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Comparison of the effects of aerobic and force exercise in patients with heart failure after a cardiovascular rehabilitation program: randomized controlled trial

Comparación de los efectos del ejercicio aeróbico y de fuerza en pacientes con falla cardíaca luego de un programa de rehabilitación cardiovascular: ensayo controlado aleatorizado

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Palabras clave:
Ejercicio, falla cardiaca, rehabilitación cardiaca, entrenamiento de fuerza.

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ABSTRACT

Introduction and objectives: Cardiovascular diseases are the leading cause of mortality worldwide. Currently, rehabilitation programs are shown as adequate treatments to mitigate the effects of heart failure. The main objective is to compare the effects of aerobic exercise and strength in patients with heart failure after a cardiovascular rehabilitation program. **Material and methods:** Randomized controlled trial over a period of three years with a sample of 920 patients with heart failure distributed in two groups (aerobic exercise plus upper limb -MMSS- training and aerobic exercise plus training of lower limbs -MMII-). Blood samples were taken to determine blood glucose levels and lipid profile. In addition, tests for aerobic capacity, maximum heart rate, anthropometry, depression, anxiety, clinical and hemodynamic parameters. The tests were performed before and after 24 training sessions, 60 min, three times a week for two months. **Results:** Comparing the results between the groups, it was possible to show better results in the majority of the variables of group 2 (aerobic exercise + strength training MMII) ($p \leq 0.05\%$). However, no significant post training differences were found in the HDL, LDL and triglyceride variables ($p \geq 0.05\%$). **Conclusions:** An aerobic training program combined with strength for patients with heart failure improves aerobic capacity, exercise tolerance, ejection fraction, glycemic indexes, MHR, muscle percentage and decreases body fat percentage and levels of depression and anxiety. These

RESUMEN

Introducción y objetivos: *A nivel mundial, las enfermedades cardiovasculares son la primera causa de mortalidad. Actualmente, los programas de rehabilitación se muestran como un tratamiento efectivo para mitigar los efectos de la insuficiencia cardiaca. Se genera como objetivo principal comparar los efectos del ejercicio aeróbico y de fuerza en pacientes con falla cardíaca luego de un programa de rehabilitación cardiovascular.* ***Material y métodos:*** *Ensayo controlado aleatorizado en un periodo de tres años con una muestra de 920 pacientes con falla cardiaca distribuidos en dos grupos (Ejercicio aeróbico más entrenamiento de miembros superiores -MMSS- y ejercicio aeróbico más entrenamiento de miembros inferiores -MMII-). Se realizaron muestras hematológicas para determinar los niveles de glucemia y perfil lipídico. Además, pruebas y test para capacidad aeróbica, frecuencia cardiaca máxima (FCM), antropometría, depresión, ansiedad, parámetros clínicos y hemodinámicos. Las pruebas se realizaron antes y después de 24 sesiones de entrenamiento de 60 minutos, tres veces por semana durante dos meses.* ***Resultados:*** *Al comparar los resultados entre los grupos, se logró evidenciar mejores resultados en la mayoría de las variables del grupo experimental 2 (ejercicio aeróbico + entrenamiento de fuerza MMII) ($p \leq 0.05\%$). Sin embargo, no se encontró ninguna diferencia significativa post entrenamiento en las variables de HDL, LDL y triglicéridos ($p \geq 0.05\%$).* ***Conclusiones:***

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benefits stand out to a greater extent in an aerobic workout combined with MMII strength.

Un programa de entrenamiento aeróbico combinado con fuerza para pacientes con falla cardiaca mejora la capacidad aeróbica, tolerancia al ejercicio, fracción de eyección, índices glucémicos, FCM, porcentaje muscular y disminuye el porcentaje graso corporal y los niveles de depresión y ansiedad. Dichos beneficios sobresalen en mayor medida en un entrenamiento aeróbico combinado con fuerza de MMII.

INTRODUCTION

Cardiovascular diseases (CVD) are the set of alterations of the heart and blood vessels throughout the body. Among the diseases that cause most deaths in the world are noncommunicable diseases (NCDs) or chronic diseases, with a mortality indicator per year of 9 million between 2005 and 2010.[1] The first cause of mortality in the world are CVD that represent 48.8% of deaths per year, that is, 17.5 million deaths per year.[2] Of these diseases, 16.5% of these are of cerebrovascular origin; due to stroke, 9.1% due to arterial hypertension, 8.5%; for heart failure, 3.2% arteriopathies and other diseases;[3-5] however, these diseases are preventable.[6]

Hence, the need and importance of the left ventricle ejection fraction (LVEF) and its quantification. It is an essential point for prognostic assessment, to create intervention strategies and to conclude important decisions in patients with heart failure (HF), highlighting that heart failure has multiple manifestations which are encompassed by the classification of the Colombian Society of Cardiology where it is mentioned that heart failure is divided into: heart failure with preserved ejection fraction and with reduced ejection fraction. Thus, this is why echocardiography is the most useful and required non-invasive diagnostic test in patients with heart failure, since it confirms the diagnosis, complications and can determine the etiology of heart diseases.

Cardiovascular rehabilitation (CVR) takes a predominant role in this type of patients. In particular, it provides a multidisciplinary intervention that contributes to improving physical, social and emotional impact.[7-9] These programs allow to promote the changes in the behavior of the disease, reducing dependence on drugs and improving the quality of life.

Likewise, rehabilitation programs contribute to modify alterations of the bone, joint and muscle system on cardiac function, vascular, neurohumoral and inflammatory reflexes.[10] On the other hand, physical exercise in patients with heart disease allows acting on the anthropometric characteristics, reducing fat body mass, increasing muscle mass and acting on metabolic risk factors, decreasing insulin resistance.[11] And from there, serving as the main engine, to decrease the cardiovascular risk factors and in its effect the metabolic syndrome.

Therefore, muscular alterations are given in relation to the reduction of lean muscle mass, leading to a decrease in muscle diameter and this is directly associated with the stage of the disease. This leads to establish the recurrent intolerance to exercise that has been shown in some researches on the relationship of muscle volume and functional capacity in heart failure.[12-14]

In addition, different investigations also explain changes in type I (oxygen-dependent) muscle fibers in cardiac alterations, thus reducing resistance to fatigue, and therefore, muscle strength itself is a predictor of survival with emphasis on muscle strength in lower limbs (MMII).[15] Like the results presented by Leong et al.[16] from the PURE study that included 140,000 patients between 35 and 70 years, which concludes with the direct relationship of strength as a biomarker of cardiovascular, non-cardiovascular mortality and stroke.

As also, a direct relationship between muscle strength and maximum oxygen consumption (maximum VO_2), suggesting the implications and benefits of CVR and physical exercise in heart disease.[17] It should also be mentioned that greater levels of hand strength decrease the risk of mortality from any cause by 31% and higher levels of force measured with knee extension decrease the risk by 14%.[18] However, taking into account the benefits of CVR, it is important to highlight the relationship between strength and muscle mass with functional capacity in patients with HF who increase the prognosis of life without increasing the risk of fatal events.[19]

On the other hand, we mentioned that the effect of aerobic exercise in rehabilitation generates an increase in cardiac output and tissue perfusion at the muscular level, there is an increase in ventricular filling and beat volume, which increases the coronary vascular bed, improves the vasodilator response, the blood supply and decreases the viscosity to generate less resistance on the blood flow.[20] Likewise, the improvements on the ejection fraction over the volume of the left ventricle have been discussed. Also, an increased response is shown in the endothelial and mitochondrial function that improves the prognosis that is reduced with age.[21]

The above concepts highlight the importance and need to include strength training and aerobic exercise in cardiovascular patients. However, the guidelines and consensus for cardiac rehabilitation do not cover this topic as a main pillar of cardiovascular rehabilitation. That is why it is proposed as a research question: what are the effects of aerobic exercise with strength in patients with heart failure after a cardiovascular rehabilitation program? Based on these results, the role of strength work and aerobic exercise in patients attending cardiac rehabilitation can be clarified and thus determine the importance and necessity of this training mode. Having said all this, it is postulated as a hypothesis that cardiac rehabilitation patients under combined resistance exercise in lower limbs (MMII) and aerobic show greater benefits compared to aerobic exercise combined with strength in upper limbs (MMSS).

Due, that the muscular reduction in the inferior limbs stands out for its great importance since it generates a serious decrease in the functional capacity of the people, leading to a functional incapacity consequent with a rapid loss of strength (Fibers type II).[22,23] One of the causes is a lower resistance of these fibers, denervation, deficit in the gene expression of myosin type II[24] and a lower resistance of these fibers to oxidative stress.[25] In addition, there are conclusions that show mechanisms that could be related to the deficit of testosterone in the elderly.[23]

On the other hand, the mechanisms of regeneration and repair of muscle fibers are compromised in the elderly, generated by less activity of satellite cells[22] oxidative stress[24] and inadequate regulation to generate repair of damaged muscle fibers. In addition, several studies have shown that the poor tolerance to exercise of patients with heart failure is of multifactorial origin and includes some aspects such as: 1) respiratory limitation; 2) dysfunction of the peripheral musculature and 3) cardiovascular damage. 4) advanced age with muscle weakness of lower limbs.

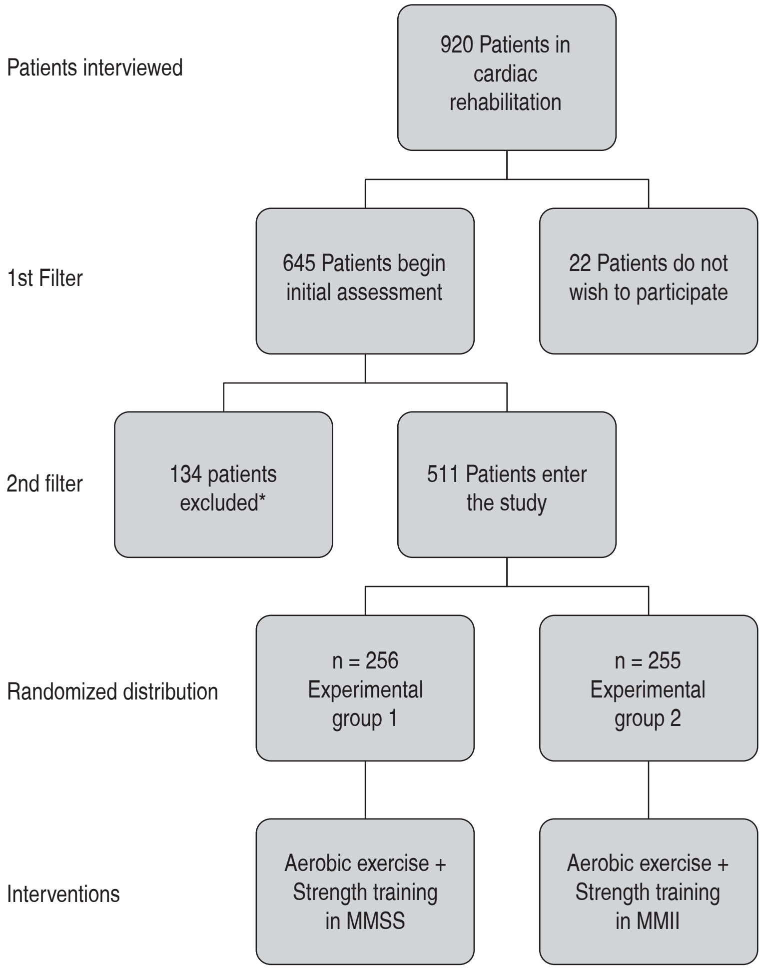
Therefore, the following objective is generated: to determine and compare the effects of aerobic exercise plus strength training in upper limbs versus aerobic exercise plus strength training for lower limbs.

MATERIAL AND METHODS

The study was conducted with a sample of 920 high-risk patients in cardiac rehabilitation, which after the exclusion criteria, was of 511 individuals who were organized into 2 groups *(Figure 1)*. This investigation was a randomized controlled trial with a basic probabilistic sampling by means of a table of random numbers, which its order was randomized through the program Microsoft Excel 16.0 being that, experimental group 1 ended with 256 participants (aerobic exercise + strength training in upper limbs) and experimental group 2 with 255 (aerobic exercise + strength training for lower limbs). The present investigation was carried out in a period of 3 years (April 2014-2017) which contains the following attributes:

Characteristics of the participants

The participants had similar characteristics taking into account ejection fraction,



MMSS = Superior members, MMII = Lower members.
*134 patients excluded (seven due to infectious disease, seven thrombophlebitis, nine unstable angina, nine decompensated diabetes, 21 due to systolic hypertension >190 mmHg, 22 reported painful safernectomy that prevented testing, and 59 patients at the initial assessment had decompensated heart failure.

Figure 1: Flow diagram of patient distribution.

functional class, glucose, lipid profile, muscle percentage, fat and body mass index (BMI), abdominal circumference, overweight, obesity, prevalence of diabetes, arterial hypertension (HTN), kidney disease, cardiovascular risk factors and cardiovascular surgical procedure for their respective analysis. In addition, all participants were classified as high risk patients according to the stratification proposed by the American Association of Cardiovascular and Pulmonary Rehabilitation.[26]

Inclusion criteria

The patients had to be in the post-operative stage of cardiovascular surgery that go to a phase II cardiac rehabilitation program, which at the time had to sign an informed consent endorsed by the ethics and research committee of the institution. Likewise, it was necessary for participants to have heart failure with ejection fraction greater than 35%; do not have any inconvenience when doing the questionnaires, tests and measures that the investigation demands, and a commitment to go 3 times a week to cardiac rehabilitation.

Exclusion criteria

Patients who had severe pain in the lower limbs, unstable angina, heart rate > 120 bpm at rest, systolic blood pressure > 190 mmHg, diastolic blood pressure > 120 mmHg were excluded. Similarly, patients who had a positive contraindication for cardiac rehabilitation were not admitted in the study *(Table 1)*. In addition, we pointed out that the participant had the option of being able to withdraw from the research when he wished or to show hemodynamic instability without improving during any test or during the intervention process.

Anthropometric measurement

In all the participants the following data were obtained: Family and personal history using a self-created questionnaire. Likewise, anthropometric measures (weight, height, body mass index, abdominal circumference, fat and muscle percentage) using standardized techniques in the Colombian population.

The weight, fat percentage and muscle, were obtained by using the Tezzio TB-30037 digital scale previously calibrated and located on a flat and stable surface, using the indications in the user's manual. On the other hand, the size was obtained with the Kramer 2104 Adult Acrylic Wall Height Measurement, placing the patient standing, with the head in Frankfort plane and with the shoulders relaxed to avoid lordosis and MMII completely against the wall.

Table 1: Contraindications of cardiac rehabilitation.

Early AMI
Unstable angina
Severe valve disease
Decompensated heart failure
Severe orthopedic condition that prevents the realization of exercises
Complex ventricular arrhythmias
Suspected trunk lesion of the left coronary artery
Symptomatic severe obstruction of the left ventricular outflow tract
All acute infectious symptoms
Unbalanced hypertension: TAS > 190 mmHg and/ or TAD > 120 mmHg
Orthostatic hypotension above 20 mmHg with symptoms
Pulmonary thromboembolism and thrombophlebitis
Dissecting aortic aneurysm
Infectious endocarditis
Severe congenital heart disease not corrected
Uncorrected third degree atrioventricular block
Decompensated diabetes
Other metabolic conditions, such as acute thyroiditis, hypokalemia, hyperkalemia or hypovolemia

AMI = Acute myocardial infarction, TAS = Systolic blood pressure, TAD = Diastolic blood pressure, HT = High blood pressure.

Table 2: New York Association functional classification.

Class I	No limitation of physical activity. The ordinary activity does not cause excessive fatigue, palpitations, dyspnea or angina pain
Class II	Slight limitation of physical activity. Comfortable at rest. Ordinary activity causes fatigue, palpitations, dyspnea or angina pain
Class III	Marked limitation of physical activity. Comfortable at rest. Physical activity less than ordinary causes fatigue, palpitations, dyspnea or angina pain
Class IV	Inability to carry out any physical activity without discomfort. Symptoms of heart failure or angina syndrome may be present even at rest. If any physical activity is done, the discomfort increases

Having said the above, with these variables the BMI was determined in kg/m-1.

Then, with a tape measure and a precision of 1mm, the abdominal circumference measurement was collected taking the anatomical referents described by Frisancho.[27] The «*Waist circumference cut points for the diagnosis of abdominal obesity in the Colombian population using bioimpedancetry as reference standard*» were chosen as cutting points: in men 91 cm and women 89 cm according to Buendía R et al.[28]

Clinical and hemodynamic parameters

Following all the above procedures, fasting blood glucose levels were determined on the first and last day of the training session using an Accu-Chek® Performa glucometer following the technical specifications suggested by the manufacturer. The blood sample was taken between 07:00 and 08:00 a.m., after 8-10 hours of fasting. It should be added that blood samples were collected in the laboratory of the hospital to define the levels of cholesterol, triglycerides, low density lipoproteins (LDL) and high density lipoproteins (HDL). Each patient underwent 2-D (two-dimensional) echocardiography before and after surgery. In this same assessment, the functional class of each patient was identified according to the NYHA classification which, designates 4 classes (I, II, III and IV) based on the limitations of physical activity of the patient, caused by cardiac symptoms *(Table 2)*. Similarly, perceived dyspnea and effort were assessed using the modified Borg scale.[29] The heart rate was detected by the Polar Multisport RS800CX system and the respiratory one, just as the systolic and diastolic blood pressure was obtained manually, while the oxygen saturation was obtained with a portable pulse oximeter (Nellcor Puritan Bennett).

Tests and questionnaires

From the beginning, the patient underwent a medical assessment by the area of physiatry to understand the current state of the patient, sociodemographic, anthropometric and physiological characteristics. On the same day, tolerance to exercise was estimated by the 6-minute walk test, which was performed before and after 24 sessions of cardiac rehabilitation. The protocol of the 6-minute walk test was performed according to the *ATS Statement: Guidelines for the six-minute walk test of the American Thoracic Society*.[30,31] On the other hand, to denote the initial weight of strength training for upper limbs (MMSS) and lower limbs (MMII), weights were used in repetition series with increase or decrease of the load of 2.5 to 8 lb, until achieving the maximum weight to lift. A maximum repetition (1RM) was considered appropriate with a full extension of the muscle group used, without muscle substitutions. After this evaluation day, the patient had to return for an effort test according to the Naughton protocol, which is recommended in high-risk patients, with stages of 2 minutes. We emphasize that for these tests, the patient was told that he should avoid smoking, drinking or any type of drug or medication that could alter his vital signs or performance during the test.

Depression and anxiety

The HADS questionnaire (Hospital Anxiety and Depression Scale: Zigmond and Snaith, 1983, republished by De las Cuevas, C. et al., 1995)[32] was used for anxiety and depression. Regarding anxiety, the questions are aimed at identifying if the user has been tense, worried or with some kind of fear. However, the questions of depression are aimed at identifying if the user shows disinterest in the activities of daily life, negativity about things and their attitude to be happy. At this point it is emphasized that the questionnaire was applied by two independent and blinded authors (P. P-R and D. P-F); which delivered the questionnaires to two other authors (R. P-R and C. Q-G) for verification and analysis.

Assignment of the sample

This research reported a population of 511 participants (289 men versus 222 women) who were divided into 2 groups using a simple probabilistic model by a table of random numbers, whose randomization was carried out in the Microsoft Excel program 16.0.

Blind methodology

A simple blind clinical study was carried out, in which the patients were assessed by a non-research professional (physiatrist of the cardiac rehabilitation service), as well as blood tests. Afterwards, patients accessed a database in Microsoft Excel 16.0 exclusively with an identification number that allowed blinding of the authors. Blindly, a first author (J. P-R) captured the result of the assignment of the participants in the 2 cardiac rehabilitation groups and provided the list of experimental groups 1 and 2 to the blinded authors P. P-R and D. P-F; R. P-R and C. Q-G; respectively.

The researchers prepared the questionnaires and tests without them knowing the assignment of each patient. After the tests, participants were suggested to approach cardiac rehabilitation to let them know their schedule and start date to the training program. Ignoring the cardiopulmonary rehabilitators, after 24 training sessions according to the assigned group, they gave an accurate report on the physiological changes and behavior in each training session.

However, we emphasize that from the initial tests until the end of the training program the authors did not establish conversation outside the topic with the participants or therapists. Exclusively the author J. P-R. held periodic meetings with the cardiopulmonary rehabilitators to notice and harmonize the training of each group but not intimate with the participants.

After the training program, tests were carried out to the patients of each group to calculate the post-training changes. Taking into account the information collected pre- and post, the statistical analyzes for experimental group 1 were carried out by K. S-P and J. H-S; experimental group 2 for P. P-R and D. P-F. Finally, once the different variables were studied in a blinded manner, all the authors were informed about the groups with their corresponding patients and results in order to elaborate the conclusions.

Intervention by group

The cardiac rehabilitation program consisted of 24 sessions of 60 minutes a day (10 minutes of warm-up, 40 minutes of training and 10 minutes of cool down phase), three times a week, for two months. With regard to warming, it was based on mobilization exercises by muscle groups. Cool down phase was done with propioception exercises, stretching, coordination and breathing exercises.

Related to the 40 minutes of training, it was modified according to the assigned group. Patients of experimental group 1 performed aerobic exercise on a treadmill and an elliptical bike plus strength exercises for upper limbs with dumbbells, multi-strength equipment and Theraband. On the other hand, patients of the experimental group 2 executed the same order of experimental group 1, but the strength training was focused only for the lower limbs with theraband, multi-strength equipment and exercises for activation of the sole-twin pump.

The work force for aerobic exercise was 50 to 70% of their maximum heart rate (MHR) achieved in the stress test according to the Naughton protocol. For strength, between 30% to 50% of 1 RM was determined, prolonging a percentage of heart rate that did not surpass 70% of the MHR nor the subjective uptake of physical effort to more than 6 on the modified Borg scale. For groups 1 and 2, strength training was based on a progressive increase in load Kraemer and Ratamess (2005).

Ethical considerations

It should be noted that the design and development of the research was carried out under the ethical considerations of the Declaration of Helsinki and Resolution No. 008430 of the Ministry of Health of Colombia and with the approval of the directors and the Ethics and Research Committee of the institution where the research was conducted.

Statistic analysis

First, a database was created in Microsoft Excel 16.0 with all the patients, test results and pre- and post-training measures. Then, the descriptive statistics was carried out to estimate and show the data by averages with their corresponding standard deviation. The normality of the data was assessed by means of the Kolmogorov-Smirnov test and the indication of specificity was evident for all the analyzes. Likewise, for the pre- and post-training relationship, the analysis of variance ANOVA (Analysis of one-way variance) and subsequently post hoc tests was used, through the Tukey test, to assess the characteristics of the different age groups, gender and anthropometry. In all cases, a significance level of 5% was established ($p < 0.05$) and carried out in the Stata program.

RESULTS

The cardiac rehabilitation program included 920 patients in the period studied, allowing an initial sample of 645 patients who met the inclusion criteria. After the application of the exclusion criteria 134 of them came out, allowing the final sample of 511 (M: 289 versus F: 222) patients with cardiovascular postoperative diagnosis and heart failure.

Regarding the academic level, 29% studied up to secondary education, 51% university students and 19% had only attended primary school. Cardiovascular surgical procedures performed were: *(Table 3)*.

Concerning the levels of depression and anxiety, a post-training improvement was demonstrated in all the intervention groups; the decrease being greater in the cases reported in experimental group 1 (aerobic exercise + strength training for upper limbs) *(Table 4)*. On the other hand, when comparing blood lipid profile values, fasting glycemic levels, muscle, fat percentage and BMI and maximum oxygen consumption (VO_2) as an indicator of tolerance to exercise and the distance in meters completed before and after the intervention of each training program based on aerobic exercise plus a component of muscular strength, showed a significant improvement in

Table 3: Initial characteristics of the study population.

Characteristics	Experimental group 1 n= 256	Experimental group 2 n= 255
Gender	M: 155 W: 101	M: 134 W: 121
Age (years)	67 ± 8	64 ± 5
Ejection fraction (%)	40 ± 2.6	40 ± 3.5
Height (m)	1.60 ± 12	1.64 ± 15.4
Body weight (kg)	80 ± 14.9	79 ± 11.6
BMI	32 ± 3.1	31 ± 4.6
Abdominal circumference (cm)	90 ± 6.5	93 ± 9.7
Fat percentage (%)	25 ± 2.4	29 ± 4.3
Muscle percentage (%)	32 ± 9.1	30 ± 12.9
Total cholesterol (mg/dL)	195 ± 29.5	208 ± 29.6
Triglycerides (mg/dL)	120 ± 12	160 ± 18.2
LDL (mg/dL)	116 ± 23.4	112 ± 12.7
HDL (mg/dL)	41 ± 2.6	45 ± 9.3
Glucose (mg/dL)	131 ± 11.5	124 ± 9.5
Estimated VO_2	7.3 ± 5.7	7.8 ± 4.3
METs	2.0 ± 1.6	2.2 ± 1.2
Distance traveled (m)	243 ± 23	219 ± 53
HRM in effort test	146 ± 16	148 ± 12
Overweight and/or obesity	78%	81%
Abdominal obesity	88%	89%
Dyslipidemia	57%	49%
Arterial hypertension	78%	82%
Diabetes	60%	57%
Renal disease	9%	11%
Sedentary*	91%	95%
Depression	21%	27%
Anxiety	11%	15%
Smoking	76%	86%
Alcoholism	13%	20%
Inadequate food intake	56%	30%
AMI history	89%	93%
Female gender	39%	47%
Age†	91%	94%
Myocardial revascularization	47.7%	44.3%
Angioplasty	29.7%	35.3%
Valvular replacement	10.1%	12.5%
CIA Closing	5.1%	2.8%
Bentall surgery	6.3%	3.9%
Heart transplant	1.2%	1.2%

HDL = High density lipoproteins, LDL = Low density lipoproteins, BMI = Body mass index; VO_2 = Maximum oxygen consumption, HRM = Maximum heart rate, CIA = Interatrial communication, METs = Metabolic equivalent, AMI = Acute myocardial infarction.
* Less than 150 minutes per week.
† Women > 65 years and men > 40 years according to Anchique, C. Rev Colomb Cardiol 2011; 18 (4): 177-182).

Table 4: Prevalence of depression and anxiety before and after training.

	Experimental group 1 n = 256		Experimental group 2 n = 255	
Characteristics	Pre (%)	Post (%)	Pre (%)	Post (%)
Depression	21	11	27	7
Anxiety	13	7	15	4

all variables ($p \leq 0.05\%$). In addition, when comparing the results between the groups, it was possible to show better results with significant difference in experimental group 2 (aerobic exercise + strength training for lower limbs) ($p \leq 0.05\%$). Similarly, an increase in muscle strength after training of 21 and 24% was observed in experimental group 1 and experimental group 2 respectively. However, no significant pre-post difference was found in the HDL, LDL and triglyceride variables ($p \geq 0.05\%$) *(Table 5)*.

On the other hand, during the sessions of the training program, participants reported a perceived dyspnea according to the Borg scale between 6 to 8 (moderate intensity) as well as the feeling of fatigue during exercise. There were no hemodynamic, electrocardiographic or metabolic complications during the training sessions of each of the participants.

Regarding the perception of the exercise using the Borg scale for dyspnea and fatigue, meters traveled, METs (metabolic equivalent) and VO_2 as indicators of tolerance to exercise at the beginning and end of the intervention in each group, an improvement was observed significant in all the variables. Highlighting that, after the intervention, higher values were observed in VO_2 for experimental group 2 (7.8 ± 4.3 mL/kg-1/min-1 versus 17.45 ± 3.3 mL/kg-1/min-1). in comparison with experimental group 1 (7.3 ± 5.7 mL/kg-1/min-1 versus 12.4 ± 3.3 mL/kg-1/min-1). As in the values of METs (2.22 ± 1.2 versus 4.98 ± 0.9) *(Figure 2)*, meters traveled (219 ± 53 m versus 399 ± 18 m), dyspnea (8 ± 3.8 versus 4.3 ± 2.3) and fatigue (9 ± 1.1 versus 3 ± 2.6) *(Table 5)*.

Table 5: Analysis of post-training changes.

	Experimental group 1 n = 256		Experimental group 2 n = 255		Group 1 versus Group 2
Variables	Pre	Post	Pre	Post	p
Ejection fraction (%)	40 ± 2.6	45 ± 4.6	40 ± 3.5	48 ± 1.3	< 0.001
Body weight (kg)	80 ± 14.9	75 ± 4.5	79 ± 11.6	72 ± 4.7	< 0.001
Body mass index	32 ± 3.1	28 ± 5.3	31 ± 4.6	25 ± 3.5	0.001
Abdominal circumference (cm)	90 ± 6.5	86 ± 6.1	93 ± 9.7	84 ± 5.4	< 0.001
Fat percentage	25 ± 2.4	21 ± 5.5	29 ± 4.3	23 ± 4.9	0.001
Muscle percentage	32 ± 9.1	36 ± 5.7	30 ± 12.9	38 ± 6.3	0.001
Total cholesterol (mg/dL)	195 ± 29.5	182 ± 21.4	208 ± 29.6	173 ± 16.5	0.001
Triglycerides (mg/dL)	120 ± 12.7	117 ± 16.3	160 ± 18.2	138 ± 7.7	< 0.001
LDL (mg/dL)	116 ± 23.4	109 ± 12.6	112 ± 12.7	109 ± 11.6	> 0.05
HDL (mg/dL)	41 ± 2.6	47 ± 3.4	45 ± 9.3	51 ± 2.3	> 0.05
Glucose (mg/dL)	141 ± 11.5	129 ± 5.5	134 ± 9.5	115 ± 4.8	0.002
Estimated VO_2	7.3 ± 5.7	12.41 ± 3.3	7.8 ± 4.3	17.45 ± 3.3	0.001
METs	2.0 ± 1.6	3.5 ± 0.9	2.2 ± 1.2	4.9 ± 0.9	0.001
Dyspnea post TC6M	9 ± 2.4	7.02 ± 1.6	8 ± 3.8	4.3 ± 2.3	0.001
Fatigue post TC6M	8 ± 1.7	5 ± 2.3	9 ± 1.1	3 ± 2.6	0.001
Distance traveled (m)	243 ± 23	312 ± 29	219 ± 53	399 ± 18	< 0.001
HRM in effort test	146 ± 16	150 ± 11	148 ± 12	161 ± 8	0.001

HDL = High density lipoproteins, LDL = Low density lipoproteins, VO_2 = Maximum oxygen consumption, HRM = Maximum heart rate, METs = Metabolic equivalent, TC6M = 6-minute walk test.

DISCUSSION

Endurance exercises aim to increase strength, power and muscular endurance.[32] In addition, physical training causes positive effects on cardiovascular function; since it generates hemodynamic, hormonal, metabolic, neurological and respiratory function changes. Likewise, it helps to mitigate the presence and advances of cardiovascular risk factors, without any effect on cardiovascular mortality, when compared with sedentary patients as mentioned by Powel R et al,[33] whose results agree in a great way with those presented in this investigation.

Likewise, exercise has benefits in patients with heart disease. However, any recommendation for the exercise of these patients should be based on the particular pathology of the person, individual response to the exercise and the measurements obtained during the stress test, which should also contemplate the adaptation to a force test.[34-36]

According to the Australian Institute for Sports, the volume and intensity of exercise recommended will depend on the severity of the syndrome, although it is agreed that in most patients with HF it should consist of a combination of low to moderate intensity aerobic exercise in most days of the week and strength training prescribed individually from low to moderate intensity at least twice a week.[37,38] That is why, the present investigation carried out tests to determine 1RM, estimated VO_2 and MHR of the participants and thus be able to generate a prescription of the individualized exercise according to the needs of the individual. Since strength is shown to be a predictor of cardiovascular, non-cardiovascular mortality, myocardial infarction and stroke in people between 30 and 75 years of age.

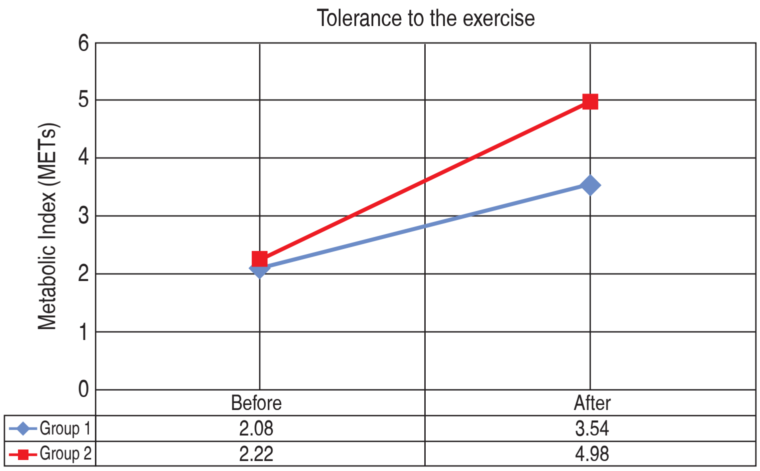


Figure 2: Metabolic index before and after.

Therefore, the methodology used and our results indicate that the unique and universal prescription of the elements that make up the physical exercise of patients with HF (type of exercise, intensity, duration, frequency, progression and recovery) is not possible due to the multiple cardiovascular risk factors and the characteristics of each individual, as well as the diversity of complex alterations that these patients present. However, different studies mention that physical exercise can satisfactorily increase the perception of exercise and improve the symptomatology of individuals with heart failure with reduced and preserved ejection fraction, which, in turn, increases the quality of life.[39,40]

Therefore, we recommend an initial assessment, test and individualized measures and interventions.[41] Currently, guidelines worldwide, developed by experts and current evidence such as the American Heart Association (AHA)[42] and the American Association of Cardiovascular and Pulmonary Rehabilitation (AACVPR)[43] show the general training regulations for heart disease.

There are also consensus and guidelines according to the different areas of the world that contribute to the knowledge of the care of heart patients such as: the Australian Cardiovascular Health and Rehabilitation Association (ACRA)[44-46] in Australia, European Association of Cardiovascular Prevention and Rehabilitation (EACPR)[47] for Europe and in South America the American South Society of Cardiology and the Inter-American Committee on Cardiovascular Prevention.[48] In addition, there are specific countries such as: France,[49] United Kingdom,[50] Ireland,[51] Japan,[52] Canada,[53] England,[54] Germany,[55] Scotland,[56] New Zealand,[57] Netherlands[58] and the United States.[41,59,60] However, all these guidelines conclude that the intervention in cardiac rehabilitation must be accompanied by: aerobic exercise, strength, endurance and flexibility; although to date there is no international consensus on the intensities and frequencies of each intervention, since it varies according to the country, continent or association.[61]

According to the citation of McCartney (2011), in the study by Wenger et al.,[62] they analyzed 12 investigations where 100% of the sample had coronary heart disease. Resistance training was applied for MMSS and MMII with load of 30%-60% of 1RM, there were found benefits in strength and muscular resistance on the study population. This research supports our results as well as those found by Brown J (2001);[63] Bjarnoson B, Mayer W, Meister E et al. (2004);[64] Stiwart K, Franklin BA. (2001)[65] who mention that strength training compared to aerobic exercise, has a greater increase given by mechanisms such as the increase in cardiac output at the expense of heart rate more than the ejection volume.

Similarly, an increase in muscle strength of 21% and 24% was observed in experimental group 2 and control group respectively; without presence of adverse clinical events or intolerance to activity, as in those published by Thibaut G, Labrunée M, Besnier F, et al. (2016),[66] Anderson L et al. (2016);[67] Gayda M, Ribeiro P, Juneau M et al. (2016),[68] Nogueira F, Sousa A, Souza F et al. (2016).[69]

Considering the above mentioned, our results show that strength training with aerobic exercise is necessary in cardiovascular patients, due to its effects on multiple cardiopulmonary variables. These beneficial effects manage to trigger an increase in oxygen consumption and temporarily in the heart rate values associated with sympathetic stimulation, which triggers a progressive increase in catecholamine levels.

Now, the strength-endurance exercise has an important effect on the synthesis of contractile proteins responsible for muscle hypertrophy and strength, in addition to those involved in oxidative metabolism. Although the strength-endurance exercise essentially employs the glycolytic-anaerobic pathway during training, the temporal sequence of use of energy substrates during anaerobic muscle work is sufficient to induce increases in temperature, pH and impact the glycogen deposits of muscles involved in muscle contraction and affect protein synthesis and mitochondrial biogenesis.[70,71] These affirmations were corroborated by Zapata-Lamana R, Cigarroa I, Diaz E et al. (2015).[72]

The evidence suggests that the strength-resistance exercise produces a series of physiological adaptations such as the increase of mitochondrial enzymes, mitochondrial proliferation, conversion of muscle fiber types and vascular remodeling, including capillarization.[73] Therefore, the effects of strength training will depend on the type of muscular work, intensity, time and duration of the program.

Limitations of the study

One of the main limitations of the study, common in this type of research are the multiple variables that exist around the cardiovascular patient. Among them, the pharmacological treatment and the quality of life; which were not included as variables to be evaluated; although inescapably, they fulfill a predominant factor in the cardiovascular response to exercise. In addition, it is important to note that the present investigation used the 6-minute walk test to determine the VO_2 values but, if possible, an ergospirometry or a gas analysis, would be ideal for the investigation.

CONCLUSIONS

It was possible to demonstrate greater benefits in the patients who were given aerobic training plus strength training in lower limbs compared to the aerobic training group plus strength training in upper limbs.

Aerobic training combined with strength exercises is effective as long as an adequate assessment, prescription and monitoring of the exercise is carried out, safely carrying more activities of daily life, leisure and work; as well as giving greater and better social and family integration to patients with cardiovascular disorders.

REFERENCES

1. Mathers CD, Loncar D. Updated projections of global mortality and burden of disease, 2002-2030: data sources, methods and results. WHO. 2005; 1-130.
2. Capewell S, Ford E, Croft J, Critchley J, Greenlund K, Labarthec D. Cardiovascular risk factor trends and potential for reducing coronary heart disease mortality in the United States of America. Bulletin of the World Health Organization. 2010; 88: 120-130.
3. National Center for Health Statistics. Mortality multiple cause micro-data files. (2014): public use data file and documentation: NHLBI tabulations. [Internet] [Último ingreso 05 February 2018] http://www.cdc.gov/nchs/data_access/Vitalstatsonline.
4. Ford ES, Ajani UA, Croft JB, Critchley JA, Labarthe DR, Kottke TE et al. Explaining the decrease in U.S. deaths from coronary disease, 1980-2000. N Engl J Med. 2007; 356: 2388-2398.
5. Heidenreich PA, Trogdon JG, Khavjou OA, Butler J, Dracup K, Ezekowitz MD et al. American Heart Association Advocacy Coordinating Committee; Stroke Council; Council on Cardiovascular Radiology and Intervention; Council on Clinical Cardiology; Council on Epidemiology and Prevention; Council on Arteriosclerosis; Thrombosis and Vascular Biology; Council on Cardiopulmonary; Critical Care; Perioperative and Resuscitation; Council on Cardiovascular Nursing; Council on the Kidney in Cardiovascular Disease: A policy statement from the American Heart Association. Circulation. 2011; 123: 933-944.
6. Benjamin EJ, Blaha MJ, Chiuve SE, Cushman M, Das SR, Deo R et al. Representación del Comité de Estadísticas y del Subcomité de Estadísticas de Ataque Cerebral de la American Heart Association. Estadísticas de enfermedad cardiaca y de ataque cerebral -información actualizada para 2017: un informe del American Heart Association Circulation. 2017; doi: 10.1161/CIR.0000000000000485.
7. Piepoli MF, Davos C, Francis DP, Coats AJ. ExTraMATCH Collaborative. Exercise training meta-analysis of trials in patients with chronic heart failure (ExTraMATCH). BMJ. 2004; 328: 189-193.
8. Komasi S, Saeidi M, Montazeri N, Masoumi M, Soroush A, Ezzati P. Which factors unexpectedly increase depressive symptom severity in patients at the end of a cardiac rehabilitation program? Ann Rehabil Med. 2015; 39 (6): 872-879.
9. Heydarpour B, Saeidi M, Ezzati P, Soroush A, Komasi S. Sociodemographic predictors in failure to complete outpatient cardiac rehabilitation. Ann Rehabil Med. 2015; 39 (6): 863-871.
10. Márquez J, Suárez G, Márquez J. Beneficios del ejercicio en la insuficiencia cardiaca. Rev Chil Cardiol. 2013; 32: 58-65.

11. Mcmurray J, Adamopoulos S, Anker SD, Auric-Chio A, Bohm M, Dickstein K et al. ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure 2012: The Task Force for the Diagnosis and Treatment of Acute and Chronic Heart Failure 2012 of the European Society of Cardiology. Developed in collaboration with the Heart Failure Association (HFA) of the ESC. Eur Heart J England. 2012; 33: 1787-1847.
12. Hulsmann M, Quittan M, Berger R, Crevenna R, Springer C, Nuhr M et al. Muscle strength as a predictor of long-term survival in severe congestive heart failure. Eur J Heart Failure. 2003; 6: 101-107.
13. Minotti JR, Pillay P, Oka R, Wells L, Christoph I, Massie BM. Skeletal muscle size: relationship to muscle function in heart failure. J Appl Physiol. 1993; 75 (1): 373-381.
14. Mancini DM, Walter G, Reichek N, Lenkinski R, McCully KK, Mullen JL et al. Contribution of skeletal muscle atrophy to exercise intolerance and altered muscle metabolism in heart failure. Circulation. 1992; 85 (4): 1364-1373.
15. Braith RW, Magyari PM, Pierce GL, Edwards DG, Hill JA, White LJ et al. Effect of resistance exercise on skeletal muscle myopathy in heart transplant recipients. Am J Cardiol. 2005; 95 (10): 1192-1198.
16. Leong D, Teo K, Rangarajan S, Lopez-Jaramillo P, Avezum A, Orlandini A. Prognostic value of grip strength: findings from the Prospective Urban Rural Epidemiology (PURE) study. 2015; [Publicado online el Mayo 14] http://dx.doi.org/10.1016/S0140-6736(14)62000-6.
17. Najafi F, Nalini M. Hospital-based versus hybrid cardiac rehabilitation program in coronary bypass surgery patients in western Iran: effects on exercise capacity, risk factors, psychological factors, and quality of life. J Cardiopulm Rehabil Prev. 2015; 35: 29-36.
18. García-Hermoso A, Cavero-Redondo I, Ramírez-Vélez R, Ruiz J, Ortega FB, Lee DC et al. Muscular strength as a predictor of all-cause mortality in apparently healthy population: a systematic review and meta-analysis of data from approximately 2 million men and women, Archives Of Physical Medicine And Rehabilitation. Arch Phys Med Rehabil. 2018; 99 (10): 2100-2113. e5. doi: 10.1016/j.apmr.2018.01.008.
19. Giuliano C, Karahalios A, Neil C et al. The effects of resistance training on muscle strength, quality of life and aerobic capacity in patients with chronic heart failure — A meta-analysis. Int J Cardiol. 2017; 15 (227): 413-423. DOI:10.1016/j.ijcard.2016.11.023.
20. Smart N, Marwick TH. Exercise training for patients with heart failure: a systematic review of factors that improve mortality and morbidity. Am J Med. 2004; 116: 693-706.
21. Wisloff U, Stoylen A, Loennechen J, Bruvold M, Rognmo O, Haram PM et al. Superior cardiovascular effect of aerobic interval training versus moderate continuous training in heart failure patients: a randomized study. Circulation. 2007; 115: 3086-3094.
22. Adamo ML, Farrar RP. Resistance training, and IGF involvement in the maintenance of muscle mass Turing the aging process. Ageing Res Rev. 2006; 5: 310-331.
23. Verdijk LB, Koopman R, Schaart G, Meijer K, Savelberg HH, Van Loon LJ. Satellite cell content is specifically reduced in type II skeletal muscle fibres in the elderly. Am J Physiol Endocrinol Metab. 2007; 292: 151-157.
24. Jones TE, Stephenson KW, King JG, Knight KR, Marshall TL, Scott WB. Sarcopenia mechanisms and treatments. J Geriatr Phys Ther. 2009; 32: 83-89.
25. Thompson LV. Age-related muscle dysfunction. Exp Gerontol. 2009; 44: 106-111.
26. Frisancho R. Anthropometric standard for the assessment of growth and nutritional status. Chapter II: Methods and materials. Ann Arbor: University of Michigan Press. 1993, p.p. 9-31.
27. Buendia R, Zambrano M, Diaz A, Reino A, Ramirez J, Espinosa E. Puntos de corte de perímetro de cintura para el diagnóstico de obesidad abdominal en población colombiana usando bioimpedanciometría como estándar de referencia. Rev Colomb Cardiol. 2016; 23 (1): 19-25.
28. Fett CA, Fett WCR, Marchini JS. Circuit weight training vs. jogging in metabolic risk factors of overweight/obese women. Arq Bra Cardiol. 2009; 93: 519-525.
29. Enright P, Sherrill D. Reference Equations for the Six-Minute Walk in Healthy Adults. Am J Respir Crit Care Med. 1998; 158: 1384-1387.
30. American Thoracic Society. ATS statement: guidelines for the six-minute walk test. Am J Respir Crit Care Med. 2002; 166: 111-117.
31. De las Cuevas C, Garcia-Estrada A, Gonzalez J. Hospital anxiety and depression scale y psicopatología afectiva. AN. Psiquiatría. 1995; 11 (4): 126-130.
32. Fletcher B, Magyari P, Prussak K, Churilla C. Entrenamiento físico en pacientes con insuficiencia cardíaca. Rev Med Clin Condes. 2012; 23 (6): 757-765.
33. Powel R, McGregor G, Ennis S, Kimani P, Underwood M. Is exercise-based cardiac rehabilitation effective? A systematic review and meta-analysis to re-examine the evidence. BMJ Open. 2018; 8: e019656. doi:10.1136/bmjopen-2017-019656.
34. Corra U, Piepoli MF, Carre F, Heuschmann P, Hoffmann U, Verschuren M et al. Secondary prevention through cardiac rehabilitation: Physical activity counselling and exercise training: Key components of the position paper from the cardiac rehabilitation section of the European Association of cardiovascular prevention and rehabilitation. Eur Heart J. 2010; 31: 1967-1974.
35. Pozo P, González G. La prescripción del ejercicio de fuerza en la insuficiencia cardíaca crónica: una revisión del estado actual de la situación. Enferm Cardiol. 2012; XIX (55-56): 17-21.
36. Thomas RJ, Balady G, Banka G et al. 2018 ACC/AHA Clinical Performance and Quality Measures for Cardiac Rehabilitation. J Am Coll Cardiol. 2018; 71 (16): 1814-1837. doi: 10.1016/j.jacc.2018.01.004.
37. Selig SE, Levinger I, Williams AD, Smart N, Holland DJ, Maiorana A et al. Exercise & Sports Science Australia Position Statement on exercise training and chronic heart failure. J Sci Med Sport. 2010; 13 (3): 288-294.
38. Kitzman DW, Haykowsky MJ. Invited editorial commentary for American Heart Journal mechanisms of exercise training in heart failure with preserved ejection fraction: Central disappointment and peripheral promise. Am Heart J. 2012; 164: 807-809.
39. Kitzman DW, Brubaker PH, Herrington DM et al. Effect of endurance exercise training on endothelial function and arterial stiffness in older patients with heart failure and preserved ejection fraction: a randomized,

controlled, single-blind trial. J Am Coll Cardiol. 2013; 62: 584-592.
40. Kitzman DW, Brubaker PH, Morgan TM et al. Exercise training in older patients with heart failure and preserved ejection fraction: a randomized, controlled, single-blind trial. Circ Heart Fail. 2010; 3: 659-667.
41. Pereira Rodríguez J, Rincón González G, Niño Serrato D. Insuficiencia cardíaca: aspectos básicos de una epidemia en aumento. CorSalud 2016; 8 (1): 58-70.
42. Balady GJ, Williams MA, Ades PA et al. Core components of cardiac rehabilitation/secondary prevention programs: 2007 update: a scientific statement from the American Heart Association Exercise, Cardiac Rehabilitation, and Prevention Committee, the Council on Clinical Cardiology; the Councils on Cardiovascular Nursing, Epidemiology and Prevention, Physical Activity, and the American Association of Cardiovascular and Pulmonary Rehabilitation. Circulation. 2007; 115: 2675-2682.
43. American Association of Cardiovascular and Pulmonary Rehabilitation. Guidelines for Cardiac Rehabilitation and Secondary Prevention Programs, 5th ed. Champaign, IL: Human Kinetics, 2013.
44. Goble AJ, Worcester MUC. Best Practice Guidelines for Cardiac Rehabilitation and Secondary Prevention. Carlton, Australia: Department of Human Services Victoria. 1999; Available in: http://www.rehabilitacioncardiaca.org/files/Guideli nes_Rehabilitation_Australia_0.pdf (Último ingreso 13 Marzo 2018).
45. Woodruffe S, Neubeck L, Clark RA. Australian Cardiovascular Health and Rehabilitation Association (ACRA) core components of cardiovascular disease secondary prevention and cardiac rehabilitation 2014. Heart Lung Circ. 2015; 24: 430-441.
46. NSW Department of Health. NSW Chronic Care Program: Implementing Rehabilitation for Chronic Disease – Volume 2. Sydney: NSW Department of Health. 2006; [Último ingreso 13 marzo 2018] Available in: http://www1.health.nsw.gov.au/pds/ActivePDSDocuments/GL2006_02 2.pdf.
47. Piepoli MF, Corra U, Benzer W et al. Secondary prevention through cardiac rehabilitation. Eur J Cardiovasc Prev Rehabil. 2010; 17: 1-17.
48. Herdy AH, Lopez-Jimenez F, Terzic CP. South American guidelines for cardiovascular disease prevention and rehabilitation. Arq Bras Cardiol. 2014; 103: 1-31.
49. Pavy B, Iliou MC, Verges-Patois B. French Society of Cardiology guidelines for cardiac rehabilitation in adults. Arch Cardiovasc Dis. 2012; 105: 309-328.
50. British Association for Cardiovascular Prevention and Rehabilitation. The BACPR Standards and Core Components for Cardiovascular Disease Prevention and Rehabilitation 2012. 2nd ed. London: British Cardiovascular Society. Available in: http://www.bacpr.com/resources/46C_BACPR_Standards_and_Core_Components_2012.pdf [Último ingreso 13 March 2018].
51. McCreery C, Cradock K, Fallon N, et al. Cardiac Rehabilitation Guidelines 2013. Dublin: Irish Association of Cardiac Rehabilitation. 2013; Available in: http://www.iacr.info/wp-content/uploads/2015/03/IACR-Guidelines 2013.pdf [Último ingreso 14 Marzo 2018].
52. Japanese Circulation Society Joint Working Group. Guidelines for rehabilitation in patients with cardiovascular disease. Circ J. 2014; 78: 2022-2093.
53. Stone JA, Arthur H, Suskin N. Canadian Guidelines for Cardiac Rehabilitation and Cardiovascular Disease Prevention: Translating Knowledge into Action, 3rd ed. Winnipeg, Canada: Canadian Association of Cardiac Rehabilitation, 2009.
54. Strategic Commissioning Development Unit. Service Specification for Cardiac Rehabilitation Services. London: Department of Health England. 2016. [Último ingreso 14 Marzo 2018] Available in https://www.england.nhs.uk/wp-content/uploads/2016/07/HLCF.pdf
55. Bjarnason-Wehrens B, Mayer-Berger W, Meister ER et al. Recommendations for resistance exercise in cardiac rehabilitation. Recommendations of the German Federation for Cardiovascular Prevention and Rehabilitation. Eur J Cardiovasc Prev Rehabil. 2004; 11: 352-361.
56. Rehabilitation: A National Clinical Guideline. Edinburgh: Scottish Intercollegiate Guidelines Network. 2002. [Último ingreso 15 Marzo 2018] Available in: http://www.scotphn.net/wp-content/uploads/2015/ 11/Cardiac_Rehabilitation.pdf.
57. Heart Foundation and New Zealand Guidelines Group. Evidence-Based Best Practice Guideline: Cardiac Rehabilitation. Wellington: New Zealand Guideline Group. 2009 [Último ingreso 15 Marzo 2018] Available in: http://www.moh.govt.nz/NoteBook/nbbooks.nsf/0/9874D7743DE4CCA9CC2579E2007E4FA2/$file/cardiovascular-guidelines-handbook.pdf.
58. Royal Dutch Society for Physical Therapy. KNGF clinical practice guideline for physical therapy in patients undergoing cardiac rehabilitation. Dutch J Phys Ther. 2011; 121: 1-47.
59. American Association of Cardiovascular and Pulmonary Rehabilitation. Guidelines for Cardiac Rehabilitation and Secondary Prevention Programs 5th Edition With Web Resource. Champaign, IL: Human Kinetics. 2013. [Último ingreso 20 marzo 2017] Available in: http://www.humankinetics.com/products/all-products/guidelines-for-cardiac-rehabilitation -and-secondary-prevention-programs-5th-edition-with-web-resource.
60. Williams MA, Haskell WL, Ades PA, 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. Circul. 2007; 116: 572-584.
61. Price K, Gordon B, Bird S, Benson A. A review of guidelines for cardiac rehabilitation exercise programmes: Is there an international consensus? Eur J Prev Cardiol. 2016; 23 (16): 1715-1733.
62. McCartney. The safety of resistance training: hemodinamic factors and cardiovascular incidents. In: Graves JE, Franklin BA. Resistance training for health and rehabilitation. USA: Human Kinetics, 2001, p.p. 83-93.
63. Brown J. Metabolic, cardiovascular, pulmonary and endocrine responses and adaptation to resistance exercise. In: Graves JE, Franklin BA. Resistance Training for Health and Rehabilitation. USA: Human Kinetics; 2001; p.p. 33-60.

64. Bjarnoson B, Mayer W, Meister ER et al. Recommendations for resistance exercise in cardiac rehabilitation. Recommendation of the German Federation for cardiovascular prevention and rehabilitation. Eur J Cardiovasc Prev Rehabil. 2004; 11: 352-361.
65. Stiwart K, Franklin BA. Resistance training in patients with coronary heart disease. In: Graves JF, Franklin BA. Resistance training for health and rehabilitation. Champaign, Ill.: Human Kinetics. 2001, p. 217-235.
66. Guiraud T, Labrunée M, Besnier F et al. Whole-body strength training with Huber Motion Lab and traditional strength training in cardiac rehabilitation: A randomized controlled study. Ann Phys Rehabil Med. 2017; 60 (1): 20-26. DOI:10.1016/j.rehab.2016.07.385
67. Anderson L, Thompson DR, Oldridge N, Zwisler AD, Rees K, Martin N et al. Exercise-based cardiac rehabilitation for coronary heart disease. Cochrane Database Syst Rev. 2016; 1: CD001800.
68. Gayda M, Ribeiro P, Juneau M, Nigam A. Comparison of different forms of exercise training in patients with cardiac disease: where does high-intensity interval training fit? Can J Cardiol. 2016; 32 (4): 485-94.
69. Nogueira F, Sousa A, Souza F, Pinto V, Silva P, Saraiva R. Effect of physical exercise training in patients with Chagas heart disease: study protocol for a randomized controlled trial (PEACH study). Trials. 2016; 17: 433.
70. Gibala M, Little J, Maureen J, MacDonald M, Hawley J. Physiological adaptations to low-volume, high-intensity interval training in health and disease. J Physiol. 2012; 590: 1077-1084.
71. Wang L, Sahlin K. The effect of continuous and interval exercise on PGC-1a and PDK4 mRNA in type I and type II fibres of human skeletal muscle. Acta Physiologica. 2012; 204: 525-532.
72. Zapata-Lamana R, Cigarroa I, Diaz E et al. Efectos del entrenamiento fuerza-resistencia en el control de glucosa y función muscular en mujeres adultas sedentarias de Los Ángeles, Chile. Rehabilitación (Madr). 2015; 49 (4): 202-209.
73. Steele J, Fisher J, McGuff D, Bruce-Low S, Smith D. Resistance training to momentary muscular failure improves cardiovascular fitness in humans: a review of acute physiological responses and chronic physiological adaptations. JEP online. 2012; 15: 53-80.

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