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Randomized and comparative study between two intra-hospital exercise programs for heart transplant patients

Estudo randomizado e comparativo entre dois programas de exercícios intra-hospitalares para pacientes de transplante de coração

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Abstract

Objective: **To compare the effects of two physical therapy exercise in-hospital programs in pulmonary function and functional capacity of patients in the postoperative period of heart transplantation.**

Methods: **Twenty-two heart transplanted patients were randomized to the control group (CG, n=11) and training group (TG, n=11). The control group conducted the exercise program adopted as routine in the institution and the training group has had a protocol consisting of 10 stages, with incremental exercises: breathing exercises, resistance training, stretching and walking. The programs began on the first day after extubation and stretched until hospital discharge. Assessed pulmonary function, distance walked in six minutes walk test (6MWT) and peripheral muscle strength by one repetition maximum test (1RM).**

Results: **Similar behavior was observed between the two groups treated, with statistically significant increases between the first and second test of the following variables: FVC (59% in CG and 35.2% in TG); MIP (8.6% in CG and 53.5% in TG), MEP (28.8% in CG and 40.7% in TG) and 6MWT (44.5% in CG and 31.4% in TG). There was an increase of peripheral strength by 1RM test, over time, to the muscle groups of the elbow flexors, shoulder flexors, hip abductors and knee flexors.**

Conclusion: **Heart transplant patients benefit from exercise programs in hospital, regardless of the program type applied. A new training proposal did not result in superiority compared to routine programme applied. Exercise protocols provided improves in ventilatory variables and functional capacity of this population.**

Descriptors: **Heart transplantation. Rehabilitation. Physical therapy modalities.**

Resumo

Objetivo: **Comparar os efeitos de dois programas fisioterapêuticos de exercícios intra-hospitalares na função pulmonar e na capacidade funcional de pacientes no período pós-operatório de transplante cardíaco.**

Métodos: **Vinte e dois transplantados de coração foram randomizados em Grupo Controle (GC, n=11) e Grupo de Treinamento (GT, n=11). O GC realizou o programa de exercícios adotado como rotina na instituição e o GT realizou protocolo**

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Abbreviations, acronyms & symbols	
6MWT	Six Minute Walk Test
BP	Blood pressure
CG	Control group
CMV	Controled mandatory ventilation mode
FC	Functional capacity
FVC	Forced vital capacity
HF	Heart failure
HR	Heart rate
HT	Heart transplantation
L	Liters
LL	Lower limbs
LVEF	Left ventricular ejection fraction
MEP	Maximal expiratory pressure
MIP	Maximal inspiratory pressure
PP	Postoperative period
PEEP	Positive end-expiratory pressure
RTG	Resistance training group
SpO_2	Peripheral oxygen saturation
TG	Training group
UL	Upper limbs

constituído de 10 fases, com exercícios incrementais: exercícios respiratórios, resistidos, alongamentos e caminhada. Os programas tiveram início no primeiro dia após a extubação e se estenderam até a alta hospitalar. Avaliou-se função pulmonar, distância percorrida no teste de caminhada dos seis minutos (TC6M) e força muscular periférica pelo teste de uma repetição máxima (1RM).

***Resultados:* Observou-se comportamento semelhante entre os dois grupos tratados, com aumentos estatisticamente significantes entre o primeiro e o segundo teste das variáveis: CVF (59% no GC; 35,2% no GT); PIMax (8,6% no GC; 53,5% no GT, PEMax (28,8% no GC; 40,7% no GT) e TC6M (44,5% no GC; 31,4% no GT). Houve aumento de força periférica pelo teste de 1RM para os músculos flexores de cotovelo, flexores de ombro, abdutores de quadril e flexores de joelho ao longo do tempo.**

***Conclusão:* Pacientes transplantados de coração se beneficiam da aplicação de programas de exercícios no período intra-hospitalar, independente do tipo de programa aplicado. Uma nova proposta de treinamento não resultou em superioridade em relação ao programa aplicado de rotina. Os protocolos de exercícios proporcionaram melhora das variáveis ventilatórias e da capacidade funcional dessa população.**

***Descritores:* Transplante de coração. Reabilitação. Modalidades de fisioterapia.**

INTRODUCTION

Heart failure (HF) is a clinical syndrome being the final common pathway of heart disease caused by structural or functional abnormalities, acquired or inherited, leading to worsening of filling capacity and ventricular ejection. The heart becomes unable to maintain the tissues demands resulting in symptoms such as fatigue, dyspnea and intolerance to physical exertion [1,2].

In advanced stages of HF (functional classes III and IV), heart transplantation (HT) becomes a treatment able to restore hemodynamic function, improve quality of life and survival. It is recommended for patients whose symptoms do not respond to drug therapy or other surgical procedures [3].

Since the first human HT performed in South Africa by Christiaan Barnard in 1967, HT has improved since its initial experimental stage to devote these days as a treatment of choice for patients with end-stage HF, especially after the development of immunosuppressive therapy [4]. Actually, the survival of patients submitted to HT is 80%, 70% and 60% in one, five and 10 years, respectively [3].

Most individuals waiting for a HT have prolonged hospital stay due to prolonged inotropic support or mechanical circulatory support [5]. Even after surgery, these individuals show changes in hemodynamic performance due to central alterations, such as autonomic denervation graft, endothelial dysfunction, diastolic dysfunction and accelerated coronary atherosclerosis and poor adaptation of the peripheral muscles [6]. Thus, even after HT, the peripheral changes due to advanced HF remains, resulting in a state of physical deconditioning. For this reason an exercise program should be started early, still in the hospital, with a continuing period of exercise program after discharge, so that patients can return to a lifestyle similar to that they had before the illness, allowing social interaction and satisfactory return to an active and productive life [7].

Although widely recommended in the literature, there are few studies evaluating the use of exercise protocols in the postoperative period (PP) of HT in the hospital. In our institution, patients undergoing HT perform routinely respiratory therapy and general exercises. We follow a terapeutic plan tailored to each patient. However, we don´t have these results controlled and compared to specific protocols applied to HT patients.

In order to analyze the implementation of a new assistance program based on progression of exercises, we compared the effects of two programs of physical therapy exercises on pulmonary function and functional capacity in patients undergoing HT during hospitalization.

METHODS

This prospective, randomized and longitudinal follow-up study, was approved by the Hospital das Clinicas Ethics Committee from the University of São Paulo Medical School (HC-FMUSP) under the number 1080/08. The study included only individuals who signed an informed consent form, according to Resolution 196/96.

Patients who underwent orthotopic HT at the Heart Institute, from February 2009 to November 2011, aged over 13 years participated in this study. During this period, 26 individuals who initially filled the criteria for hemodynamic stability and absence of acute or chronic lung disease, neurological and orthopedic complications hindering the realization of the proposed protocols were included. Four individuals were excluded from the program: an individual due to secondary symptomatic hypertension to cyclosporine therapy, two for neurological complications and one due to death related to acute rejection from the graft. Therefore, 22 subjects completed the study, 11 patients in the control group (CG), which performed the conventional physiotherapy program, and 11 in the training group (TG), which performed a new exercise program (Figure 1). These patients did not perform exercise programs in the preoperative period.

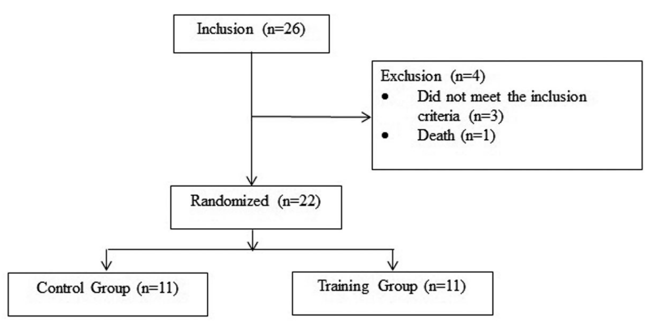

Fig. 1 - Flowchart of studied patients

Patients were admitted to the Surgical Intensive Care Unit in the immediate PP, in intubation and mechanical ventilation (Hamilton-Switzerland, Galileo® model), on controled mandatory ventilation mode (CMV), with a tidal volume of 8 ml/kg, respiratory rate of 12 breaths/min; fraction of inspired oxygen of 60% and positive end-expiratory pressure (PEEP) of 5 cmH_2O, as Unit routine [8].

The study began on the day after extubation, which followed institutional protocol [8]. Bedridden patients or patients using vasoactive drugs initiated protocol in phases 1 and 2 and continued to phase 3 only when they were hemodynamically stable, with or without vasoactive drugs.

After the withdrawal of ventilatory support, patients were randomized to CG or TG. This randomization process was performed by sealed opaque envelopes. An independent individual generated a sequence of random numbers, putting up one by one in sealed envelopes. Patients were randomly and consecutively allocated in one of the study groups by the withdrawal of one envelope for each patient.

Pulmonary function was evalueted in terms of respiratory muscle strength and forced vital capacity (FVC). Respiratory muscle strength, expressed by maximal inspiratory pressure (MIP) and maximal expiratory pressure (MEP) was obtained by manovacuometry (Marshall Town® model). The patient was positioned sitting with a nose clip to allow only oral breathing during the test. A maximal inspiratory effort from residual volume (RV) was requested through a mouthpiece connected to a manometer. We considered the largest deflection obtained in the apparatus for the MIP value. Similarly, the expiratory effort was requested from the total lung capacity (TLC) to obtain the MEP value. The measurements were repeated for at least three times for each parameter, accepting less than 10% difference betwen the measures. The highest value was considered, since this has not been the last measure [9]. The values are expressed in cmH_2O and percentage of predicted values, according to Neder [10]. The FVC was measured by ventilometry (Mark Wright Spirometer 8® model). FVC was obtained in liters (L) through a maximum inspiration followed by expiration until the maximum RV. The measurement was performed three times, accepting a difference less than 10% betwen the measures, considering the highest value obtained, since it was not the last one. All tests were performed on the first day after extubation (1st test) and on the day before hospital discharge (2nd test).

The functional capacity (FC) was assessed using the Six Minute Walk Test (6MWT) performed according to the Guidelines of the American Thoracic Society [11], with the distance measured in meters and percentage of predicted values and calculated according to the equation proposed by Enright & Sherrill [12]. The first 6MWT was performed as soon as the patients had conditions for ambulation, which occurred at the end of the first week after extubation. The second test was performed on the day before discharge.

The dynamics of peripheral muscle strength was assessed by the One Repetition Maximum Test (1RM), following the protocol adapted to the Guidelines of the American College of Sports Medicine [13]. Muscle groups responsible for elbow flexion, shoulder flexion, shoulder abduction, elbow extension, knee extension, hip abduction and knee flexion were tested. The first 1RM test was performed at the end of the first week after extubation and the second, on the day before discharge. Once defined the maximum load reached in the first test, we applied a load for resistance training of 50% 1RM set for each muscle group.

Exercise Programs

CG performed the exercise program adopted as routine in the institution, composed by series of 10 repetitions of the following exercises: (a) diaphragmatic breathing exercises, inspiration in 3 times associated with upper limbs elevation in flexion and in abduction to 90°, (b) general exercises like bending their knees to hip height, lower limbs abduction to 45°, plantar flexion and dorsiflexion (c) orientation for ambulation without pre-established target distance. The session was conducted once a day, five times a week, under a physiotherapist supervision.

Phase 1: (A) Breathing exercises (10 repetitions)- sitting position. 1. Diaphragmatic breathing: with your hands under the abdomen, breathe through your nose and release the air through your mouth, filling the air in the abdomen inspiration and emptying at expiration (repeat in 2 and 3 times). 2. Diaphragmatic breathing with elevation of upper limbs: raise your arms in inspiration and lower them at expiration (repeat in 2 and 3 times). 3. Shoulder Abduction and adduction inspiring and expiring up to 90°. (B) 1. Active exercises (10 repetitions)- sitting position. 2. Metabolic Exercises (plantar flexion and dorsiflexion circular movements) 3. Knee flexion-extension 4. Elevation of lower limbs alternating sides with knees flexion. 5. Elevation of lower limbs alternating sides with knees extended. **Phase 2:** Exercises A and B 1 of phase 1. (C) 1. Ortostatism: 2. Static gait (20 steps). **Phase 3:** Exercises A and B 1 of phase 1. (B) 2. Active exercises (10 repetitions)- standing. 1. Raise the body on the balls of his feet and back with your heels on the floor. 2. Hip abduction and adduction at 45° on both sides. 3. Flex the knee back with heel trying to pull over on the buttocks. Exercises C1 from phase 2. **Phase 4:** Exercises A, B1 from phase 1 and B2from phase 3. (C) 2. Walking: 1. Static gait (40 steps). 2. 150 meters walk. **Phase 5:** Exercises A from phase 1 and B2 from fase3. C. Walking: 1. Static gait (40 steps) 2. 300 meters walk.	**Phase 6:** Exercises A from phase 1, B2 from phase 3 (2 x 10 repetitions). C. Walking: 1. Static gait (40 steps) 2. Walk 600 meters. (D). Stretching: (keep for 20"each positioning) * Head (lateral, front and back) * Stretch (upward and posterior) * Triceps brachial (horizontal adduction of shoulder with elbow flexion) * Triceps surae and Ischia tibial * Quadriceps * Circular movements of the shoulders. **Stage 7.** Items A2 and 3 from phase 1. (B) 3. Resistance exercises (load according to the 1RM, 1 set of 10 repetitions). Upper limbs: -flexion of the elbows -extension of elbows - anterior flexion of the shoulder 90° -abduction/adduction of upper limbs up to shoulder height. Lower limbs: -knee extension seated -bending on his knees at the height of the hip -knees bending backwards with the heel trying to pull over on the buttocks. -abduction/adduction of lower limbs to 45º. C. Walking: 1. lateral Gait (20 steps for each side) 2.600 metres walk. D. Stretches from phase 6. **Stage 8.** Items A2 and 3 of phase 1. Item B3 of phase 7 C. Walking 1. Lateral gait (20 steps) 2. 900 meter walk. D. Stretches described in Phase 6. E. **Stage 9.** Repeat Step 8. One floor down stairs and ride the elevator. **Phase 10.** Repeat Step 8. One floor down stairs and rise again.

Fig. 2 - Intra-hospital exercise program for heart transplant patients

TG performed exercise program consisted in 10 phases of increasing complexity, including breathing exercises, active, resistance and aerobic exercises and stretching, as shown in Figure 2. The phases were established in order to promote incremental effort; progression to a new phase depended on the patient's clinical response and ability to perform the proposed activities at each phase without compensation and independently; progression was also based on the perception effort assessed by the modified Borg scale [14] which consists in a score of 0 to 10 grades, using descriptive terms. Patients were instructed to maintain a score of 4 (somewhat severe) to 6 (severe). When the score reached 7 (very severe) the patient was oriented to regress one phase of the protocol. The progression phases were suspended or had regression when it was necessary to remain at rest, for medical request, or when the patient was unable to carry out the activities by side effects of immunosuppressive therapy. During the exercise sessions, heart rate (HR), blood pressure (BP) and peripheral oxygen saturation (SpO_2) from the TG patients were monitored at the beginning, during the activity, at the end of the sessions and 5 minutes after the sessions, in order to evaluate the safety of the proposed protocol.

The statistical analysis used to compare the groups consisted on Student t test for normally distributed data which are presented as mean and standard deviation, or its corresponding Mann-Whitney, presented as median and interquartile ranges. To test the homogeneity between the proportions we used the chi-square test or Fisher's exact test. The variables were subjected to analysis of variance for repeated measures ANOVA and when the normality assumption was rejected we used the Friedman test [15]. The level of statistical significance was 5%.

Table 1. Anthropometric data and left ventricular ejection fraction

	Control (n=11)	Training (n=11)	*P*-value
Age (years)	42.0 ± 16.46	39.0 ± 17.54	0.613
Weight (Kg)	60.0 ± 10.72	59.2 ± 9.03	0.725
Height (m)	1.68 ± 8.74	1.66 ± 6.3	0.582
BMI (Kg/m²)	21.38 ± 2.74	21.45 ± 3.26	0.956
LVEF (%)	18 (16-20)	20 (20-20)	0.278

BMI = body mass index; LVEF (%) = left ventricular ejection fraction. Kg = kilograms; m² = square meter

RESULTS

The general anthropometric characteristics and left ventricular ejection fraction (LVEF) values had no statistically significant difference between the groups, as shown in Table 1. There was a prevalence of 63.64% males in the population studied, with an equal proportion in both groups.

Chagas cardiomyopathy was the etiology of HF in 28% of patients in the CG and 55% in TG; idiopathic dilated cardiomyopathy in 45% of CG and 18% in TG; ischemic cardiomyopathy in 9% in both groups and other causes 9% in both groups.

Mechanical ventilation time was 11.83 hours (7.85 - 21.17) in CG and 8.33 hours (4.93 - 10.94) in TG, with no statistically significant difference between groups (*P*=0.094). The length of hospital stay in the postoperative period was 34 days (26 - 48) in CG and 32 days (21 - 46) in TG (*P*=0.768). The application period of the protocols was 26 ± 12 sessions in CG and 18 ± 6 sessions in TG, with no statistically significant difference between groups (*P*=0.074).

When comparing the responses against exercise programs applied, we had a statistically significant increase in MIP, MEP and FVC variables in both groups, as shown in Table 2. The same was observed in the 6MWT (Table 3) and in 1RM test for the movements of elbow flexion, shoulder flexion, hip abduction and knee flexion (Table 4). Although the TG values were higher than those of the CG, they did not reach statistical significance.

Table 2. Lung function variables before and after the implementation of training programs

	Control		Training		*P* Group	*P* Time
	1st Test	2nd Test	1st Test	2nd Test		
MIP	58 ± 30	63 ± 29*	52 ± 23	80 ± 31*	0.619	0.007
MIP% pred	53	57*	50	73*	0.616	0.009
MEP	59 ± 30	76 ± 34*	59 ± 33	83 ± 27*	0.828	0.001
MEP% pred	50	65*	54	73*	0.684	0.002
FVC (L)	1.84 ± 0.87	2.93±1.31*	1.96±0.45	2.65 ± 1.04*	0.785	0.002
FVC% pred	45 ± 25	67 ± 26*	48 ± 11	67 ± 29*	0.878	0.003

MIP = maximum inspiratory pressure, MIP% pred = maximum inspiratory pressure in percentage of predicted, MEP= maximum expiratory pressure and MEP%pred = maximum expiratory pressure in percentage of predicted, FVC = forced vital capacity, FVC% pred = forced vital capacity in percentage of predicted.

** $P<0.05$ when compared with the value obtained in 1st intra-group test*

Table 3. Functional capacity variables before and after the implementation of the training programs

	Control		Training		*P* Group	*P* Time
	1st Test	2nd Test	1st Test	2nd Test		
6MWT	272 ± 168	393 ± 155*	322 ± 83	423 ± 70*	0.430	0.001
6MWT%pred	41	60*	50	66*	0.323	0.001

6MWT = six minute walk test, 6MWT% pred = six-minute walk test in percentage of predicted values.
** P<0.05 when compared with the value obtained in the 1st test, intra-group test*

Table 4. Test of 1RM values before and after implementation of the training programs

	Training		Control		*P* Group	*P* Time
	1st Test	2nd Test	1st Test	2nd Test		
Elbow flexion	3.91	4.45*	3.36	4.45*	0.38	0.009
Shoulder flexion	2.18	2.82*	1.73	2.0*	0.22	0.024
Shoulder abduction	2.09	2.36	1.45	2.0	0.257	0.055
Elbow extension	1.91	2.54	1.82	1.82	0.353	0.132
Knee extension	6.0	7.0	4.54	5.73	0.361	0.054
Hip abduction	3.64	4.86*	3.18	3.91*	0.438	0.015
Knee flexion	3.27	4.86*	3.0	4.45*	0.749	0.005

1RM= one repetition maximum test.
** P<0.05 when compared with the value obtained in the 1st intra-group test*

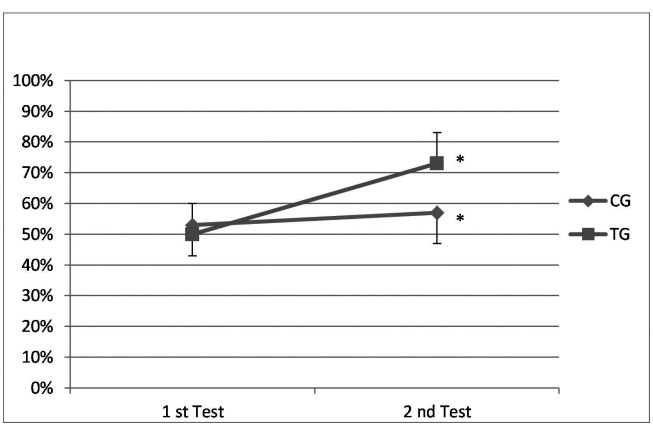

Fig. 3 - Values of maximal inspiratory pressure expressed as percentage of predicted values

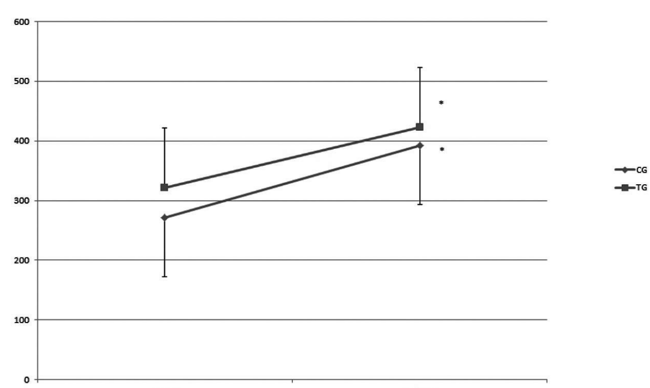

Fig. 4 - Distance in the Six Minute Walk Test before and after the training programs

The mean MIP, expressed as percentage of predicted values , in CG was 53% and 57% in the first and second tests respectively and in TG was 50% and 73%, respectively. There was no statistically significant difference between groups (*P*=0.616), but over time, the patients showed significant gains (*P*=0.009) (Figure 3).

6MWT mean values were 272m in the first test and 393m in the second test for CG, and 322m and 423m, respectively, in TG. The performance of the groups was similar (*P*=0.430), with significant improvement in the second test (*P*=0.001) (Figure 4).

Peripheral muscle strength increased significantly in the second test compared to the first test for the following muscle groups: elbow flexion (*P*=0.009), shoulder flexion (*P*=0.024), hip abduction (*P*=0.015) and knee flexion (*P*=0.005), as shown in Table 4.

DISCUSSION

Exercise programs are important for HT patients and should be started as early as possible to restore their FC after the surgical procedure, but also to recover part of the muscle dysfunction due to the long period of deconditioning in the preoperative phase and to the effects of immunosuppressive therapy in skeletal muscle [16].

Our study evaluated the effects of exercise programs immediately after HT still in hospital phase. The literature is rich in studies that evaluate the effectiveness of programs in post discharge phases (II and III). However, studies addressing phase I are scarce, probably due to the diversity in patient outcomes. Protocols assistance are applied by different transplant centers, but there is little information on the impact of such assistance [17]. In our institution, the exercise program is performed tailored to each patient. To compare this program with a new proposal that includes exercise progression based on the complexity execution and resistance exercises, was the aim of this study.

Two programs of therapeutic exercise have been applied to patients in the PP of heart transplantation. The CG performed exercises according to a protocol routinely practiced in the institution and TG performed a new exercise protocol based on incremental workloads. Our data show that the implementation of both protocols contributed to the improvement in lung function, in peripheral muscle strength and physical performance over time, with no differences between the protocols.

Lung function may change in heart transplant in the PP, as well as in other cardio-thoracic surgery [18]. Ferreira et al. [19] observed a reduction in vital capacity 40%-50% compared to preoperative values for at least 10-14 days after cardiac surgery and abdominal surgery. It is believed that factors such as pain, abnormal respiratory mechanics due to the sternotomy and the deleterious effects of general anesthesia on pulmonary function, contributes to these findings. In HT, poor preoperative condition and the surgical procedure itself favor the reduced respiratory capacity and increased pulmonary secretions, which can be minimized through breathing exercises, bronchial hygiene and cough stimuli.

Coronel et al. [20], in a retrospective cohort study evaluated 21 patients undergoing HT. The authors observed a volume and lung capacity reduction and a respiratory muscle strength decrease on the first postoperative day compared to the preoperative period and recovery of these values on the 14th postoperative day. The improvement of FVC, MIP and MEP between the first and 14th postoperative day was 70.1%, 75.1% and 62.8%, respectively.

In our study, there was an improvement in ventilatory variables between the first and second tests but our medium datas are lower than those observed by Coronel et al. [20] (59% in the CG *versus* 35.2% in TG for FVC, 8.6% in CG *versus* 53.5% in TG for MIP and 28.8% in the CG *versus* 40.7% in TG for MEP). Our results corroborate the finding that changes in ventilatory function in patients undergoing HT are predictable, but these recover the expression of respiratory muscle strength and lung capacity within two weeks, besides improving FC, considering the association between the HT surgery and functional rehabilitation a good therapeutic strategy for the treatment of advanced HF patients.

In relation to the MIP, both groups were lower than 70% of predicted values at the beginning of the programs adopted in our study and only the TG reached average values above this threshold in the second test. According to Borges [21], respiratory muscle weakness, characterized by MIP less than 70% of predicted values, is one of the risk factors for the development of postoperative pulmonary complications in patients undergoing cardiac surgery. Thus, programs that contribute to the improvement of muscle strength are beneficial, regardless the association of specific inspiratory muscle training, thus minimizing the risk of complications.

The improvement of FC in our study, 44.5% in CG and 31.4% in TG, was more expressive than in the study of Coronel et al. [20], where FC improved only 11.2% between tests. We believe that this result is due to the stimulus given to the patient to walk in the PP in our institution, either randomly (CG) or standardized by the proposed protocol (TG), where at the final phase, phase 10, the patients walked at least 900m per day and went up and down a flight of stairs. In the PP of coronary artery bypass surgery, we have demonstrated that a moderate supervised walking program during hospitalization improves walking ability at hospital discharge [22]. Thus, the inclusion of hiking seems an important feature in phase I cardiac rehabilitation programs for improvement in FC patients in the PP of cardiac surgery, as well as in HT surgery.

Although the early indication of exercise in the PP of HT is a consensus, there are few publications that describe the protocols implemented in this population in the hospital phase. According to the Brazilian Cardiology Guidelines for Heart Transplantation [23], general exercises should be started in the immediate postoperative period, increased gradually until the patient develops muscle strength and adequate endurance to restore a level of fitness. The ambulation should be started as soon as possible and after discharge, the supervised program should include stretching, aerobic and endurance exercises. The intensity of aerobic activity can be prescribed between the anaerobic threshold and respiratory compensation point obtained in the cardiopulmonary exercise test, or 60%-85% of maximum HR achieved in the testing effort. Increased intensity during the program should be done gradually, taking into account the HR, BP, Borg scale and rejection episodes.

Squires [24] recommend performing passive mobility exercises for upper limbs (UL) and lower limbs (LL), exercises to get up and sit in the chair and ambulation prescribed after extubation of the HT patient, which in general occurs within the first 24 hours after surgery. A walk or aerobic exercises on a stationary bicycle for 20 to 30 minutes can be tolerated using prescription based on the Borg scale between 11 and 13. Training for strength gain is indicated for the first six months after HT, when the authors recommend a maximum weight of 5 kg for bilateral UL exercises, to avoid complications with the surgical incision, as sternal instability. Our patients underwent resistance training with a maximum of 2 kg to 3 kg for UL and LL, considered safe within the exercise protocol proposed. The use of resistance exercises during exercise programs in the PP of HT is being increasingly used, since this method helps to minimize the deleterious effects of corticosteroids and immunosuppressants. It is common to skeletal muscle atrophy and weakness in addition to osteoporosis in recipients of organ transplantation as a side effect of this drug therapy. In this context, resistance exercise have osteogenic effect, since during its execution leads to bone deformation, generating cellular responses that determine the release of bone growth factors [16].

Braith et al. [25], in 2005, evaluated 15 HT patients who were randomized into CG, who performed a walking program (n=7), and a resistance training group (RTG), who performed walking and resistance exercise (n=8). Both programs began two months before surgery and lasted up to 6 months after HT. The exercise protocol consisted of a 5 minutes warm-up, followed by strengthening exercises for UL and LL at 50% 1RM, a series of 10 to 15 repetitions, twice a week. In biopsies of the right vastus lateralis, a significant increase in citrate synthase was observed, and 3 hydroxyacyl CoA dehydrogenase and lactate dehydrogenase activity in the RTG when compared to CG. The concentration of the type I myosin heavy chains increased 73% in the RTG, while decreased 28% in the CG. The type II myosin heavy chain increased 17% in the CG but decreased by 33% in the RTG, with $P \leq 0.05$. This was the first study to demonstrate that resistance training stimulates the change of type II muscle fiber, less oxidative, for the most fatigue-resistant, type I, in HT patients, demonstrating that resistance exercise in the post-transplant period is effective in increasing enzyme reserves and change the morphology of the muscle fiber, making the HT individual more capable to practice physical activity and to respond for the metabolic requirements necessary to perform the activities of daily living.

Therefore, there is a need to develop protocols with specific exercises for the HT population, which consider both the aerobic and resistance training. Encouraging the practice of physical activity and adopting a healthy lifestyle should be initiated with educational and preventive actions still in-hospital phase [23]. Our study has the limitation, for a better power of analysis, of a small sample size. More studies are needed to evaluate exercise programs in the PP of HT, including pre-operative data and effects over time.

CONCLUSION

Results showed that HT patients had benefits with the implementation of exercise programs in-hospital period, regardless of the type of the program implemented. A new training proposal resulted in no superiority over the routine program. Exercise protocols improved ventilatory variables and the FC of this population.

Authors' roles & responsibilities	
TSK	Conception and design of the study, implementation of projects and /or experiments, data analysis, writing of the manuscript
POA	Conception and design of the study, implementation of projects and/or experiments
KRL	Implementation of projects and or experiments
EAB	Final approval of manuscript
MIZF	Critical review and final approval of the manuscript
EN	Critical review and final approval of the manuscript

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