RESEARCH ARTICLE

P-ISSN : 2527-4627
Warmadewa Medical Journal
Available online http://ejournal.warmadewa.ac.id/index.php/warmadewa_medical_journal

WMJ (Warmadewa Medical Journal), Vol. 7 No. 1 Mei 2022, Hal. 13-21

Exercise and Sports Activities in Patients with Heart Failure

Sidhi Laksono[1,2] , Hillary Kusharsasmita[3]
[1]Department of Cardiology and Vascular Medicine, Central Pertamina Hospital, South Jakarta, Indonesia
[2]Faculty of Medicine, Universitas Muhammadiyah Prof Dr Hamka, Tangerang, Indonesia
[3]Faculty of Medicine, Universitas Diponegoro, Semarang, Indonesia
E-mail[1]: sidhilaksono@uhamka.ac.id

Abstract

Exercise training is an essential additional non-pharmacological method to treat heart failure patients that has been shown to have significant impacts on mortality, morbidity, exercise capacity and quality of life. Various type of training are developed to resolve the needs of heart failure patients, including those who want to participate in sport activities. It is critical and challenging to prescribe personalized exercise training program perfectly, therefore, this review provides brief overview of the advantages and recommendations to prescribe individualized type of exercise training including aerobic, resistance, respiratory, aquatic and competitive sport activities for patients with heart failure. A comprehensive electronic search was conducted using PubMed, Google Scholar, and ScienceDirect. The search was limited to English-language publications from 2004 to 2021. Hand searching of relevant journals and reference lists was also performed. Exercise training should be component of a comprehensive heart failure care approach. Each patient with heart failure may have a different endurance to tolerate the same relative training. Individualized exercise training combined with a preliminary examination improves disability while also decreasing morbidity and mortality

Keywords: heart failure, nonpharmacological management, sport exercise

INTRODUCTION

Heart failure (HF) is characterized by an intolerance to exercise, with early lethargy and shortness of breath as common symptoms. These symptoms have an impact on the ability to carry out daily activities, thereby reducing the quality of life. Prior to the late 1980s, all stages and types of heart failure (HF) were advised to bed rest and limit physical activity. Prolonged bed rest and physical activity, on the other hand, can result in skeletal muscle atrophy, pulmonary embolism, venous thrombosis, further decrease in exercise tolerance, and exacerbation of symptoms.(1) Therefore, several studies conducted over the last two decades have shown that exercise training in people with chronic heart failure (CHF) is safe.(2)

Exercise is different from physical activity. Any bodily movement produced by skeletal muscles which results in energy expenditure is classified as physical activity. On the other hand, sports training is defined as a structured, repetitive, and targeted physical activity to improve or maintain one or more components of physical fitness. Five main components can be used to express physical fitness, including morphological, muscular, motor, cardiorespiratory, and metabolic components. Morphological components include body mass relative to height, body composition, distribution of subcutaneous fat, visceral fat in the abdomen, bone density, and flexibility.(3) Muscle components include explosive power or strength, isometric strength, and muscle endurance. Motor components include agility, balance, coordination, and speed of movement. The cardiorespiratory components include endurance or sub-maximal exercise capacity, maximal aerobic power, heart function, lung function, and blood pressure (BP). Finally, metabolic components include glucose tolerance, insulin sensitivity, lipid and lipoprotein metabolism, and substrate oxidation characteristics.(4) Furthermore, exercise training does not produce further damage to the myocardium, and rehabilitation programs have been associated with various physiological, musculoskeletal, and psychological benefits.[5]

Therefore, sports training and exercise activity programs present some unique problems for doctors in prescribing a personalized program that is appropriate for each patient. In this article, we aim to discuss the types of exercise and sports activities in CHF patients, their benefits, special considerations, and prior assessments that are needed to guide comprehensive management of heart failure patients.

METHODS

A comprehensive electronic search was performed using PubMed, Google Scholar, and ScienceDirect. The search was limited to English-language publications from 2004 to 2021. A direct search of relevant journals and reference lists was also conducted. Searches include reviews, original papers, and case reports. The exclusion criteria were articles in languages other than English, articles without full access. Keywords used: exercise, training, sport, activity, heart failure.

The retrieved articles were compiled and managed using Mendeley software. The search was carried out with multiple databases, resulted in several duplicate citations, which were removed using Mendeley software. The search results were then sorted by title and abstract, followed by reading the full text and eliminating articles that include the exclusion criteria.

INITIAL EVALUATION

A comprehensive clinical examination is required in patients with confirmed CHF before starting an exercise program, including treatment of the underlying cause of CHF, appropriate pharmacologic therapy, and exclusion of contraindications to exercise. In addition, exercise intervention should be performed only in clinically stable individuals. As a result, any indicators of instability, such as recent weight change (>1.8kg in 1-3 days), uncontrolled resting heart rate (eg >100 beats per minute), or sudden changes in symptoms or exercise tolerance arrives, should be ruled out and the patient should be referred to his primary physician.[6] Daily changes in body weight, rhythm status, and congestive symptoms should be monitored as they may indicate decompensated heart failure.

In CHF, contraindications to initiating exercise training include hypotension or hypertension at rest or during exercise, unstable heart disease, worsening heart failure symptoms, myocardial ischemia despite therapy (exercise may be permitted to the ischemic threshold), or severe and unresponsive pulmonary disease. treated properly. [6]

EARLY ASSESSMENT OF CARDIOLOGICAL EXAMINATION

A comprehensive cardiologic examination, including assessment of comorbidities and severity of CHF, is required for a comprehensive clinical evaluation by measuring blood natriuretic peptide and echocardiography. To achieve the desired exercise intensity, oxygen uptake, or its estimate, must be measured during a maximum or symptom-limited exercise test.[7] The most frequent and widely used indirect technique is based on heart rate (HR), which is easy to monitor and has a linear relationship with oxygen uptake.[8] The heart rate reserve method (HRR = HRmax - HRrest) is a practical and widely used approach that takes the percentage reduction between HRmax and resting HR and then adds it to the resting HR. HRmax is predicted by the equation [HRmax = 220 - age]. Practically, exercise training sessions for cardiac patients are recommended at 40-70% of the HRR. This is also known as the Karvonen formula, and is reliable for patients with normal sinus rhythm whose resting and maximal heart rates are accurate.[9]

Direct maximal exercise testing with cardiopulmonary exercise testing (CPET) is also necessary to assess functional capacity, exercise-induced arrhythmias, or hemodynamic compromise and determine exercise intensity. CPET assesses a comprehensive exercise response and considers the impact (including interactions) of the cardiovascular, respiratory, musculoskeletal, and hematological systems. This test offers information about respiratory gas exchange, such as oxygen uptake (VO2) and carbon dioxide output (VCO2), as well as tidal volume (VT) and minute ventilation (VE), as well as other variables such as electrocardiogram, blood pressure, and oxygen saturation. O2 is determined by cellular O2 demand and increases linearly with increasing external work. In healthy individuals, a faster rate of increase in work results in more work being done, although the VO2 peak achieved was independent of the rate of increase in work. As the effort increases, the VO2 increases until it reaches a plateau. This is the highest achievable VO2 for a subject and is referred to as maximum VO2 or VO2max. This reflects the highest amount of oxidative metabolism involving large muscle groups. If a clear plateau is not reached during CPET, the highest VO2 achieved is the VO2peak which can be used instead of VO2max. An indicator of aerobic exercise capacity is VO2max (also known as VO2Peak). Decreased VO2max or VO2Peak indicates decreased exercise capacity, which may be due to cardiac, pulmonary, gas exchange, neuromuscular, muscle, or effort limitations.[10]

Fick's equation describes the relationship between exercise capacity and cardiac performance as follows: VO2 = Q (CaO2 – CvO2) (VO2: oxygen consumption; Q: cardiac output; CaO2: arterial oxygen content; CvO2: venous oxygen content) and shows that exercise capacity depends on both central and peripheral cardiac mechanisms. In individuals with chronic heart failure (CHF), the relationship between peak oxygen consumption (VO2peak) and resting left ventricular ejection fraction (LVEF) is low. Therefore, during exercise, cardiac reserve and peripheral factors involved in oxygen transfer (peripheral vascular function), oxygen uptake and utilization (skeletal muscle), increased receptor activity, and ventilation inefficiency should be considered.[11]

However, not all facilities have gas exchange equipment, and there are various other approaches to measuring the functional effects of exercise beyond the HRR. Some patients, for example, may need to adjust after exercise to engage in submaximal activity for extended periods of time, remain independent, continue to work, or rejoin their acquaintances on the golf course. This can be an important goal for certain patients and can occur even with a slight change in maximum oxygen uptake.[7]

Training sessions should be tailored over several weeks based on symptoms and objective outcomes during exercise testing, such as maximum exercise capacity, heart rate response, or arrhythmias. In atrial fibrillation (AF), exercise can only be measured using strength or with the Borg Rating of Perceived Exertion (RPE) score to measure the level of intensity of physical activity . Exercise should ideally be monitored through an exercise-based cardiac rehabilitation program, with unsupervised home-based sessions added progressively.[11] When all of these precautions are taken, the overall risk of exercise is minimal, even during higher intensity exercise and in patients with severe heart failure.[4] Follow-up examinations for exercise recommendations should be scheduled for Follow-up examinations for exercise recommendations should be performed at least every 3-6 months . The interval between examinations should be determined by disease severity and comorbidities, location of sessions (supervised vs. home-based), patient age, and adherence.

DOI: https://doi.org/10.22225/wmj.7.1.3954.13-22

Diabetes, obesity, lung disease, and musculoskeletal problems are frequent comorbidities in CHF patients, and they should be considered carefully when designing an exercise training program. Apart from cardiovascular disease, these disorders can significantly limit the patient's ability to exercise. In addition, many CHF patients have little or no history of recent sports participation and are thus severely deconditioned.(7) As a result, the initial intensity level should be kept low for the first few sessions. If tolerated, this low intensity can be compensated by increasing the duration or frequency of exercise.

TYPES OF SPORT EXERCISE FOR HEART FAILURE PATIENTS

Aerobic Sports Exercise or cardiorespiratory endurance

Aerobic exercise is activity performed at an intensity that allows the metabolism of stored energy to take place primarily through aerobic glycolysis. In addition to the glycolytic pathway, lipid metabolism (b-oxidation) also participates during aerobic exercise. Aerobic exercise involves large muscle groups performing dynamic activity, which results in a slight increase in heart rate and energy expenditure. Cycling, jogging, and walking at low to moderate intensity are examples of aerobic exercise.(3)

Aerobic or resistance exercise is the most studied training modality in CHF patients, and is recommended as a baseline exercise.(3) Cycling is generally preferred for its reproducible power output, decently low workload, and low injury rate. Traditionally, the maximal exercise intensity for patients with heart failure is defined as the first ventilatory anaerobic threshold (VAT) of 50-60% of VO2peak, minimizing exercise-related risks and side effects.(12)

However, because CHF patients require a higher percentage of their VO2 peak (when compared to normal individuals) to perform activities of daily living], and because one of the main goals of exercise training is to enable these patients to perform daily tasks with less effort, intensity training above VAT has been tested and introduced gradually.(13) The respiratory compensation point (RCP), which is 65-90% of VO2peak which is strongly associated with “critical power,” or the boundary between high intensity and intense effort, is currently recognized as the limit for prolonged aerobic exercise with no additional risk to the patient. with HF.(14)

Exercise intensity ranging from 70% to 80% of peak VO2 is now recommended. Nonetheless, aerobic exercise intensities as low as 40% of VO2peak have been shown to be effective in heart failure patients with a substantial reduction in pre-training VO2peak and/or exercise-related risk.(12) Because of its established effectiveness and safety, aerobic exercise is recommended for stable patients [New York Heart Association (NYHA) class I-II].15 Moderate continuous exercise (MCE) is the most frequently evaluated exercise mode. In MCE, the first 1-2 weeks, exercise intensity should be maintained at a lower intensity (40% of VO2peak) in NYHA functional class III patients, based on reported symptoms and clinical status. As a primary goal, this should be followed by a progressive increase in intensity up to 50-70% VO2peak, and if tolerated, up to 85% VO2peak.(6)

High-intensity interval training (HIIT) programs have recently become popular as an alternative exercise method for low-risk patients.(16) HIIT is described as a high-intensity submaximal performed at intervals of one to four minutes aiming at 90% to 95% of maximal heart rate and is separated by an active recovery period of three minutes of moderate intensity. In a recent meta-analysis, HIIT was superior to MCE in increasing VO2peak in people with heart failure with reduced ejection fraction (HFrEF) with a 40% reduction in ejection fraction in the short term. This advantage, however, disappeared in the subgroup analysis of the isocaloric protocols. The HITT program may advise low-risk individuals with stable heart failure who wish to return to high-intensity mixed aerobic and endurance exercise.(17)

Aerobic exercise improves angiogenesis, vasodilation, and endothelial function, reduces oxidative stress and peripheral vascular resistance in active tissues and increases metabolic capacity and musculoskeletal blood flow.(18) Aerobic exercise also causes a decrease in VE at submaximal workload, a decrease in respiratory rate, a decrease in VT, a decrease in the ventilation equivalent value for CO2 slope values (VE/VCO2), and an increase in the anaerobic threshold.(19) Both at rest and during activity, exercise training reduces subjective feelings of dyspnea.(15)

Resistance or Strength Training

Skeletal muscle weakness, especially in the upper extremities, often makes it difficult for patients with heart failure to perform daily activities.(20) Exercise training in heart failure patients with impaired skeletal muscle function and muscle wasting should initially focus on increasing muscle mass through resistance training.(21) Resistance training, in general, can complement, but not replace aerobic exercise because it reverses loss of skeletal muscle mass and deconditioning without placing too much stress on the heart.(22) Resistance training can be isometric (muscle length remains constant without joint movement) or dynamic (contraction with changes in muscle length and joint movement throughout the range of motion). Sustained maximum isometric (static) muscle activity, on the other hand, is contraindicated because it can induce the Valsalva maneuver at moderate to high loads, if not actively prevented by regular breathing, and may result in unwanted fluctuations in blood pressure.

Heart failure patients should train smaller muscle groups (including upper and lower body muscle groups) dynamically, avoiding the Valsalva maneuver, and at low to moderate intensity. Strengthening of 4-10 muscle groups in the upper, lower, and trunk is recommended depending on the NYHA class. 30 The intensity of resistance training is usually determined in one maximum repetition (1 RM). One maximum repetition (RM) is the highest amount of weight a person can lift with one repetition over a range of motion. Generally, exercise is performed at 40-60% of 1-RM.(23)

Resistance training should be performed 2-3 times per week for maximum strength gain. The training intensity should ideally be set at a resistance level that allows the patient to complete 10-15 repetitions on the 15 RPE Borg scale. As previously stated, most standard exercise training programs include a combination of aerobic and resistance training. Beckers and colleagues found that combined exercise had more significant effects on submaximal exercise capacity, muscle strength, and quality of life in heart failure patients than pure resistance training, with no negative impact on left ventricular remodeling or outcome parameters.(24) Resistance programs, on the other hand, may be considered especially for low-risk stable individuals who wish to return to strength-related sports, such as weightlifting. According to a meta-analysis, resistance training as a sole intervention can improve muscle strength, aerobic capacity, and quality of life in HFrEF patients who are unable to participate in an aerobic exercise program. Furthermore, in patients with advanced heart failure with minimal exercise tolerance, small muscle groups can be trained safely.(25)

Breathing Exercises

In patients with advanced heart failure, respiratory muscle dysfunction, characterized by respiratory muscle fiber atrophy, deoxygenation, and impaired mitochondrial oxidative capacity has been predominantly observed.(26) Respiratory muscle dysfunction, characterized by respiratory muscle fiber atrophy, deoxygenation, and altered mitochondrial oxidative capacity, has been seen in patients with advanced heart failure. Maximum inspiratory pressure (PImax) measures the strength of the inspiratory muscles. This was assessed at the oral level by asking the participant to take the maximum inhalation while at the residual volume for at least one second. According to the force-length correlation, the higher the position of the diaphragm (the longer the diaphragm rest or, the lower the lung volume), the greater the PImax. These measurements are not affected by the patient's breathing and are highly reproducible.[(25)]

In patients with heart failure, a PImax of less than 70% of the predicted value indicates respiratory muscle weakness.[(27)] Inspiratory muscular endurance refers to the capacity to maintain a certain respiratory pressure over time, which can be assessed by asking the patient to maintain a PImax over time to achieve a sustained maximum inspiratory pressure.[28] Next, the highest pressure that the patient can hold for at least one minute is measured, which is called the maximum threshold pressure (Pth max). Inspiratory muscle training improves VO2peak, dyspnea, and muscle strength and typically consists of several sessions per week with an intensity ranging from 30% to 60% of maximum inspiratory pressure and a duration ranging from 15-30 minutes for an average of 10-12 weeks. This training modality should be advised to people who are most seriously deconditioned to maximize the benefits to the heart as an initial option before moving on to traditional sports training and sports participation. [(28)]

Aquatic Exercise

Aquatic exercise is not recommended for those with heart failure because of concerns that the increase in central blood volume and cardiac preload caused by hydrostatic pressure may be intolerable. When the body is immersed in water, the hydrostatic pressure induces a central shift in blood volume. Immersion in water over the diaphragm, on the other hand, can result in a 10-15mmHg increase in central venous pressure (CVP). Immersion in the sternal notch transfers up to 700 ml of blood from the periphery to the chest cavity. This position has also increased the mean pulmonary artery pressure to an abnormally high level (53mmHg).[(29)] The increase in venous return that occurs after immersion also has an effect on the renal system. Changes include lower plasma concentrations of renin, angiotensin II, aldosterone, adrenaline, and noradrenaline, as well as increased diuresis.[(30)]

On the other hand, a recent meta-analysis found that water sports training may be safe and therapeutically beneficial. Aquatic exercise training, a similar ground-based training protocol, improves exercise capacity, muscle strength, and quality of life in patients with stable heart failure. For carefully selected patients, water sports training can provide a safe and effective alternative to a typical land-based exercise program. Ground-based training may be challenging for the vulnerable elderly and those with co-morbidities such as chronic pain, orthopedic disorders or balance disorders, which contribute to reduced levels of participation in physical activity.[31] Aquatic exercise (exercise performed in thermoneutral water [32–34 °C]) has been offered as a potential treatment option for these patients. Warm water and a low-load environment minimize discomfort, and training can be performed using the principles of hydrodynamics, which can improve postural stability, exercise capacity, and walking endurance.[(32)]

Considerations in Sports Activities in Heart Failure Patients

When making recommendations about an exercise program or exercise participation, the clinician should determine the type of exercise, the frequency and duration of the exercise program, and the intensity that seems most suitable for the individual. In choosing the most comfortable exercise, the doctor can determine the type of exercise (skill, strength, mix, or endurance) and the frequency, duration, and intensity of muscle work that must be maintained, preferably through an exercise program. To accurately determine individual endurance intensity or type of exercise or mixed exercise, individuals should perform a maximal exercise test with a 12-lead ECG recording or, preferably, with simultaneous pulmonary gas exchange (CPET) measurements.(33)

Competitive Sports

Competitive sports participation can be explored among a selected group of low-risk individuals. Prior to returning to sports, a thorough examination using a maximal exercise test (preferably CPET) is recommended, particularly before starting moderate to high intensity, mixed and strength training. Asymptomatic individuals with an EF > 50% (HFpEF) or mid-range (EF > 40-50%) who are properly treated may be eligible to participate in some competitive sports in the absence of exercise-induced arrhythmias or hypotension. In such circumstances, a gradual increase in the exercise dose is recommended. The duration of this exercise is determined by functional ability and reported symptoms. High-intensity, mixed, and high-demand endurance sports may impose some limitations, particularly on elderly individuals. Skill-based sports should be excluded from any restrictions. Patients at higher risk, such as those who are not optimally treated, those who remain on NYHA II or III despite optimal therapy, and those with exercise-induced arrhythmias or exercise-induced hypotension, should not participate in competitive sports, especially those who involves moderate to high cardiopulmonary stress during training or competition.(33,34)

Recreational Sports

Similar risk stratification techniques apply to patients who wish to take part in recreational sports and leisure activities. A gradual increase in the exercise dose is recommended. All asymptomatic people should engage in low to moderate intensity skill, strength, mixed, and endurance exercise. High-intensity recreational activities, including competitive sports, should be considered only in asymptomatic persons with HFmrEF (EF 40-49%) who do not have exercise-induced arrhythmias or hypotension. Asymptomatic individuals with HFrEF who are properly treated can participate in recreational sports related to low to moderate intensity skills, as well as low intensity endurance sports. Participation in low-intensity skill-related sports is possible in individuals with HFrEF who have minimal exercise tolerance, are frequently decompensated, or who use left ventricular assist devices. Low -intensity endurance activities, such as walking or cycling, should be recommended on a regular basis to increase basic exercise capacity.(33,35)

CONCLUSIONS

A comprehensive heart failure management strategy should include exercise training. Proper evaluation of the frequency, intensity, duration and type of exercise or Frequency, Intensity, Time, and Type (FITT) will lead to a better physiological response to exercise training. The critical challenge is that each patient with heart failure may differ in their capacity to endure relatively similar exercise stimuli, which requires special attention to tailoring exercise programs, even those who wish to participate in sports. In addition, individualized exercise training with early evaluation increases the rate of disability, also reduces morbidity and mortality.

AKNOWLEDGEMENT

The author would like to thank all those who have supported this manuscript.

REFERENCES

1. Giannuzi P. Recommendations for exercise training in chronic heart failure patients. Working group on cardiac rehabilitation & exercise physiology and working group on heart failure of the European Society of Cardiology. Eur Hear J. 2001;22:125–35.
2. Larsen AI, Dickstein K. Exercise training in congestive heart failure. A review of the current status. Minerva Cardioangiol. 2005 Aug;53 (4):275–86.
3. Vanhees L, Rauch B, Piepoli M, van Buuren F, Takken T, Börjesson M, et al. Importance of characteristics and modalities of physical activity and exercise in the management of cardiovascular health in individuals with cardiovascular disease (Part III). Eur J Prev Cardiol. 2012 Dec;19 (6):1333–56.
4. Rognmo O, Moholdt T, Bakken H, Hole T, Mølstad P, Myhr NE, et al. Cardiovascular Risk of High-Versus Moderate-Intensity Aerobic Exercise in Coronary Heart Disease Patients. Circulation. 2012;126(12):1436–40.
5. Pina IL, Apstein CS, Balady GJ, Belardinelli R, Chaitman BR, Duscha BD, et al. Exercise and heart failure: a statement from the Committee on Exercise, Rehabilitation, and Prevention. Circulation. 2003;107:1210.
6. Piepoli MF, Davos C, Francis DP, Coats AJS. Exercise training meta-analysis of trials in patients with chronic heart failure (ExTraMATCH). BMJ. 2004 Jan;328(7433):189.
7. Myers J. Principles of exercise prescription for patients with chronic heart failure. Heart Fail Rev. 2008;13(1):61–8.
8. Guazzi M. Assessment for Exercise Prescription in Heart Failure. Card Fail Rev. 2015;1(1):46.
9. Myers J, Hadley D, Oswald U, Bruner K, Kottman W, Hsu L, et al. Effects of exercise training on heart rate recovery in patients with chronic heart failure. Am Heart J. 2007 Jun;153(6):1056–63.
10. Datta D, Normandin E, ZuWallack R. Cardiopulmonary exercise testing in the assessment of exertional dyspnea. Ann Thorac Med [Internet]. 2015;10(2):77–86. Available from: https://pubmed.ncbi.nlm.nih.gov/25829957
11. Long L, Mordi IR, Bridges C, Sagar VA, Davies EJ, Coats AJ, et al. Exercise-based cardiac rehabilitation for adults with heart failure. Cochrane database Syst Rev. 2019 Jan;1(1):CD003331.
12. Maeyer C, Beckers P, Vrints CJ, Conraads VM. Exercise training in chronic heart failure. Ther Adv Chronic Dis. 2013;4(3):105–17.
13. Kervio G, Ville NS, Leclercq C, Daubert J-C, Carre F. Cardiorespiratory adaptations during the six-minute walk test in chronic heart failure patients. Eur J Cardiovasc Prev Rehabil Off J Eur Soc Cardiol Work Groups Epidemiol Prev Card Rehabil Exerc Physiol. 2004 Apr;11(2):171–7.
14. Carvalho VO, Mezzani A. Aerobic exercise training intensity in patients with chronic heart failure: principles of assessment and prescription. Eur J Cardiovasc Prev Rehabil Off J Eur Soc Cardiol Work Groups Epidemiol Prev Card Rehabil Exerc Physiol. 2011 Feb;18(1):5–14.
15. Laoutaris ID, Dritsas A, Brown MD, Manginas A, Kallistratos MS, Sfirakis P, et al. Inspiratory muscle

training in a patient with left ventricular assist device. Hellenic J Cardiol. 2006;47(4):238–41.

16. Ellingsen Ø, Halle M, Conraads V, Støylen A, Dalen H, Delagardelle C, et al. SMARTEX Heart Failure Study (Study of Myocardial Recovery After Exercise Training in Heart Failure) Group. High-intensity interval training in patients with heart failure with reduced ejection fraction. Circulation. 2017;135 (9):839–49.
17. Gomes-Neto M, Duraes AR, Reis HFC dos, Neves VR, Martinez BP, Carvalho VO. High-intensity interval training versus moderate-intensity continuous training on exercise capacity and quality of life in patients with coronary artery disease: A systematic review and meta-analysis. Eur J Prev Cardiol. 2017;24 (16):1696–707.
18. Duscha BD, Schulze CP, Robbins JL, Forman DE. Implications of chronic heart failure on peripheral vasculature and skeletal muscle before and after exercise training. Heart Fail Rev. 2008;13(1):21–37.
19. Klecha A, Kawecka-Jaszcz K, Bacior B, Kubinyi A, Pasowicz M, Klimeczek P, et al. Physical training in patients with chronic heart failure of ischemic origin: Effect on exercise capacity and left ventricular remodeling. Eur J Prev Cardiol. 2007;14(1):85–91.
20. Bjarnason-Wehrens B, Mayer-Berger W, Meister ER, Baum K, Hambrecht R, Gielen S. Recommendations for resistance exercise in cardiac rehabilitation. Recommendations of the German Federation for Cardiovascular Prevention and Rehabilitation. Eur J Cardiovasc Prev Rehabil Off J Eur Soc Cardiol Work Groups Epidemiol Prev Card Rehabil Exerc Physiol. 2004 Aug;11(4):352–61.
21. Conraads VM, Beckers PJ. Exercise training in heart failure: practical guidance. Heart. 2010 Dec;96 (24):2025–31.
22. Caforio ALP, Adler Y, Agostini C, Allanore Y, Anastasakis A, Arad M, et al. Diagnosis and management of myocardial involvement in systemic immune-mediated diseases: a position statement of the European Society of Cardiology Working Group on Myocardial and Pericardial Disease. Eur Heart J. 2017;38(35):2649–62.
23. Williams MA, Haskell WL, Ades PA, Amsterdam EA, Bittner V, Franklin BA, et al. Resistance exercise in individuals with and without cardiovascular disease: 2007 update: a scientific statement from the American Heart Association Council on Clinical Cardiology and Council on Nutrition, Physical Activity, and Metabolism. Circulation. 2007 Jul;116(5):572–84.
24. Beckers PJ, Denollet J, Possemiers NM, Wuyts FL, Vrints CJ, Conraads VM. Combined endurance-resistance training vs. endurance training in patients with chronic heart failure: a prospective randomized study. Eur Heart J. 2008 Aug;29(15):1858–66.
25. Giallauria F, Piccioli L, Vitale G, Sarullo FM. Exercise training in patients with chronic heart failure: A new challenge for cardiac rehabilitation community. Monaldi Arch Chest Dis. 2018;88(3):38–44.
26. Wong E, Selig S, Hare DL. Respiratory muscle dysfunction and training in chronic heart failure. Heart Lung Circ. 2011 May;20 (5):289–94.
27. Dall'Ago P. Chiappa GR, Guths H, Stein R, Ribeiro JP. Inspiratory muscle Train patients with Hear Fail inspiratory muscle weakness a

randomized trial J Am Coll Cardiol. 2006;47:757–63.

28. Laoutaris ID, Dritsas A, Brown MD, Manginas A, Kallistratos MS, Degiannis D, et al. Immune response to inspiratory muscle training in patients with chronic heart failure. Eur J Cardiovasc Prev Rehabil Off J Eur Soc Cardiol Work Groups Epidemiol Prev Card Rehabil Exerc Physiol. 2007 Oct;14(5):679–85.

29. Adsett J, Mullins R. Evidence based guidelines for exercise and chronic heart failure. Pathways home Proj. 2010;4–17.

30. Wong AM, Lin Y-C, Chou S-W, Tang F-T, Wong P-Y. Coordination exercise and postural stability in elderly people: effect of Tai Chi Chuan. Arch Phys Med Rehabil. 2001;82(5):608–12.

31. Murad K, Kitzman DW. Frailty and multiple comorbidities in the elderly patient with heart failure: implications for management. Heart Fail Rev. 2012 Sep;17(4–5):581–8.

32. Vivas J, Arias P, Cudeiro J. Aquatic therapy versus conventional land-based therapy for Parkinson's disease: an open-label pilot study. Arch Phys Med Rehabil. 2011 Aug;92(8):1202–10.

33. Pelliccia A, Sharma S, Gati S, Bäck M, Börjesson M, Caselli S, et al. 2020 ESC Guidelines on sports cardiology and exercise in patients with cardiovascular disease: The Task Force on sports cardiology and exercise in patients with cardiovascular disease of the European Society of Cardiology (ESC). Eur Heart J. 2021;42(1):17–96.

34. Pandey A, Garg S, Khunger M, Darden D, Ayers C, Kumbhani DJ, Mayo HG, de Lemos JA, Berry JD. Dose-Response Relationship Between Physical Activity and Risk of Heart Failure: A Meta-Analysis. Circulation. 2015 Nov 10;132 (19):1786-94. doi: 10.1161/ CIRCULATIONAHA.115.015853. Epub 2015 Oct 5. PMID: 26438781.

35. Howden EJ, Sarma S, Lawley JS, Opondo M, Cornwell W, Stoller D, Urey MA, Adams-Huet B, Levine BD. Reversing the Cardiac Effects of Sedentary Aging in Middle Age-A Randomized Controlled Trial: Implications For Heart Failure Prevention. Circulation. 2018 Apr 10;137(15):1549-1560. doi: 10.1161/ CIRCULATIONAHA.117.030617. Epub 2018 Jan 8. PMID: 29311053; PMCID: PMC5893372.