handheld dynamometer (Camry digital hand dynamometer, EH 101-17). The participant was asked to press the handle as much force as possible with the dominant side hand and the scores were noted. Three measurements were taken and the average value was included for data analysis. It is a valid and reliable tool to measure upper limb strength.[13]

Muscle quantity: Muscle quantity or muscle mass was measured with a magnetic resonance imaging (MRI) scan (Philips Ingenia, 1.5 TS, MA, USA) and it is a non-invasive type of measurement. The three major muscle cross-sectional areas such as mid of arm (biceps), mid of thigh (quadriceps), and mid-calf muscles were measured.[14]

Kinesiophobia: Tampa scale of kinesiophobia – 11 was used to measure the fear of movement due to muscle weakness. It is a questionnaire consisting of 11 questions that include somatic factors and activity avoidance and was measured on a 4-point Likert scale. The highest scores indicate maximum fear and the lowest scores indicate minimum fear of movement. It is a reliable and valid tool to measure kinesiophobia in older adults with sarcopenia.[15]

Quality of life: It was measured subjectively by the Sarcopenia and Quality of Life (SarQol) questionnaire. The participant was asked to complete the questionnaire themselves. It measures the physical, psychological, and social aspects of the health of sarcopenia patients and is a reliable and valid tool.[16]

The number of participants required was calculated through basic data from a previous pilot study.[17] The primary outcome variable selected was the handgrip strength, 35 participants were required in each group to improve the mean difference of 40% and a standard deviation of 2. Taking into account a 10% dropout, the number of participants was increased to 38 in each group and 76 participants were recruited in total. The power of the study was set at 80% and the significance level was 0.05. The sample size was calculated using G*Power (version 3.1.9.7) statistical science software.

Due to the design and study settings, it was not feasible to blind the treating therapist involved in the study. The therapist who was assessing the outcomes at baseline, after four weeks, at eight weeks and at six months, was blinded. Hence, the treating and assessing therapists were different individuals and the assessing therapist remained blinded to the participants. Participants were instructed not to disclose their study procedures and treatment protocol with fellow participants and the assessing therapist.

The participants' demographic and clinical characteristics were presented, tabulated, and analyzed for study homogeneity using the Kolmogorov–Smirnov test. The baseline, four weeks, eight weeks, and six months follow up measurements of primary and secondary variables were measured and presented as mean $\pm$ standard deviation. The mixed model with repeated measures was performed to measure the group $\times$ time effect of all variables. The independent *t*-test was performed to find the difference between the treatment groups and repeated measures analysis of variance was performed to find the intra-group effects with planned and corrected Bonferroni post hoc tests. The Pearson correlation coefficient test was used to find the relation between the primary and secondary variables. The whole statistical analysis was performed with IBM SPSS Statistics for Windows (version 20.0) and the statistically significant value was set at 0.05.

Results

Out of 121 participants screened, 76 ($N = 76$) participants were eligible to participate, and they were randomized into two groups. Two participants from the low-intensity aerobic training group and three participants from the high-intensity aerobic training group dropped out after eight weeks of training due to some personal inconveniences. Also, one participant (due to infection) from the low-intensity group and three participants (one due to infection and two participants due to abnormal vital signs) from the high intensity group dropped out at the end of six months follow up analysis (Figure 1).

Table 1. Demographic details of low and high intensity aerobic training groups.

Variable	LAT group (Mean ± SD)	HAT group (Mean ± SD)	*P*-value
Age (years)	63.2 ± 3.1	64.1 ± 3.2	0.217
Height (m)	1.66 ± 0.22	1.67 ± 0.21	0.839
Weight (kg)	74.6 ± 3.1	75.8 ± 3.5	0.117
BMI (kg/m^2)	23.1 ± 1.6	22.8 ± 1.7	0.430
VO_2 max (ml/kg/min)	17.8 ± 1.2	17.6 ± 1.1	0.451
HR (beats/min)	79.5 ± 4.8	78.9 ± 4.2	0.563

LAT: low intensity aerobic training; HAT: high intensity aerobic training; m: meter; kg: kilogram; min: minute; ml: milliliter; SD: standard deviation; BMI: mody mass index; VO_2: oxygen volume; HR: heart rate.

The participant's demographic and clinical characteristics were analyzed between the groups for the study homogeneity by using Kolmogorov–Smirnov test and the test showed no significant difference in age, height, weight, and body mass index measures ($P > 0.05$) and the data represented was suitable for further statistical analysis. The clinical exercise fitness measures such as maxVO_2 and heartbeat were used to plan the aerobic exercise training, which showed no significant difference and the data ($P > 0.05$) is presented as mean and SD in Table 1.

The 2 × 4 (group × time) repeated measure multivariate analysis of variance with planned, corrected post hoc tests for all the outcome variables shows a significant difference ($P < 0.001$) between the groups. The overall univariate *P*-value for group and time also shows a significant difference ($P < 0.001$). The 2 × 4 (group × time) mixed model with repeated measures of the primary variable (handgrip strength) shows a significant difference ($P < 0.001$), but muscle quantity (mid-arm, mid-thigh, and mid-calf) failed to show the difference ($P > 0.05$) between the groups at various intervals. At four weeks of intervention, handgrip strength improved more ($P < 0.001$) in the low-intensity aerobic training group than the high-intensity aerobic training group, but not in muscle quantity in mid-arm, mid-thigh, and mid-calf measurements. The same changes have been observed in the eight weeks and at the six months follow up. At the end of the six months follow up, the handgrip strength improved more ($P < 0.001$) in the low-intensity aerobic training group than the high-intensity aerobic training group, but not in muscle quantity in mid-arm, mid-thigh, and mid-calf measurements (Table 2). The post hoc Bonferroni test shows more significant changes in the primary outcome variable, at the six months follow-up period. On calculating the effect size, the overall changes noted in handgrip strength (d=4.87) of the low-intensity aerobic training group were categorized into large effects. However, the low-intensity aerobic training group shows a Minimal Clinically Important Difference Score (MCID) (handgrip strength – 3.90) than the high-intensity aerobic training group.

The secondary outcome measures such as kinesiophobia and quality of life were measured with Tamba scale of Kinesioiphobia – 11 and Sarcopenia Quality of Life scales. After four weeks of intervention, kinesiophobia level and the quality of life improved more ($P < 0.001$) in the low-intensity aerobic training group than the high-intensity aerobic training group. The same growth can be noted in the eight weeks and six months follow up. At the end of the six months follow up, again both the kinesiophobia level and quality of life showed more improvement ($P < 0.001$) in the low-intensity group than the high-intensity group (Table 2). On calculating the effect size, the low-intensity group noted larger effects in the kinesiophobia level (d=4.76) and the quality of life (d=11.55) when compared to the high-intensity group.

Discussion

The results of this trial show that low-intensity aerobic training combined with resistance training

Table 2. Comparative analysis of low and high intensity aerobic training groups at baseline, four weeks, eight weeks, and six months.

Variable	Duration	LAT group (Mean ± SD)	HAT group (Mean ± SD)	*P*-value
Hand grip strength (Hand dynamometer – kg)	Base line	28.4 ± 0.7	28.5 ± 0.6	0.505
	4 weeks	29.4 ± 0.5	29.2 ± 0.6	0.118
	8 weeks	31.5 ± 0.6	29.8 ± 0.5	0.001*
	6 months	34.3 ± 0.8	30.4 ± 0.8	0.003*
Muscle quantity (MRI – mid arm: cm^2)	Base line	55.9 ± 1.7	56.3 ± 1.1	0.227
	4 weeks	57.5 ± 1.0	57.9 ± 0.9	0.070
	8 weeks	58.9 ± 0.6	59.0 ± 0.5	0.432
	6 months	61.4 ± 0.5	61.5 ± 0.2	0.256
Muscle quantity (MRI – mid thigh: cm^2)	Base line	63.4 ± 0.8	63.5 ± 0.8	0.587
	4 weeks	65.3 ± 0.6	65.5 ± 0.6	0.150
	8 weeks	68.4 ± 0.6	68.5 ± 0.6	0.469
	6 months	72.5 ± 0.8	72.6 ± 0.8	0.587
Muscle quantity (MRI – mid calf: cm^2)	Base line	60.2 ± 1.1	60.2 ± 1.1	1.000
	4 weeks	65.2 ± 0.6	65.2 ± 0.6	1.000
	8 weeks	66.3 ± 0.5	66.4 ± 0.5	0.386
	6 months	68.7 ± 0.5	68.7 ± 0.5	1.000
Kinesiophobia (TSK-11)	Base line	32.1 ± 1.0	32.3 ± 0.9	0.362
	4 weeks	23.5 ± 0.9	29.9 ± 0.9	0.001*
	8 weeks	18.0 ± 0.9	24.5 ± 1.4	0.001*
	6 months	13.5 ± 1.0	18.2 ± 1.0	0.001*
Quality of life (SarQol)	Base line	57.3 ± 1.0	57.7 ± 1.0	0.085
	4 weeks	63.0 ± 0.7	58.8 ± 0.9	0.001*
	8 weeks	69.0 ± 1.0	60.5 ± 0.8	0.001*
	6 months	72.6 ± 1.0	62.2 ± 0.8	0.001*

LAT: low intensity aerobic training; HAT: high intensity aerobic training; SD: standard deviation; kg: kilogram; cm: centimeter; MRI: magnetic resonance imaging; TSK: Tamba scale of kinesiophobia; SarQol: sarcopenia quality of life.
*Significant difference.

has better effects on handgrip strength, kinesiophobia status, and quality of life than high-intensity aerobic training combined with resistance training in post-COVID-19 sarcopenia patients. At the same time, both the groups showed a similar improvement in the muscle cross-sectional area at various intervals during the training and at the six months follow up. The intra-group analysis shows that both the groups have shown significant improvement in all the variables irrespective of exercise intensity. The sarcopenia and physical frailty in older people: multi-component treatment strategies guidelines provide treatment strategies for older adults with sarcopenia, which could have been followed in the COVID-19 scenario.[18] Izquierdo et al.[7] noted that older persons with sarcopenia admitted in the hospital or home quarantine for COVID-19 have to undergo regular exercise training for better outcomes.

Generally, aerobic training are the safe physical activities that lead to whole-body activation and induce skeletal muscle properties. It promotes overall energy expenditure; improves physical fitness and paves a pathway for healthy aging. Among the other types of aerobic training, the low-intensity aerobic training improves the overall endurance capacity by activating skeletal muscle's oxidative capacity and improves the blood flow to the cell. This is because the greatest demand by the cell is during physical activity and it becomes enhanced during these exercises.[19,20] Regarding muscle strength (handgrip strength), our report shows a significant difference between the two groups. Goto et al.[21] observed that the difference in the muscle strength in low and high-intensity aerobic training exercises could be due to the difference in energy metabolism or difference in training duration.

At the same time, muscle quantity (arm, thigh, and calf) – cross sectional area did not show any statistical difference in low and high-intensity aerobic training exercises, which is in agreement with a study by Pasini et al.,[12] because these exercises did not have any role in altering the number and size of the fast-twitch muscle fibers. Participants of both the groups performed resistance training for the major group muscles such as shoulder flexors, extensors and abductors, elbow flexors and extensors, hip flexors and extensors, knee flexors and extensors, abdominal and back muscles which provides similar improvement in muscle quantity. Cadore et al., stated that the order of performing exercises (aerobic training followed with resistance training) would play an important role in improving the muscle strength and muscle mass, but in our study, aerobic training was given first followed by resistance training. This could be the cause for little changes in the muscle mass in both groups and the exact mechanism behind the effects of order of training was not found yet. Furthermore, it is observed that the little differences in muscle quantity in these groups could be due to either demographic characteristics or exercise parameters.[22]

Moreover, inclusion of resistance training would induce and recruit the new satellite cells into the weak muscle fibers and increase the number of myonuclei. This process would increase the strength and power of the muscle fibers but it also depends upon the age of the person and the type of training.[23] Bowen et al.[24] noticed that in older adults there is a substantial changes in hormonal and inflammatory markers helped in the improvement of muscle strength and physical performance after low and high intensity aerobic training exercises. Improving muscle strength is closely related to the improvement in activities of daily living, which decrease the kinesiophobia status. These overall changes improved the quality of life of COVID-19 infected older adults with sarcopenia symptoms, which was in agreement with Rejeski et al.[25] The reports also suggest that low or high-intensity aerobic training combined with resistance training improved the psychological effects in older adults with sarcopenia symptoms. Moreover, greater reduction in kinesiophobia status and improvement in the quality of life were noted in the low-intensity aerobic training group than the high-intensity aerobic training group.

The difference in clinical and psychological variables in low and high-intensity aerobic training in post-COVID-19 older adults with sarcopenia would be due to its variations in parameters such as frequency, intensity, time, and mode of execution of the exercises. Also, the muscle reaction to different exercise training protocols may be reduced in older adults when compared to younger people, which shows the physiological reserve at different stages of life. A combined aerobic and resistance training program may help to overcome this problem in sarcopenia patients, which was investigated by Cruz-Jentoff et al.[26] and Deutz et al.[27] Tieland et al.[28] noticed that combined exercise training with adequate protein intake improves the muscle strength, physical performance, and quality of life in frail, older patients than exercise training alone.

Few limitations were noticed during the execution of the whole trial. First, the effects of aerobic training on older females were not included due to social and cultural restrictions involved in the process. Second, the sample size was calculated using univariate G*Power analysis, but this study has undergone multivariate analysis. Hence, the number of samples included in the study would not be sufficient enough to generalize the results. Third, the study did not include any physical activity measures which would represent an improvement in actual function or mobility. Lastly, there is an absence of a control group (no exercise group), which may provide the absolute benefit or harm of low or high-intensity aerobic training exercises. Further investigation is needed, with a larger sample size with a control group on this training's long-term efficacy and sustainability. The reports of the study would be helpful for the health professionals to prevent or postpone the negative consequences of sarcopenia in older adults.

This study reports that low-intensity aerobic training exercises improved the clinical (muscle strength) and psychological (kinesiophobia and quality of life) aspects in comparison to high-intensity aerobic training in older adults with sarcopenia symptoms following post-COVID-19 infection. At the same time, both types of aerobic training exercises showed negligible or little role in increasing the muscle quantity – cross-sectional area.

Clinical messages

- Low-intensity aerobic training improved the hand-grip strength, kinesiophobia status, and quality of life aspects more than high-intensity aerobic training in older adults with sarcopenia symptoms.
- Low and high-intensity aerobic training has similar role in increasing the muscle cross-sectional area of arm, thigh, and calf region in older adults with sarcopenia symptoms.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This research was funded by the Deanship of Scientific Research at Princess Nourah Bint Abdulrahman University through the Fast-track Research Funding Program.

Ethical approval number

RHPT/020/044.

Clinical trial registration

Clinical Trials.gov ID: NCT04796064.

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Supplemental material

Supplemental material for this article is available online.

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