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Effects of cardio respiratory heated water-based training in an adult after heart transplantation

Abstract

Introduction: Heart transplant (HT) has been the technique of effective choice for the treatment of individuals with refractory heart failure. After HT, physical training becomes imperative in order to mitigate the muscular and cardiovascular impairment that is established. Hydrotherapy when performed in heated water has shown significant muscle and cardiovascular benefits.

Case report: A 38-year-old female volunteer, post-HT (<1 year), underwent a heated water based exercise protocol of 10 weeks. Hemodynamic data, distance in the six minute walk test (6 MWT), velocity in the walking speed test (WST), respiratory and lower limb muscle strength and quality of life (QoL) were evaluated at baseline and post training.

Results: There was an increase in the muscular strength of the lower limbs and inspiratory muscles. In the 6MWT, an increase in distance walked with a relative decrease of systolic blood pressure (SBP), diastolic blood pressure (DBP) and double product (DP) was observed. Furthermore, there was an increase in the left ventricle ejection fraction (LVEF). There was an increase in the walking speed observed in the 10m WST. Regarding the QoL, an improvement in all domains of the SF-36 was observed.

Conclusion: The present study showed that an exercise protocol performed in warm water was safe and effective for improving hemodynamic variables, muscle strength, functional capacity and quality of life.

Keywords: heart transplant, hydrotherapy, blood pressure, heart rate, systolic volume and quality of life

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Introduction

Heart transplantation (HT) has been the technique of effective choice for the treatment of individuals with refractory heart failure.[1,2] In the last ten years, 2558 HTs were performed in Brazil, of which, 357 were performed between January and December 2016, with 178 of these carried out in the southeast region.[2] Furthermore, it should be stated that heart transplanted cases still scarce in Brazil, when compared to worldwide.[3]

After receiving the transplanted heart, metabolic impairment is systemic, causing musculoskeletal damage, such as reduction of oxidative enzymatic activity and decreased capillarization.[4] The occurrence of sarcopenia, atrophy, generalized muscle weakness, lower aerobic capacity and high blood pressure (HBP) is inherent, resulting from the hospitalization period and the physical inactivity and potentiated by the use of immunosuppressive drugs.[4,5]

To mitigate the pervasive harmful effects brought about by the HT guided exercises are prescribed. Exercises performed in water are one of the therapeutic modalities with exponential benefits. Aquatic physiotherapy has shown important muscle and cardiovascular benefits.[6] Immersion in water may affect hemodynamic variables, as the external hydrostatic pressure increases the venous return, central blood volume and heart output (HO) with concomitant reduction of heart rate (HR) and peripheral vascular resistance (PVR).[7] In addition to improvements in the renal and cardiac functions, systolic and diastolic blood pressure can be reduced at rest with physical training (PT).[6–9]

Considering the benefits of aquatic physiotherapy and the need for a well structured and differentiated rehabilitation for individuals submitted to HT, the aim of this study was to evaluate the cardio respiratory effects of an aquatic physiotherapy exercise program in a young adult after HT.

Case characteristics

This female volunteer was 38 years of age and had undergone a heart transplant in February 2016 due to dilated peripartum cardiomyopathy, in the Clinical Hospital (CH) of Belo Horizonte. Two months after the HT, the subject was referred to the University of Itaúna Integrated Physiotherapy Clinics (CIFUI), located in Itaúna MG, to initiate Cardiovascular soil Rehabilitation for six months. After this period, due the particularly rare case and the benefits of water based exercises, this volunteer was invited to participate in this study.

Materials and methods

Methods

The study was approved by the Research Ethics Committee of the University of Itaúna, under authorization No. 1.843.378. The evaluations and the exercise program were carried out in the CIFUI.

The initiation of the study occurred after authorization from the aforementioned clinic and the signing of the consent form by the volunteer.

Strength test

The microFet2® manual dynamometer (Hoggan Health Industries, Salt Lake City, UT, USA) was used to evaluate the isometric strength of the plantar flexors, extensors, and knee flexors of the lower limbs (LLs).[10] The manual dynamometer Takei®5401 (Yashiroda, Niigata-shi, Japan) was used to evaluate manual grip strength. The isometric strength measurement was performed at baseline and after the end of the training. To begin the test of the knee extensors and flexors, the volunteer was positioned with hips and knees at 90° flexion, the test was started with a range of motion (ROM) of 85° of knee flexion-extension. In the plantar flexion test, the volunteer was placed in dorsal decubitus, with hip, knees and ankles in a neutral position and a dynamometer positioned between the anti-foot of the volunteer and the wall of the evaluation room. Finally, the manual pre-test was performed with the volunteer in orthostatism, with the upper limbs (ULs) in a neutral position, and dynamometer adjusted in the middle phalanges. As familiarization training, the volunteer performed two maximal contractions. Three maximal repetitions, maintained for five seconds were considered for the tests, with a rest interval of one minute between each effort. To stimulate the volunteer, standardized verbal feedback was given by the researcher responsible.

The dynamometers were properly calibrated and operationalized according to the manufacturer's instructions. All the measurement such as calibration, training or the researchers and placement were performed carefully.

Functional capacity tests

For the measurement of the functional capacity, the volunteer was first submitted to the 6-Minute Walk Test (6MWT), which was performed according to the American Thoracic Society[11] recommendations, in a corridor of at least 50 meters and free of circulation of people. Next, the Walking Speed Test (WST) was carried out, in which the volunteer was instructed to walk 14 meters and the time, in seconds, was recorded, with the first two meters (acceleration phase) and the last two meters (deceleration phase) disregarded.[12] Three measures of the time taken were collected.

Respiratory muscle strength

For the evaluation of respiratory muscle strength, the maximum inspiratory pressure (MIP) and the maximum expiratory pressure (MEP) were measured. For this, a 300cmH_2O CriticalMed® manuvacuometer and nasal clip were used, having been sterilized. Measurements of MIP and MEP were measured according to Neder et al.[13] Measurements were taken with a minimum interval of one minute between each.

Quality of life

Quality of life was assessed using the SF-36 multidimensional questionnaire, which consists of 36 items, encompassing eight domains: functional capacity, limitations in physical aspects, pain, general health status, vitality, social aspects, emotional aspects and mental health. It presents a final score for each item from 0 to 100, where 0 corresponds to the worst general state of health and 100 the best state of health.[14]

Borg scale

The level of fatigue was assessed by the modified Borg scale, which consists of a vertical graded scale from 0 to 10, with verbal expressions corresponding to a progressive increase in the level of perceived exertion, dyspnea or fatigue.[15]

Ejection fraction (LVEF)

The left ventricular ejection fraction (LVEF) was measured by means of a Doppler echocardiogram performed by the volunteer. The LVEF (%) calculation was performed by the Teichholz method, which estimates the ejection fraction of the LV through the measurements of LV end-diastolic diameter (LVDD) and LV end-systolic diameter (LVSD).[16] Two pre-HT scans (2011 and 2013), one post-HT (2016) and one exam after 10 weeks of PT in water (2017) were considered.

Procedure

After signing the consent form, an evaluation form was filled out containing demographic (name, age, gender) and clinical (previous history, medications in use and details about the health condition) data. Vital data such as blood pressure (BP), heart rate (HR), respiratory rate (RR), oxygen saturation (SO_2), and fatigue level measured by the Borg scale were collected, with the muscular strength and respiratory force tests being applied first. The volunteer then responded to the SF-36 questionnaire, which was administered through an interview with a trained evaluator, with the participant in complete privacy. Once again, the vital data for the application of the 6MWT and WST were measured.

The evaluations were performed at two moments: baseline (pre-exercise) and after completing the 30 training sessions (end of the training).

The exercise protocol was performed in a 5.6 meter-long swimming pool heated to 33°C, three times a week, for approximately 60 minutes per session. It was structured in three phases: Phase 1 - adaptive, from the first to the third week, where a free walking warm-up was performed without resistance, followed by walking training with resistance of 2Kg on both LLs, stationary bicycle and ending with relaxation where the volunteer was positioned horizontally with the use of floats. Phase 2 - intermediate, performed from the fourth to the sixth week, where there was an increase in resistance to 3kg, hydrodynamic dumbbells with resistance equivalent to 1kg and step squatting exercise. Phase 3 - advanced, carried out from seventh to tenth week, with load increase to 4kg on the ankle cuffs and 2kg on the dumbbells, adding lateral walking with resistance ankle cuffs, stationary running, walking with abdominal resistance (aquajogger vest) and up and down stairs functional training.[17,18] The intensity of the exercises was controlled through the perceived exertion scale between 4–6[15] and saturation level (SO_2) above 90%.

Immersion was made to the level of the xiphoid process. Throughout the training, the volunteer was monitored by two trained researchers. Vital data such as HR (heart rate monitor Oregon® - HR102), BP(stethoscope Littmann® and sphygmomanometer TENSO med®) and saturation level (NONIN®onyx 9500) were measured before, during (every ten minutes) and after each session. The volunteer was allowed a rest period between activities, if necessary.

Data analysis

Descriptive statistics including mean (standard deviation), percentage and frequency were used to present the results.

Results

The 38-year old volunteer, eight months after HT due to dilated cardiomyopathy, had a body mass of 83kg and body mass index (BMI) of 28.42kg/m^2. During the exercise program, the volunteer used calcium carbonate, sodium alendronate, antibacterials, mycophenolate mofetil, immunosuppressants, corticosteroids, antiallergics, ferrous sulfate and antihypertensives.

The muscle strength test, in Kgf, showed gains of more than 220% for knee flexor strength and above 100% for left knee extensors after compliance with the training protocol, with gains of over 12% in all muscle groups tested. Table 1 shows the percentage of strength gain in all muscle groups evaluated before and after the PT in water.

Table 1 Descriptive data of isometric muscle strength using portable hand dynamometer in Kgf (force production in kilograms). Considering the three repetitions and using the mean of the three measures, the Standard deviation and percentage of gain were used for the demonstration of the results

Muscle group	baseline	After training	% gain
Right knee Flex.	3.40(0)	12.10(0.6)	255.90
Left knee Flex.	2.60(0.3)	8.40(0.4)	223.10
Right knee Ex.	10.70(1.1)	14.96(2.3)	39.81
Left knee Ex.	6.03(0.3)	12.20(1.3)	102.30
Right plantar Flex.	25.70(2.2)	30.70(3.7)	19.50
Left plantar Flex.	13.40(5.5)	22.00(0.9)	64.20
Right palmar Grasp	22.60(1.1)	25.40(1.6)	12.40
Left palmar Grasp	21.60(1.0)	27.00(1.3)	25.00

Note values are expressed as mean (standard deviation)

In the 10 meter walking speed test a reduction of more than 8 seconds to complete the test was observed (baseline: 18.2s, post-intervention: 10.3s) with no change in HR (mean of 86 bpm and SpO_2 98%).

Quality of life, evaluated through the SF-36 questionnaire, confirmed the beneficial effects of the physical gains (Table 2) (Table 3).

Table 2 Descriptive data on the quality of life presented according to the SF36, before and after the PT

Domain	Baseline	After training	% gain
Functional Capacity	15.00	45.00	200.00%
Limitations in Physical Aspects	0.00	75.00	75.00%
Pain	31.00	41.00	32.00%
General Health Status	37.00	72.00	94.60%
Vitality	45.00	80.00	77.78%
Social Aspects	25.00	50.00	100.00%
Emotional Aspects	0.00	33.34	33.34%
Mental Health	44.00	64.00	45.45%

In relation to the 6MWT, the distance covered at baseline was 240 meters, with this increasing to 309 meters after the PT. A large gain in exercise capacity was observed, as well as a relative decrease in Rate-pressure (RP). The details are presented in (Table 4).

Left ventricular ejection fraction (LVEF) values are shown in Figure 1. The volunteer was submitted to four Doppler echocardiography examinations. The first two values (2011 and 2013) refer to the pre-transplantation period, while the third value (2016) corresponds to post-transplantation moment (2 months after) and finally the last value (2017) is related to the post-training moment. There was an improvement of 14% in LVEF (%) with 56% at baseline and 70% post-training.

Table 3 Descriptive data of maximal inspiratory and expiratory muscle strength, before and after the exercise protocol. The data from the six repetitions (mean, standard deviation and percentage of gain) were considered for the demonstration of the results

Variable	Baseline	After training	% gain
MIP	76.7(12)	120.0(12.7)	56.45%
MEP	80.0(22)	88.3(11.7)	10.37%
MIP%	98.0	141.6	44.50%
MEP%	108.2	108.2	0%

Note values are expressed as mean (standard deviation)

MIP, maximal inspiratory pressure; MEP: maximal expiratory pressure

Table 4 Results of the variables in the 6MWT at baseline and after 10 weeks of training. Variables were measured at rest and at the end of the 6MWT

Variables	Baseline	After 10 weeks
SBP (mm/hg)	Rest: 120 End: 130	Rest: 110 End: 120
DBP (mm/hg)	Rest: 90 End: 110	Rest: 80 End: 80
HR (mean, bpm)	82	98
Rate-pressure (bpm. mmHg)	Rest: 9840 End: 11180	Rest: 9460 End: 10320
SpO_2 (mean)	99	98
Perception of Effort (Borg)	Rest: 0 End: 2	Rest: 0 End: 2
Distance traveled (meters)	240	309

HR, heart rate; DBP, diastolic blood pressure; SBP, systolic blood pressure; SpO_2, peripheral oxygen saturation; Rate-pressure, BP, blood pressure

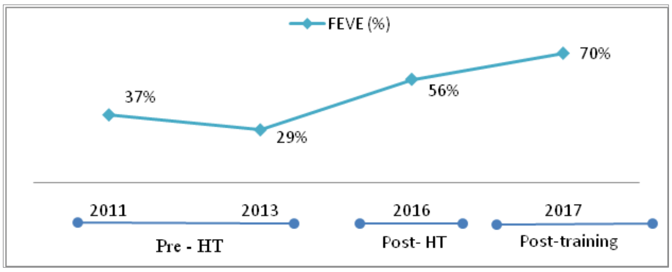

Figure 1 Percentage of LVEF pre-HT, post-HT and after 10 weeks of training.

LVEF, left ventricular ejection fraction

Discussion

The results obtained in this case study suggest that a 10-week training protocol in a heated pool was effective in increasing muscle strength, functional capacity, conditioning and walking speed. Regarding the hemodynamic variables, a relative reduction of SBP was observed from day 11. There was a reduction of the DP in the 6MWT and a significant improvement in the left ventricular ejection fraction (LVEF) of the myocardium in the post PT period. In addition to the physical gains, an improvement in the quality of life was noted, with gains of more than 30% in all domains of the SF-36 questionnaire.

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Inspiratory muscular strength

Patients undergoing cardiac surgery with extracorporeal circulation (ECC) usually present a reduction in respiratory capacity and respiratory muscle strength (RMS) after surgery. The effects of the surgery on muscle function, pain, and the presence of thoracic drains may explain this reduction and may result in impairment of respiratory function.[19,20]

Another relevant point is the previous history of dilated cardiomyopathy with congestive heart failure (CHF), which also contributes to the weakness of the inspiratory musculature.[21,22] In this way, a condition of exercise intolerance and dyspnea are installed, even in relation to performing activities of daily living (ADL).[22] The present study demonstrated that the PT resulted in an inspiratory muscle strength gain of 56.45%, although the MIP values were within the normal range. The probable explanation for this fact would be previous training that the volunteer performed with another ground-based exercise protocol.[10]

Increased RMS may contribute to improved dyspnea and exercise tolerance, in order to delay diaphragmatic fatigue.[23] In this context, other studies have demonstrated that there is a direct relationship between the increase in RMS and peripheral muscle strength.[23,24] Thus, the present results suggest that the RMS improvement may also have contributed to improved peripheral muscle strength.[24,25]

Muscle strength of LLs

It has been well described in the literature that post-HT patients exhibit a reduction in peripheral muscle strength (PMS) and increased systemic vascular resistance that can be attributed to the persistence of pre- and post-transplant abnormalities such as physical deconditioning, neuroendocrine abnormalities and the use of immunosuppressant medications.[26]

According to Pereira et al.[22] The effects of a water-based exercise program on muscle strength and functionality, include the improvement of the ability of the muscles to produce torque. The combination of the use of resistance and the turbulence of the water created during the exercises, offer additional mechanical stimuli for the gain in strength. In this way, both the walking and the impediment of the speed of the movements in the water result in greater torques at the moment of propelling the body forward.[27]

In the present study, the symmetrical gain of more than 200% in the knee flexors reflects the exercise protocol that was based on walking training exercises with free weight association on the ankles, starting at 1kg and increasing gradually to 4kg ankle cuffs on both LLs. Thus, the water resistance imposed at both the moment of the balance phase and the support phase, as well as when the body is propelled forward during walking, led to a sustained contraction of the knee and hip flexors being required. In addition, at the time of the heel shock and medium support, there was a need for an important contraction of the flexors to prevent the body from retreating backwards due to the water turbulence. Thus, hypertrophy of the quadriceps was bilaterally achieved through this exercise protocol.

These data are in agreement with Cuoco et al.[27] who showed the greater effectiveness of water-based exercises in promoting muscle strength gain in older adults.[28]

Taken together, the results of the RMS improvement associated with PMS suggest an improvement in exercise tolerance that led to increased speed and distance walked in the 6MWT.

Six-minute walk test

At baseline, the distance traveled in the 6MWT was 240m, with mean velocity of 0.67 m/s. After the HT, there was an increase in the distance traveled to 309m, with a consequent increase in the mean speed to 0.85m/s. This increase resulted in a lower cardiovascular risk for the patient, after the HT.[29,30]

In this context, Chen et al.[28] observed that the shorter distances traveled in the 6MWT were associated with higher uric acid levels and a higher risk of death or hospitalizations for cardiovascular morbidity 1 and 3 years after the HT (29). In addition, they described a walking distance of 539±108 m, about 89.9±18.2% of the predicted value for this test in post-HT patients (4.8±3.2). There was a positive correlation between walking distance and VO_2, HR and peak SBP during the maximal cardiopulmonary test. Additionally, the authors described a strong correlation between distance and quality of life measured through the SF-36, mainly in the areas of general health perception and the physical component.[29]

On the other hand, Castel et al.[30] reported that a distance of less than 225m walked in patients with moderate to severe heart failure would present a significant risk of mortality in the medium term (up to 5 years).[31]

In the present study, the increased distance covered in the 6MWT reflects cardiopulmonary and skeletal muscle adaptations following the PT, such as increased RMS and PMS. These changes probably resulted in a greater functional capacity to perform the daily tasks, as well as an increase in the quality of life of the volunteer.

Hemodynamic variables

In this study, in addition to the improvement in distance and mean velocity demonstrated in the 6MWT, there was a reduction in SBP and DBP after the 11th training session, associated with a decrease in Rate-pressure product at rest and during the 6MWT.

In the post-HT period, the heart remains denervated with an autonomic derangement of sympathetic and parasympathetic activity, usually for up to one year after the HT.[4,32] Initially, the transplanted heart presents changes in the responses to exercise, such as chronotropic and inotropic incompetence, reduced cardiac output and systolic volume, as well as systolic and diastolic dysfunction. There is also an increase in mean pulmonary artery pressure and vascular resistance at rest and during exercise. These changes result in reduced exercise capacity after HT.[4,5,26] In view of this, the increase in cardiac output (HO) elicited during exercise is mainly due to increased venous return via active muscular pumping, obeying the Frank-Starling law.[4,26]

The performance of exercises in heated water promotes an increase in venous return due to hydrostatic pressure, which increases with water depth and density, and favors the diuretic reaction, due to the suppression of the hormones, contributing to better circulation and reduction of edema.[33]

SBP and DBP

Regarding the blood pressure levels, physical training in heated water seems to reduce both SBP and DBP more effectively than ground-based exercises.[27,34] Immersion in water promotes a decrease

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in peripheral resistance due to dilation of the arterioles, with a subsequent fall in BP. With the reduction of the effects of gravity in the swimming pool, the fluid of the lower limbs will be directed toward the chest, which increases venous return and in turn, stimulates the baroreceptors to reduce the BP.[34,35]

The reduction of both SBP and DBP (of approximately 10 mmHg) observed in the present study is in agreement with the findings of other authors. Castro et al.[31] compared the behavior of SBP and DBP in post-transplant patients, identifying a greater reduction in blood pressure levels in the group that exercised in heated water (6.6 to 12.3 mmHg) in relation to the patients who performed ground-based exercise (5 to 8.3 mmHg) for 12 weeks.[9] The main effects regarding BP reduction are related to a reduction in vascular resistance, which in turn is associated with lower sympathetic system activity, improved baroreflex sensitivity and endothelial function, as well as reduced arterial stiffness.[36]

Rate-pressure product

Properly prescribed and properly performed physical training is able to reduce resting HR and HR with submaximal workloads, as well as SBP and DBP values in patients after HT.[34,35] In the present study, there was a reduction of RPP at rest and during the execution of the 6MWT after the physical training. Likewise, Marconi & Marzorati[36] observed a reduction in RPP for the same workload.[37] These results reflect improvements in the functional capacity and cardiac function exemplified by the increase in the LVEF (%).

LVEF (%)

Left ventricular function, evaluated through the Doppler echocardiogram, consists of the filling and emptying of the left ventricle, which determines the LVEF (%) and consequently translates the ability of the left ventricle to eject blood into the aorta during systole.[38] The LVEF (%) involves both the final systolic volume (FSV) and the final diastolic volume (FDV), with values ≥55% (Teicholz method) being considered normal for healthy adults.[38]

In cardiac transplant patients there is a reduction in systolic volume at rest and during exercise, when compared to healthy individuals.[39] In these patients, cardiac function is mainly limited by chronotropic incompetence and diastolic dysfunction, which can be defined by the deficit of ventricular relaxation and increase of intraventricular pressures, with consequent elevation of pulmonary capillary pressure. These changes limit the increase in cardiac output mainly in higher intensity exercise.[40]

In the present case, the initial records of the LVEF (%) show LV diastolic dysfunction, with signs of low output. Diastolic dysfunction appears to be a result of HBP and the use of immunosuppressant medications (4,5). After HT, the initial ECO shows preserved systolic function with the LV of normal dimensions. The final exam shows the LV with normal dimensions, non-hypertrophied and with preserved systolic function, with the LVEF (%) estimated at 70%. In this context, the probable participation of the aquatic physical training in this improvement of cardiac function can be hypothesized. Despite the short time after the HT (<1 year), aquatic training may have contributed, even partially, to the reduction of the post-load and improvement of endothelial and systolic function.

Gabrielsen et al.[40] demonstrated that physical training in warm water improves cardiac function through increased diastolic filling and HR reduction resulting in increased systolic volume and LVEF in patients with HF who exhibited systolic and diastolic dysfunction.[41] On the other hand, Nytroen et al.[41] submitted 48 post-treatment (8 years) patients to physical training for 12 weeks, with high intensity exercises (85 to 95% of maximal HR) and described a maximal VO_2 increase, a reduction of resting HR and no change in ejection volume.[42]

Walking speed test

The WST is an important measure that correlates with functional capacity and dynamic balance, the potential of which is to predict functional decline as well as the risk of falls.[43] The strength of the LLs and the dynamic balance are directly related to the walking speed measured in the WST.[43]

Bento et al.[43] tested the balance of 65 women aged over 60 years, before and after a 12-week exercise protocol in water. The authors showed that the training in water had a positive effect on dynamic balance, allowing the study subjects to increase their walking speed. The most plausible hypothesis is that water turbulence offers a valuable stimulus for the musculature of the LLs, as it promotes an improvement in their ability to react when confronting a disturbance.[44,45] Similarly, other studies also corroborate the increase in dynamic balance in the older adults after performing aquatic exercises that include rapid movements with change of direction.[46,47] Thus, these exercises demand rapid production of torque against the water turbulence, which favors the improvement of the functional response of the dynamic balance.

The present study confirms these findings, since at baseline the volunteer performed the 10m WST in 18.3s with a mean speed of 0.55m/s. After the training, there was an increase in the walking speed of 0.43m/s, with the 10m covered in 10.2s and a mean speed of 0.98m/s. According to Cruz et al.[47] a walking speed of 0.8m/s is the cut-off point for the diagnosis of sarcopenia, according to the algorithm proposed by the European Working Group on Sarcopenia.[48]

Quality of life

According to Trevizan et al.[48] heart transplantation per se is already a predictor of QoL improvement for transplant patients because they feel satisfied due to overcoming the pre-transplant difficulties.[49] Likewise, other studies have shown that HT surgery in patients with refractory heart failure presents better results in relation to QoL, as they see an improvement in the physical condition.[50,51]

The results obtained in the present study show that the exercise protocol in water increased the QoL improvement. There was improvement in all domains of the questionnaire, mainly in the functional capacity and limitations in physical aspects, with increases of 200% and 75%, respectively. Regarding the social and emotional aspects, the gain was 100% and 33.34%.

Improvement in functional capacity and peripheral muscle strength with greater exercise tolerance reflect the greater ability to spend more time doing activities that require physical effort or even doing leisure activities.[17] Thus, there is an increase in QoL in the physical and functional fields. In relation to the 100% gain in the social aspects domain observed in the present study, this indicates that the improvement of the physical capacity and the tolerance to the exercises can contribute to greater participation in social interaction activities, such as those of leisure.[17,52] Studies emphasize the importance of physical training for the improvement of QoL, since depression, anxiety and fatigue are conditions commonly present in post-HT subjects.[53] In this way, physical training can positively impact the emotional aspect since it reduces these conditions.[52,53]

Limitations

This was a case study with a single volunteer, therefore generalizations cannot be made. However, since the goal was specific physical training in a relatively rare particular case, the type of design fits perfectly. The training period should have been extended to more weeks and the follow-up should have been performed after a longer period. In addition, the description of other data, from complementary exams, would be important to establish more correlations, as well as clinical and functional implications.

Conclusion

The present study demonstrated that a specific 10-week water-based exercise protocol, targeting a volunteer that underwent a recent HT, resulted in significant gains in muscle strength, improvement in functional capacity, walking speed and LVEF (%), as well as improvements in the quality of life.

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Conflict of interest

The authors declare no conflict of interest.

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