Benefits of Exercise Training in the Treatment of Heart Failure. Study with a Control Group

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Objective - *Exercise training programs have been proposed as adjuncts to treatment of heart failure. The effects of a 3-month-exercise-training-program with 3 exercise sessions per week were assessed in patients with stable systolic chronic heart failure.*

Methods - *We studied 24 patients with final left ventricle diastolic diameter of 70±10mm and left ventricular ejection fraction of 37±4%. Mean age was 52±16 years. Twelve patients were assigned to an exercise training group (G1), and 12 patients were assigned to a control group (G2). Patients underwent treadmill testing, before and after exercise training, to assess distance walked, heart rate, systolic blood pressure, and double product.*

Results - *In G2 group, before and after 3 months, we observed, respectively distance walked, 623±553 and 561± 460m (ns); peak heart rate, 142±23 and 146± 33b/min (ns); systolic blood pressure, 154±36 and 164±26 mmHg (ns); and double product, 22211± 6454 and 24293±7373 (ns). In G1 group, before and after exercise, we observed: distance walked, 615±394 and 970± 537m (p<0.003) peak heart rate, 143±24 and 143±29b/min (ns); systolic blood pressure, 136±33 and 133±24 mmHg (ns); and double product, 19907± 7323 and 19115±5776, respectively. Comparing the groups, a significant difference existed regarding the variation in the double product, and in distance walked.*

Conclusion – *Exercise training programs in patients with heart failure can bring about an improvement in physical capacity.*

Key words: exercise training, exercise, heart failure

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Heart failure is currently an important public health problem. One percent of the population is estimated to have it and 1/5 die every year, at the ratio of 3/1,000 inhabitants/year. In the United States, heart failure occurs in about 2.2 million people, and contributes to over 500 thousand s hospitalizations and, approximately, 250 thousand deaths every year [1,2]. In the State of Mato Grosso, these values represent an average of 9,000 hospitalizations and 350 deaths annually, according to Sistema Único de Saúde (Single Health System) (Secretaria Estadual de Saúde do Mato Grosso) (State Health Ministry).

Despite the progress in the treatment of heart failure, high mortality and morbidity still occur [3]. Exercise training programs are among the recommended procedures to reduce morbidity and, in some situations, mortality [4-6]. Generally, procedures, which are not always available, and are expensive and complex are used for individual assessment of the benefits of the programs, such as ergospirometry, among others. This has limited their broad use in the community. On the other hand, in our community, no investigations have been performed and published about the beneficial role of exercise training programs in patients with heart failure apart from isolated cases, without a control group. Cultural factors and patients'own characteristics, such as age, ethnicity, etc., could influence possible beneficial results.

The objective of this investigation was to study the effect of exercise on the physical capacity of patients with heart failure, using a program of easy application and low cost in the community instead of complex investigations.

Methods

The investigation was performed from October 1997 to March 1999, at the ambulatory cardiology unit of the Hospital Universitário Júlio Müller (HUJM), at the Universidade Federal de Mato Grosso (Federal University of Mato Grosso), and at the Instituto de Cardiologia do Mato Grosso (Institute of Cardiology of Mato Grosso). Patients were referred primarily from 3 screening services, the University

Hospital Júlio Müller, Cardiology Institute of Mato Grosso, and Posto de Saúde do Bairro Osmar Cabral (Public health service of Osmar Cabral Court).

All patients who were sent to the cardiology ambulatory unit had on echocardiography final left ventricle diastolic diameter ≥ 60mm and ejection fraction ≤45%, with signs and symptoms of heart failure. They were invited to take part in the study by the cardiologist as long as they did not have any of the exclusion criteria, which were clinical instability in the last 3 months, uncontrolled atrial or ventricular arrhythmia, myocardial infarction in the last 3 months, angina or any other manifestation of ischemia, hypertrophic myocardiopathy, restrictive myocardiopathy, cardiopathy that required surgical correction, pulmonary disease, primary valvulopathy, associated disease involving the ability to exercise, blood hypertension, and difficulty in complying with the protocol. Of the 35 patients selected, 24 (18 men and 6 women) agreed to take part in the research and were sent to the Cardiology Institute of Mato Grosso to undergo investigation for diagnosis, improvement of the available therapeutics, and treadmill testing. Afterwards, they were sent to the physical trainer to develop the study. Patients' characteristics are found in table I. All patients gave their written consent to take part in the study, approved by the ethics committee of the Federal University of Mato Grosso. Medication remained unchanged during the application of the exercise program in both groups.

The 24 patients in the study were randomly assigned to 2 different groups: group 1 was formed by 12 patients undergoing the exercise-training program, and group 2 was formed by 12 patients who were not undergoing the exercise-training program. Both groups were followed equally by the same treatment team, except regarding the training. Selection of groups was performed using systematic probability sampling [7]. Groups were comparable in their characteristics (tab. I). We determined in both groups at the beginning of the investigation and at the end of the training period maximum distance walked on the treadmill (in meters), heart rate (in b/min) at rest and at peak exercise, systolic blood pressure at rest and at peak exercise (in mmHg), and calculation of double product (systolic blood pressure x heart rate).

The treadmill protocol used to assess patients was the modified *Naugthon* [8]. We used the electric treadmill *Ecafix,* model EG 700X, for the treadmill test, connected to an *Acer Mate* computer, with the program *Ecafix cardio perfect* (*Ecafix* 3-4 ST), model number A25374, with continuous monitoring of heart rate and of an electrocardiogram. Blood pressure was assessed with the auscultatory method with a mercury column sphygmomanometer. After 2 minutes in the upright position without exercise, patients were encouraged to perform exercises until symptoms (fatigue or dyspnea) made them unable to continue the test.

The exercise training program of patients lasted 3 months, at 3 times a week. Each session lasted 30 to 60 minutes [9-11]. Exercises were performed at the Hospital Santa Cruz during the morning.

Based on the results obtained on the initial treadmill test, exercise training was programmed over the 3 months on an individual basis for each patient. It was a specific exercise-training program, seeking to establish an intensity of variable work at 60% to 80% of the peak heart rate [12-17]. The intensity of the exercises was controlled and monitored through a cardiac monitor, *Polar* model Accurox, programmed for the patient to walk at a target heart rate. Target heart rate was assessed with the Karvonem formula, where values of peak heart rate found on the treadmill test and of heart rate at rest of patients are also present, ie, target heart rate = % of work x (peak heart rate – heart rate at rest) + heart rate at rest. We tried to reach the percentage estimated at training in relation to peak heart rate assuring that it was in the ideal intensity and was not below or above the programmed intensity, assuring, therefore, greater safety. The machine set off an alerting device automatically. In addition to heart rate monitoring, the intensity of exercises was assessed with the Borg scale for rating of effort [14,18,19]. The exercise training method used was at intervals [18-21].

Exercise training consisted of walks and localized exercises in the arms and extensions of upper and lower limbs, with their own resistance (arms, legs, and trunk) or with external resistance (dumb-bell) with performance of isotonic contractions (contraction and relaxation of skeletal muscle). These had the purpose of complementing the walking exercises, and also the stretching exercises of the great muscle groups and flexibility of the main joints (shoulder, elbow, hips, knees, and ankle) of the body [11,18].

During the exercise training program and with the improvement of patients' conditioning, some programs had

Table I - Characteristics of the patients who did and did not participate in the exercise-training program in the beginning of the investigation

Variable	Exercise training	Control group
Age (years)	48 ± 14	56 ± 16
Gender (M/F)	9/3	9/3
Functional Class-pts	I- 4. II- 4. III- 4	I- 3. II- 6. III- 3
Medication (%)		
Diuretics	75	67
ACE inhibitor	67	67
Digitalis	83	75
Antiarrhythmic drugs	8	17
Potassium chloride	33	42
Etiology (%)		
Ischemic	33.3	16.7
Enlarged idiopathic	16.7	16.7
Hypertensive	16.7	41.7
Chagasic	25	16.7
Valvular	8.3	8.3
FLVDD (mm) (mean)	70	68
Distance (m)	615.3	623.9
SBP at rest (mmhg)	107.9	121.7
Double product	19906.7	22045.8
HR at rest (b/min)	82.2	81.2
LVEF (%)	38.1	37.3

ACE - angiotensin conversion enzyme - LVEF- left ventricle ejection fraction; FLVDD- final left ventricle diastolic diameter on echocardiogram; HR- heart rate at rest; distance, meters walked in treadmill test; SBP- systolic blood pressure in mmHg; Double product, heart rate x systolic blood pressure.

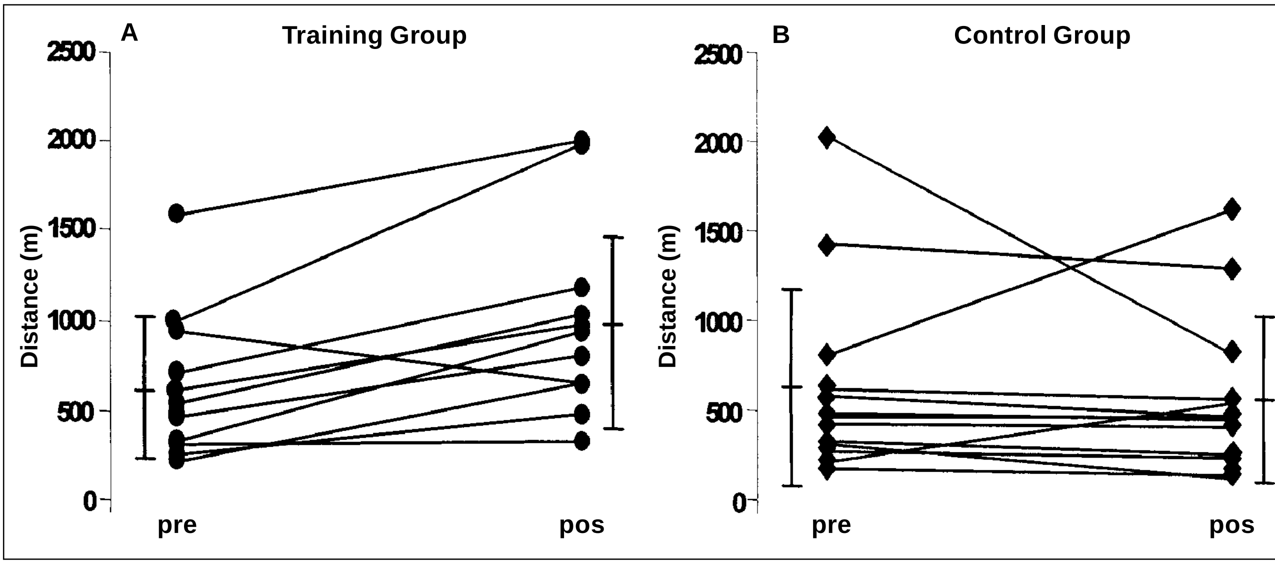

Fig. 1 - Distance walked before (Pre) and after 3 months in the exercise training group (a) and in the control group (b).

some alterations. For example, in performance, the patient increased walking speed (intensity), or increased distance walked (training volume) (1) gradually increasing exercise length up to 60 minutes and (2) increasing the percentage of workload, also gradually, up to 80% of the maximum heart rate [19,20].

Analysis of the comparison of the variation percentages between the groups was performed using the nonparametric Mann-Whitney test [9].

Studies of distance walked, heart rate, and double product were performed with the multivariate analysis of mean profiles in both groups of patients with heart failure (control and exercise group). Assessments were made at 2 different times (beginning of the study and in the end of the study), and we observed the similarity regarding the mean profile of the groups, effects of the groups at the beginning and at the end, and the effects of the initial and final moment in each group [21]. Discussion of data obtained through statistical analysis was performed at 5% significance [21].

The group comparison was performed at the beginning of the exercise training program, through the variables age, calculated using the nonparametric Mann-Whitney test, and gender, calculated using the Goodman test, for contrast of multinomial populations [10].

Results

In G2 group, the distance walked at the beginning of the study and after 3 months was 624±553m and 561±460m, respectively, with a variation of –17±86% (p=ns). In G1 group, the distance walked at the beginning of the study and after 3 months was 615±394m and 970±537m, respectively (p<0.003), with a variation of 76±71% (fig. 1).

Of the 12 patients in G1, 11 increased distance walked at the end of the program in comparison with the beginning. In G2 group, only 2 patients were able to increase the distance walked and the other 10 decreased the distance walked in comparison with the beginning.

In the control group, heart rate at rest in the beginning of the study and after 3 months was 82±13 and 87±16, respectively (p<0.05), with a variation of 7±20%. In G1 group, heart rate at rest in the beginning of the study and after 3 months was 82±15 and 78±14, respectively (p<0.05), with a variation of –8±-29% (fig. 2). In G2 group, heart rate at peak exercise at the beginning of the study and after 3 months was 142±23 and 146±33, respectively (p=ns), with a variation of 3±25%. In G1, heart rate at peak exercise at the beginning of the study and after 3 months was 143±24 and 143±29, respectively, with a variation of –0.02±25% (p=ns) (fig. 3).

Although variation in peak heart rate was not statistically different in G1, it decreased on average 15bpm after 3 months of training in 7 of the 12 patients, whereas in G2, it increased in 8 patients.

In G2, double product at rest at the beginning of the study and after 3 months was 9767±1452 and 11102±3012, respectively, with a variation of 12±24% (p=ns). In the exercise training group, double product at rest at the beginning of the study and after 3 months was 8885±1991 and 8269±1729, respectively (p<0.05), with a variation of –8.47±23.50%. In G2, double product at the beginning at peak exercise and after 3 months was 22046±6309 and 24293±7373, respectively, with a variation of 17±68%. In G1, double product at peak exercise at the beginning of the study and after 3 months was 19907±7323 and 19115±5776, respectively, with a variation of –19±27% (fig. 4).

In G2, 8 patients had a mean increase of 6295 of the double product, whereas in G1, 10 patients had decreases in double product of 3984.

At peak exercise in G2, distance walked/maximum exercise heart rate ratio before and after the 3 months was, respectively, 4.5±4.2 and 3.9±3.3m/b/min^{-1}(p=ns) (fig. 5). At

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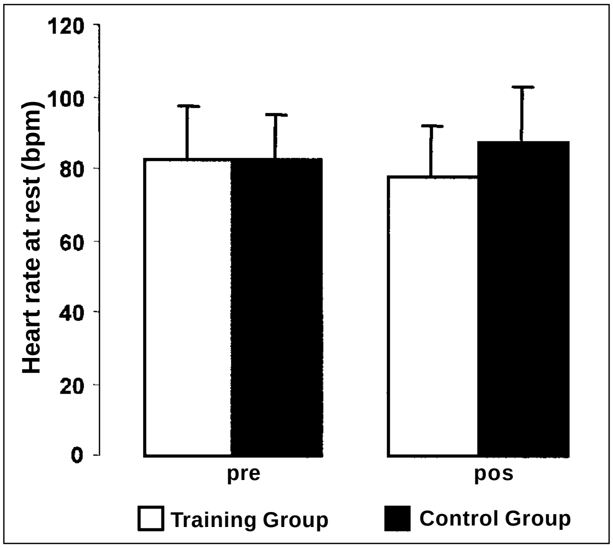

Fig. 2 - Heart rate at rest before (Pre) and after 3 months in the exercise group (a) and in the control group (b).

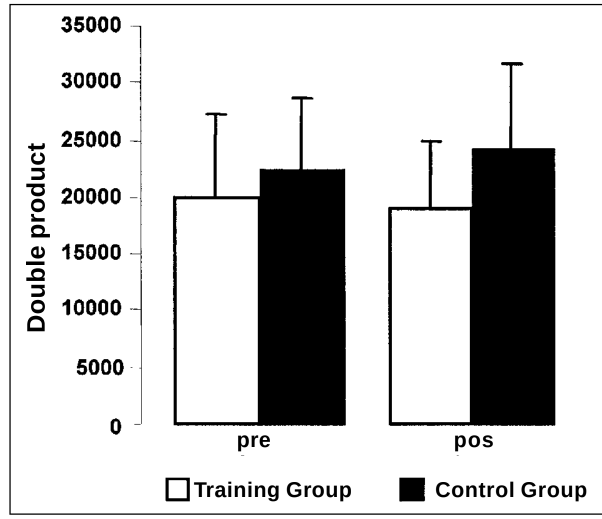

Fig. 4 - Double product at rest and exercise before (Pre) and after 3 months in the exercise group (a) and in the control group (b).

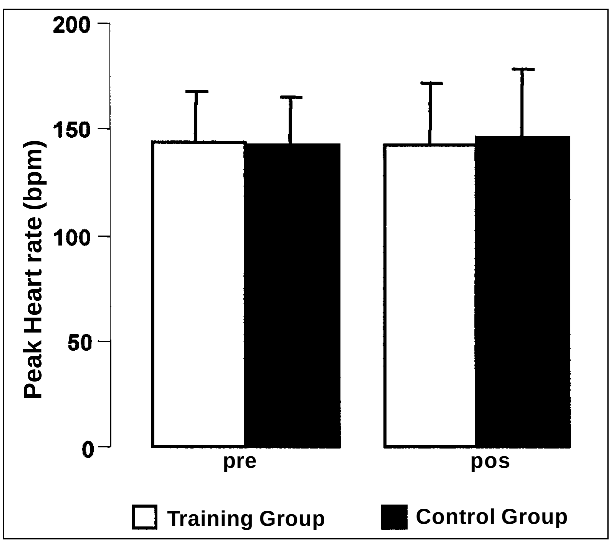

Fig. 3 - Peak exercise heart rate before (Pre) and after 3 months in the exercise training group (a) and in the control group (b).

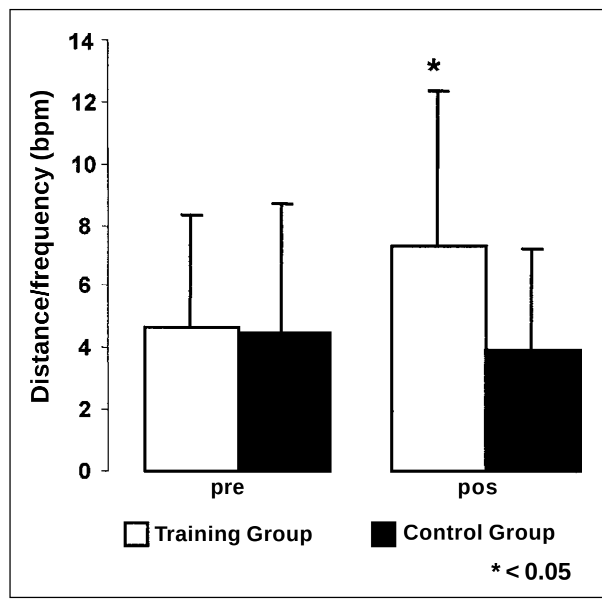

Fig. 5 - Distance walked/heart rate ratio before (Pre) and after 3 months in the exercise group and in the control group.

peak exercise in G1, the distance walked/maximum exercise heart rate ratio before and after the training period was, respectively, 4.6±3.7 and 7.3±4.9m/b/min^{-1}($p<0.0003$).

During the study period, 5 patients from G1 changed NYHA Functional Class, and at the end of the exercise training program, patients were classified as the following Functional Classes: 8 were Class I, 2 were Class II and 2 were Class III. In G2, 2 patients required hospital admission and 1 patient died. In the exercise group, none of the patients required hospital admission or died.

Discussion

Our results demonstrate that a simple and easy to apply exercise program can increase distance walked during exercise, reduce double product at peak exercise, and increase distance walked/heart rate ratio in patients with heart failure, in comparison with the control group. Treadmill assessment of exercise benefit is also possible in heart failure. Application of the program was safe, had high compliance, and the exercise group had fewer occurrences of events.

The increase in distance walked in the exercise group, together with greater effort tolerance and improvement in physical capacity, is similar to the results published by other authors, despite the small number of patients with an ischemic etiology, in our investigation [22-25]. Increase in exercise load was similar to that described by Wielenga et al [25], Tyni-Lenné et al [26], Belardinelli [27], and Oliveira et al [28]. Our exercise-training program was also similar to that reported by Wielenga et al [25], Tyni-Lenné et al [26], who used aerobic programs with local exercises. We believe that these results are due to the increase in muscle mass, greater peripheral blood flow during exercise, metabolic alterations, including improvement in the oxidative capacity of skeletal muscles, histology and biochemical alterations, as well as improvement in ergoreflex [28-30]. An increase also occurred in local strength and aerobic metabolism efficacy, because these patients have fatigue and effort intolerance as limiting factors [31,32]. Additionally, aerobic training enhances physical capacity, peak oxygen consumption, peak voluntary ventilation, and respiratory efficacy. As previously shown, distance walked is a marker of a worse prognosis and worse clinical condition, and it is possible that an increase in distance walked is accompanied by a reduction in patients' mortality, especially those with an ischemic etiology and improvement in quality of life. The several mechanisms from which training in the ischemic group may reduce mortality include development of collateral circulation, reduction in neuro-hormonal and anti-inflammatory activity, alteration of vascular complacence, increase in HDL-cholesterol and improvement in lipid profile, reduction of other risk factors for coronary disease, increased number of hospital visits, and greater compliance with treatment protocols [28,33-36].

Our data on heart rate with exercise are similar to those published by other authors [29,37]. Peak heart rate in our study was similar to that described by Oliveira et al [28]. The explanation for the uniformity in the results of heart rate seems to be the similarity in Functional Class of patients with heart failure. In the exercise training program, heart rate is the same to that reported by Coats et al [14], Sullivan et al [36], and Shephard et al [37], who used similar exercise training programs. As already reported, patients who took part in the aerobic exercise training tolerated a greater workload without increasing peak heart rate. The mechanism, which could explain the reduction in heart rate to the same workload, is probably the increase in vagal tonus and reduction in catecholamine levels with a reduction in sympathic tonus and baroreflex improvement, and greater R-R variability [39,40].

The decrease in double product with exercise was similar to that reported by other authors [40]. Uniformity of results is expected, once the population was similar and the responses were chronotropic, and blood pressure was similar. However, it was different from that reported by Shephard et al [37], which included changes in quality of life determined by the analysis of emotional alterations, fatigue, or dyspnea. The mechanisms by which exercise decreases double product is through a gain in physical capacity, causing a decrease in heart rate, without increasing blood pressure, probably because peripheral blood flow is increased and a tendency exists for vascular resistance to decrease during exercise, enhancing the number of capillaries and reducing fiber/capillary ratio [40].

The limitations of this study are the small number of patients, short follow-up period, and the different etiology of the patients with heart failure, even taking into account the significant results. A short follow-up period does not show if and how the beneficial effects are maintained over time; however, the simplicity of our method enables a high compliance rate with the treatment, which is probably the great limitation of these long-term protocols.

The present study shows the possibility of applying and developing with benefits a simple program of exercise training at health institutions, with possibilities of monitoring results. Exercise-training programs can promote beneficial psychological effects and a better quality of life.

In conclusion, exercise-training programs are rarely recommended in the community for patients with heart failure, due to fear of worsening of the symptoms during exercise. Our results are the first to demonstrate, in our community, through random study and a control group that exercise-training programs can enhance physical capacity in patients with heart failure, which is shown by the increased distance walked. The reduction in heart rate could indicate a decrease in neuro-hormonal activation. It has not been determined if increased physical capacity is associated with a better prognosis; however, the small number of adverse events in the exercise group is cause for optimism. Clinical benefits, if confirmed by other studies in our community, could indicate that exercise- training programs must be routinely applied in select patients with heart failure.

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