REVIEW ARTICLE

An overall view of aerobic physical training for chronic heart failure patients: a review study

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ABSTRACT

One of adjuvant treatment modalities for improving physical capacity and quality of life in patients with heart failure (HF) has been physical training. **Objective:** To update the knowledge on the effect of exercise training as an adjunct in the treatment of HF patients through a systematic review. **Methods:** A systematic review of randomized controlled trials was conducted using the electronic databases (PubMed/MEDLINE, EMBASE, CINAH and the Cochrane Library, searching over five years (2010-2015). Included were trials with at least three months of follow-up and the assessment of the effects of exercise interventions as a rehabilitation program component for patients with HF. **Results:** Seven clinical trials were included with 4000 participants, predominantly with reduced ejection fraction (≤ 50%) and clinical class II and III by the New York Heart Association. The exercise program, as the independent variable, reduced the general and specific risk of hospitalization for heart failure and resulted in a clinically significant improvement in the patients' quality of life. Studies with univariate meta-regression analysis showed that these benefits were independent of the type, amount of exercise, and duration of follow-up. **Conclusion:** Within the limits of this review, it was possible to show that improvements in reducing hospitalizations and in health were related to quality of life based on the engagement of HF patients in supervised exercise programs and appear to be consistent in all patients, regardless of the program's features and can increase life expectancy.

Keywords: Motor Activity, Oxygen Consumption, Quality of Life

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INTRODUCTION

According to the World Health Organization (WHO), heart failure (HF) is a major public health problem affecting more than 5.8 million people in the United States and more than 23 million people worldwide.[1] Heart failure is categorized as an increasing epidemic and is a significant socioeconomic burden. In developed countries, 1-2% of the adult population has been diagnosed with HF, but the prevalence reaches 10% among people 70 years of age or older.[2] Despite the considerable progress in the management of patients with HF, mortality and morbidity continue to be a major health concern,[3] as do the frequent hospitalizations that put one's daily life and social activities at risk. It is a complex clinical syndrome, in which the ability of the left ventricle to fill or eject the blood is impaired.[4]

People with HF present a heart with a greatly reduced capacity for exercise causing a series of unfavorable functional changes in their health with repercussions on their activities of daily living and quality of life and, finally, increasing the rate of hospitalization and mortality.[5] Throughout the world, 17-45% of patients hospitalized with HF die within one year of their admission and the majority die in the next five years.[6]

The cost of HF with hospitalizations and new admissions is high in all parts of the world affecting the budget of countries due to aging populations.[7] It is an expensive condition to treat with a cost between 1% and 2% of national health budgets and 60% of this cost is related to hospitalization.[8] In the United States, there are over 600 thousand new cases annually, with an annual expenditure of US$ 40 billion,[9] and the number of cases should increase to 1.5 million by 2040.[10]

Data from DATA SUS demonstrate that in the year 2012 alone there were 26,694 deaths by HF in Brazil. In São Paulo, HF is positioned among the 40 main causes of hospitalization in the state (ICD-10 list).[11] Survival after diagnosis of HF has improved over the past few years, but it is a treacherous syndrome that has a poor prognosis, because 30-40% of patients diagnosed with HF die within one year.[12]

The HF panorama in Brazil was outlined by the Brethe study.[5] In one year, 40% of the approximately 1,270 studied patients, hospitalized at 51 public and private hospitals in 21 Brazilian cities, have died.[5] It is estimated that 100 thousand new HF cases are diagnosed each year in the country. This situation indicates a high rate of mortality and the need for a rigorous and effective treatment to improve the physical conditions of these patients. However, American statistics lead to an inevitable fact: if the incidence of new cases of HF stays at the current level of 1% a year among those aged > 65 years, with the expected aging of the population, in 2050 there would be > 1 million new cases per year in the United States. Prevention may be an important weapon in order to combat cardiovascular diseases. Once installed, it must be treated properly, so that it does not result in decompensated HF. Current evidence has recommended physical training as a key component in the guidance of secondary HF prevention.[13] Because of its easy access and low cost, physical training can be an alternative and favorable approach as a therapy for prevention and adjuvant treatment in this syndrome. While the war to reduce the number of cardiovascular diseases, widely considered, must continue without rest, the battle to control HF has now changed to center stage. This battle will be long and difficult, because the "enemy has many faces," and it will have to be fought on several fronts at the same time and with many different weapons.

OBJECTIVE

The purpose of this systematic review was to investigate the impact of aerobic training on heart failure as an adjuvant to clinical treatment.

METHOD

A systematic review restricted to articles with human beings was performed using articles indexed in the electronic MEDLINE, EMBASE, CINAHL, Virtual Health Library (VHL) databases, using references from Latin American and Caribbean Literature in Health Sciences (LILACS), and the Cochrane Library researched between January of 2010 and December of 2015. Studies with six or more months of follow-up were included and the effects of the interventions of physical training described were evaluated. In addition, an evaluation of the bibliographic references of selected articles was made to identify other potentially relevant studies. The descriptors were obtained from the DeCS (Descriptors in Health Sciences) and MeSH (Medical Subject Headings), respectively. The descriptors used were: *Heart failure, exercise training, aerobic exercise, interval training*.

Selection of studies

The search was limited to results from full-text articles in English, Spanish, and Portuguese. As inclusion criteria, this study selected only studies on adult individuals (≥ 18 years) dating between 2010 to 2015, that lasted at least 12 weeks (three months), with each session lasting between 30 and 60 minutes, at a frequency of 2 to 5 times a week, patients in the New York Heart Association (NYHA) functional class of I, II, and III and with ejection fraction ≤ 50%.Two independent reviewers evaluated the articles to determine whether they met the criteria previously determined. The comorbidities included hypertension, diabetes, coronary heart disease, previous myocardial infarction, saphenous graft, by idiopathic cause, and Chagas disease. The pharmacological therapy included angiotensin-converting enzyme inhibitors, beta-blockers, statins, digoxin, diuretics, and oral anticoagulants. The control group could receive active interventions (e.g., educational or psychological intervention), including the usual medical care.

RESULTS

The patients with HF who participated in these reviewed reports on physical training had an average age above 50 years and were two times more likely to be male. In the initial phase of the continuous training scheme, the intensity was kept at a low level (e.g., 40-50% VO_2 peak) until exercise duration of 10-15 min was reached. In this initial phase the main objective was to gradually increase the intensity (from 50 to 60-70% of VO_2 peak); the secondary objective was to increase the length of the 15-20 minute sessions until the maintenance phase of 30 min, which was usually observed after 3-6 months.

The duration of the exercise and the frequency of training sessions were increased in accordance with the symptoms and clinical presentation. On average the frequency of training sessions was of 2 to 3 times a week with intensity between 50 and 80% of the HR reserve and by the perception of effort using the Borg scale < 15. The initial phase of the interval or intermittent training regimen was of low intensity, alternating short times (10s) with lesser intensity load exercises (50% of maximum capacity) with a longer recovery period (80s) at 20% of the load for 5-10 min. In the high intensity interval or intermittent training regimen, when well tolerated, the stimulus would last 10-30s, with a shorter recovery time (60-80s) and, therefore, increasing the intensity (60-100%). The training session should last from 15 to 30 minutes. After that, the frequency of training and duration per session is increased. In general, the duration of the sessions was between 20 and 60 min and the perception of effort by Borg scale < 15, all within the recommendations of the American College of Sports Medicine.[14] The duration of follow-up averaged 8 months and the EF varied between 15% and 50%.

Although it was not within the ambit of this review to evaluate resistance exercises (with weights), this training modality began with low intensity: 30% of 1-MR; repetitions: 5-10; Frequency: 2-3 training sessions per week, one to three circuits during each session. In moderate phase: Intensity: 30-50% of 1-MR; RPE/SPE 12-13; repetitions: 15-25; Frequency: 2-3 training sessions per week; one circuit during each session. In the phase of high intensity: Intensity: 40-60% of 1-MR; RPE/SPE ≤ 15; repetitions: 8-15; Frequency: 2-3 training sessions per week; one circuit during each session (Chart 1).

DISCUSSION

This systematic review showed that the physical training in patients with HF is well tolerated, safe, and provides a constellation of central and peripheral effects that should be valued in this syndrome. The interaction mechanisms that involve the cellular metabolism and the transfer of intracellular cardiac energy, as well as the skeletal musculature, the augmented sympathetic neuronal activation, and inflammatory cytokines contribute decisively to the development of exercise intolerance in HF.

Although central factors such as EF and/or cardiac output should play a major role in the central functional capacity of these patients, it is mainly the potential peripheral factors that are responsible for the reduction in the capacity to tolerate exercising.[15] In this regard, many benefits of regular exercise for patients with HF were documented, such as improvements in physical capacity (increase of 10-30% in maximum physical capacity),[16,17] better quality of life,[18] attenuation of endothelial dysfunction,[19] decrease in the levels of circulating catecholamines,[20] and reduction of morbidity and hospital admission.[21] These changes listed above determine the increase in the functional capacity using a lower heart rate (HR). Physical training, due to large evidence of its positive effects has been widely used as an auxiliary therapy for patients with stable HF[22] with the recommendation of the American College of Cardiology (ACC) and the American Heart Association (AHA).[23]

The majority of studies with HF have used exercises of moderate to high intensity (70-80% of HR peak). However, programs of lesser intensity at 40-50% VO_2 peak have also shown to improve their exercise capacity.[18]

Central cardiac effects

Physical training at submaximal levels in HF has no significant effect on cardiac output,[24,25,26] but a slight improvement at the peak of exercise.[20,25] Hambrecht et al.,[20] on the other hand, observed reductions in the final left ventricular diastolic diameter (LVDD), suggesting a reverse remodeling induced by physical training. In addition, it reduced the diastolic stress of the LV wall, even with a moderate workload (50% VO_2 peak) an increase of 30% in the VO_2 peak after two months was verified.[27] Belardinelli et al.[28] demonstrated improvement in the functional capacity of people with dilated cardiomyopathy and diastolic dysfunction with physical training.

Peripheral Effects

Reversible peripheral abnormalities in patients with HF include changes in skeletal muscle and vasomotor tonus. Physical training can improve the mitochondrial volume with improvement of oxidative metabolism.[24,29,30] Reduced skeletal muscle mass has been verified in patients with HF and has been related to a reduction in exercise capacity.[31,32] The inversion of change from type IIb skeletal muscle fibers (anaerobic) to type I skeletal muscle fibers (aerobic) was also demonstrated, and this adaptive response is associated with an improvement in exercise capacity.[33] A greater flow of peripheral blood and a greater efficient offer of oxygen were also observed after physical training.[34]

A beneficial effect of training on endothelial dysfunction, probably mediated by nitric oxide (NO), as suggested by Hambrecht et al.[20] and the flow of endothelium-dependent peripheral blood has been associated with a higher aerobic performance characterized by the increase of VO_2 peak.[19] Furthermore, the expression of the ribonucleic acid messenger of nicotinamide adenine dinucleotide phosphate (NADPH)-oxidase and the generation of reactive oxygen species (ROS) responsible for vasoconstriction and mediated by angiotensin II was reduced with regular exercise, demonstrating its vascular effect.[34,35] A reduction in sympathetic activity was also demonstrated.[36-39] Levels of inflammatory cytokines TNF-α and interleukin-6 (IL-6) were reduced, after training, and have been related with an improvement in exercise capacity.[40,41]

CONCLUSION

Through several mechanisms, the intolerance to exercise is the main incapacitating problem in patients with HF and physical training programs have demonstrated to improve functional capacity, quality of life, and reduced dyspnea in these patients. As the review has shown, clinical trials have demonstrated a multitude of benefits that favorably affect the exercise capacity, the metabolic function, vascular tonus, the production of cytokines, and neural activation. Therefore, physical training constitutes an important modality of a non-pharmacological treatment adjunct for patients with HF confirmed by the various positive physiological effects in patients with this syndrome. Different training modalities are available to deal with the problems with which HF patients are faced. It is essential to customize the arrangements of the prescribed exercise, so that both efficiency and safety will be guaranteed. Implanted electrical devices and mechanical support should not exclude patients from physical training; however, special precautions and a specialized approach is advisable. Future research should seek the development of more effective training modalities and the evaluation of the higher intensity models. One of the main challenges to engage patients with HF in physical training is to enhance the participation in the short as well as in the long term and gain their adhesion to the physical training.

Chart 1. Summary of the studies included in the systematic review (n = 10)

Studies	Participants	Intervention	Results
Yaylali et al. 2015[42]	HF EF 45%, NYHA II-III) Interval training: n = 13 males, 4 females, with age from 63.7 ± 8.8 years. Continuous training: n = 13 males, with ages ranging between 59.6 ± 6.8 Con years: n = 9 males, 2 females, with ages ranging between 60.6 ± 9.9 years	Exercise 1 (interval training): 30 minutes of aerobic exercise on the cycle ergometer 3x/week for 12 weeks to 50% -75% RFC/RHR. Exercise 2 (continuous training): exercise protocol similar to the training group without interval for rest	Interval training group had a significant improvement in HR of recovery.
Conraads et al. 2015[43]	HF (40%). N = 200 males (40 to 75 years)	Exercise: 3 x week for a period of 12 weeks. Exercise1: interval training (90-95% HR peak). Continuous exercise (70-75% of HR peak in bicycle). 36 sessions	VO_2 peak increased in both groups. Interval increased (22.7 ± 17.6%). Continuous (20.3 ± 15.3%)
Chrysohoou et al. 2015[44]	HF (EF ≤ 50%, NYHA II-IV): n = 50 Age group 1 63 ± 9 years, 88% males, 70% with HF by ischemia	Exercise 30 min of resistance training (intermittent 100% of the work load max, 30" at rest, for 45 min/day for 12 weeks)	VO_2peak increased by 31% and the workload increased by 25% in relation to the control group
Benda et al. 2015[45]	HF (EF < 40%, NYHA II-III) Ex: n = 28 males, age 64.0 ± 8 years	12 weeks of HIT (10 *1 minute at 90% of maximum load per 2.5 minutes at 30% of the maximum workload, interval training (alternating high/low workload or Continuous Training (30 minutes at 60-75% of the maximum load)	The training improved the maximum load, maximum oxygen consumption (VO_2 max) in relation to the predicted peak VO_2 peak in 7%, oxygen consumption at the anaerobic threshold and the maximum oxygen pulse (all $p < 0.05$)
Murad et al. 2012[46]	HF (EF < 40%, NYHA II-III) Ex: n = 11 males, 20 females, with age 68.0 ± 4.8 years Control: n = 13 males, 22 females, with age 70.1 ± 5.6 years	Exercise: supervised within the hospital with duration of 1 hour walk and 15-20 minutes of physical training in cycling, 3x/week during 16 weeks at 40% -50% to 60% -70% of heart rate reserve: controls were monitored by phone calls every 27weeks	The exercise group demonstrated significant increase in SDNN and RMSSD compared to control group
Fialho et al. 2012[47]	18 patients (13 females) with chronic chagas cardiomyopathy, with age between 30 and 72 years	Exercise 3 x per week, for 1 hour (30 minutes of aerobic activity and 30 minutes of resistance exercise and stretching), for 6 months	Average increase of VO_2 peak above 10%
Ricca--Mallada et al. 2012[48]	HF (EF *n* 40%, NYHA I-II) Ex: = 8 males, 2 females, with mean age = 59.0 ± 7.9 years	Exercise: supervised hospital-based resistance training of 55-minute bicycle circuit, 3x/week for 24 weeks at 50% -80% of HR reserve	Exercise group obtained significant increases of average interval RR [Relative Risk], HF, and LF after training
Freyssin et al. 2012[49]	26 male patients (54 ± 12 years) IT = EF (30.7 ± 7.8%) CT = EF (27.8 ± 4.7%)	2 groups did Interval training (IT) or continuous (CT) 3 sessions with 12 repetitions of 30s high intensity and 60s of complete rest. The CT group held 45 min of continuous aerobic activity	The IT group significantly increased its VO_2 peak, the duration of the exercise test, oxygen pulse, oxygen consumption in LV1, and the distance covered in the TC6/CT6. The CT group only increased the time on LV1 and the distance performed in TC6/CT6 The improvement in time in LV1 was significantly higher for the IT group than for the CT group
Smart et al. 2012[50]	23 male patients, age 61 years with EF of 28%	Intermittent aerobic exercise for 60 min; 3 x week, duration of 16 weeks; intensity: 70 of peak power (PPO). Strong 60s/weak 60s. Moderate aerobic exercise 30 min at 70% of the PPO	Intermittent = VO_2 peak increased by 21% Moderate continuous exercise = VO_2 peak increased by 13%
Iellamo et al. 2013[51]	16 male patients age = 67 years; with EF = 38%	Continuous aerobic exercise on a treadmill for 30-45 minutes at 45-60% of the HR reserve. Intermittent exercise on treadmill: Intensity: 4 min (75-80% RFC) x 3min (45-50 RFC).	VO_2peak increased by 22% for both models of intermittent and continuous training on the treadmill

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