Hong Kong Physiotherapy Journal (2015) 33, 42–49

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.hkpj-online.com

RESEARCH REPORT

Exercise training improves functional walking capacity and activity level of Nigerians with chronic biventricular heart failure

O.A. Ajiboye, PhD [a,*], C.N. Anigbogu, PhD [b], J.N. Ajuluchukwu, MD [c], S.I. Jaja, PhD [b]

[a] *Department of Physiotherapy, Lagos University Teaching Hospital/College of Medicine, University of Lagos, Lagos, Nigeria*
[b] *Department of Physiology, College of Medicine, University of Lagos, Lagos, Nigeria*
[c] *Department of Medicine, College of Medicine, University of Lagos, Lagos, Nigeria*

KEYWORDS
activity level exercise training;
chronic heart failure;
functional walking capacity

Abstract *Background:* Exercise training (ET) has been recommended as an adjunctive therapy in chronic heart failure but the role of ET in people with biventricular heart failure (BVF) has not been explored in Nigeria.
Objective: This study aimed to investigate the role of ET on functional walking capacity and activity level of Nigerians with BVF.
Methods: Sixty-six patients with chronic BVF in New York Heart Association Class II and III (mean age 54.0 ± 1.6 years) recruited from a Nigerian tertiary hospital participated in the study. They were randomized into either the exercise group or control group. These patients were on their prescribed medications and underwent education/counselling sessions. In addition, patients in the exercise group performed aerobic and resistance training thrice weekly for 12 weeks. Functional walking capacity was assessed using the 6-minute walk test, oxygen consumption was estimated using the Duke Activity Status Index questionnaire while the Veterans' Specific Activity questionnaire was used to assess the activity level.
Results: The exercise group had significant improvements in all components of functional walking capacity and activity level. No significant improvement was observed in controls ($p < 0.05$).
Conclusion: Supervised and structured ET is safe and beneficial for patients with BVF.

* Corresponding author. Department of Physiotherapy, Lagos University Teaching Hospital, Idi-Araba, Lagos, Nigeria.
E-mail address: oaajiboye@yahoo.com (O.A. Ajiboye).

http://dx.doi.org/10.1016/j.hkpj.2014.11.002
1013-7025/

Introduction

Heart failure (HF) is characterized by the inability of the heart muscle to pump an adequate volume of blood to meet tissue energy demand that results in symptoms of fatigue or dyspnoea initially on exertion and then later on progressing to dyspnoea at rest [1,2]. It is a common and disabling syndrome that is a final pathway for a number of cardiac conditions [3]. HF is the most prevalent cardiovascular disease and the leading cause of sudden cardiac death in Nigeria [4]. Although the management of HF once focused exclusively on pump performance, HF is now considered a disorder whereby the peripheral effects of the disease are so debilitating that they warrant a treatment strategy that focuses on skeletal muscle improvement and improved exercise tolerance [3,5].

Despite major advances in pharmacological treatment of HF, the number of people afflicted with HF is rising yearly and many patients suffer from dyspnoea, fatigue, diminished exercise capacity, and poor quality of life [6]. In the past, patients with HF were advised to avoid physical exertion in the hope that bed rest might minimize symptoms and in the belief that physical activity might accelerate the progression of left ventricular dysfunction [7]. It is now known that a reduction in physical activity either produced by the symptoms of HF or prescribed by physicians treating HF leads to a state of physical deconditioning that contributes to these symptoms including exercise intolerance [8]. All these symptoms may lead to a significant reduction in physical and mental health, which results in a markedly decreased quality of life. However, in addition to pharmacotherapy, exercise training has been reported to have a place in its management especially in patients with left ventricular HF [9,10]. The majority of previous studies focused on HF of ischaemic origin and among Caucasians. However, there is need to understand the response to exercise training in other populations with systolic biventricular HF secondary to either hypertension or cardiomyopathy.

Despite recommendation of exercise training in most guidelines as a useful intervention for patients with stable chronic HF, acceptance of exercise training by the medical community as an adjunct in patient management has been less enthusiastic [3]. Many physicians remain concerned about implementation of exercise programme in this high-risk group, in terms of methodology and safety [11]. Standard exercise training protocols usually involve a combination of aerobic and resistance training. Beckers et al [12] demonstrated in HF patients that combined exercise training had a more pronounced effect on submaximal exercise capacity, muscle strength, and quality of life than pure endurance training, without unfavourable effects on left ventricular remodelling and outcome parameters [12].

Robust data on improvement in outcomes of exercise training in patients with chronic HF of ischaemic aetiology due to left ventricular dysfunction exist among Caucasians. There seems to be a dearth of literature for reference in Nigeria where HF is mainly nonischaemic in aetiology and the sufferers present late for medical care with biventricular HF. Thus, supervised exercise training has not been part of HF management in Nigeria. To address these gaps in knowledge, the present study investigated the role of exercise training on exercise walking capacity and activity level of Nigerians with stable biventricular HF.

Methods

Study design

A randomized controlled trial design was used in this study. There were two treatment arms: exercise group and control group. Outcome measurements were performed at baseline and immediately after the 12-week intervention period.

Patients

Patients were recruited from a population of chronic HF patients receiving treatment at the cardiology clinic of Lagos University Teaching Hospital, Lagos, Nigeria. They were in Class II and III of the New York Heart Association (NYHA) classification. The study was carried out in the medical gymnasium of the Physiotherapy Department, Lagos University Teaching Hospital. Sample size was calculated using the equation postulated by Eng [13]. The minimum number of patients expected to participate in the study was 46, with 23 in each group.

The patients involved in this study were Nigerians diagnosed with biventricular chronic HF secondary to hypertension or of dilated cardiomyopathy. The patients were oriented to person, place, and time, in Class II and III of New York Heart Association (NYHA) classification, on their standard pharmacologic therapy for HF (diuretics, ACE inhibitors, β blockers, and digoxin). They had no change in medical therapy for at least 30 days with resting ejection fraction $\leq$ 40% as measured by echocardiography medical diagnosis of HF either hypertensive or idiopathic in origin.

Individuals with the following conditions were excluded from participating: chronic HF of ischaemic origin, valvular diseases, and rheumatic diseases, clinical evidence of decompensated HF, atrial fibrillation, acute HF within the previous 3 months, unstable angina pectoris, end-stage renal disease, or orthopaedic impediments to exercise and patients participating in a formal exercise programme within 30 days prior to this study.

Ethical considerations

The protocol for this study was approved by the Health Research and Ethics Committee of the Lagos University Teaching Hospital, Idi-Araba, Lagos, Nigeria before the commencement of the study. Written consent was also obtained from patients prior to enrolment into the study. All experiments were done in accordance with the Declaration of Helsinki.

Randomization

The patients were randomized into the exercise group or control group. A randomization list was produced by a computer generated random-number sequence in blocks of 10 to ensure consistent patient distribution in both groups.

The numbers were put separately in sealed envelopes and patients were told to pick as they reported for the study.

Education and counselling sessions

All patients recruited for this study participated in educational sessions. These were given prior to commencement, at the end of the 6^{th} week and at the end of the 12^{th} week of the study. The sessions included general health talk on prevention of complications, lifestyle modification, and healthy living.

Control group

Patients in the control group received their medical care for HF, including standard pharmacological treatment at the HF clinic. They were encouraged to continue their usual activity levels and instructed not to initiate any new exercise training during the 12-week study period.

Exercise group

Patients in the exercise training group received the same medical care from the cardiology clinic plus aerobic and resistance training. The exercise protocol was structured according to the guidelines for patients in functional Classes II and III [14]. The exercise training intervention was given 3 d/wk over 12 weeks (36 sessions). Patients were monitored throughout the training sessions and supervised by the researcher and a research assistant who had been trained in the study protocol. Each exercise session lasted 60 minutes (10-minute warm-up phase, 20-minute aerobic phase, 20 minutes of strength/resistance training, and 10-minute cool-down phase).

All patients in the exercise group performed 10 minutes of warm-up exercises in the form of mild aerobic exercises, stretching/flexibility exercises. This involved a range of motion exercises in all the major joints of the upper, lower limbs, and trunk. The warm-up exercise was done caudo-cephally. Each joint was moved at 10 repetitions.

Aerobic exercise training was conducted using an electronic bicycle ergometer (Body Coach, China). The exercises were administered according to individual tolerance. During the 20-minute aerobic phase, patients were monitored with a Polar heart rate monitor (model Pulse Sonic China) and the exercise was maintained at 60—70% peak heart rate and the blood pressure checked at interval of 2—5 minutes using a sphygmomanometer digital blood pressure monitor (model HEM- 712 CLCN2, Omron Healthcare Inc., Bannockburn, IL, USA). Intensity of the exercise was maintained at Level 3—4 of perceived exertion on the modified Borg scale of perceived exertion. The loading on the ergometer was also progressed by 5 W individually depending on their responses to treatment at the end of each month. Exercise training was performed three times weekly for 3 months between 8.00 AM and 12.00 noon. The modified Borg [15] scale of perceived exertion was used to assess the intensity.

The muscle strength of the upper and lower limbs was assessed using dumb bells, hand dynamometer, and sand bags of known weights. Patients in the exercise group performed three sets of 50% of one repetition maximum (1RM) for 10 repetitions of four major muscle groups in both the upper and lower limbs (elbow flexion—extension and knee extension—flexion exercises) per set from the 1^{st} week to the 6^{th} week, 60% of 1RM for 10 repetitions per set from the 7^{th} week to the 12^{th} week. The 20 minutes of strength/resistance training included patients performing light upper-body exercises (hand grip, flexion, extension, adduction, and abduction at the shoulder joints at 10 repetitions of 20—25% of 1RM) and lower-body exercises (hip extension, flexion, adduction, abduction). Exercises such as reciprocal pulley and stair climbing were also included in the 20-minute strength/resistance training. Patients were monitored using polar heart rate monitor and the blood pressure was checked at intervals. The modified Borg scale of perceived exertion was used to monitor the intensity. These exercises were done three times weekly for 12 weeks. Patients were asked to rest for at least 10 minutes after the training. One minute of recovery period was observed by the patients following performance of a set of resistance exercise by each muscle group.

All patients in the exercise group performed 10 minutes of cool-down exercises after the aerobic training. These involved range-of-motion exercises in all of the major joints of the upper and lower limbs and the trunk before and after commencing resistance training.

Outcome measurements

At baseline, sociodemographic data (e.g., sex, age, race, marital status) and health history data were obtained through interview and patients' hospital files. Height and weight were measured using a stadiometer scale (Health Scale ZT-120; Seradon (Model ZT 120), China). Measurement of the following outcome variables were performed at baseline and 12th week of exercise training.

Six-minute walk test

The 6-minute walk test (6MWT) was used as a measure of functional status and exercise capacity. The 6MWT was carried out using a 30-m straight walk course marked out on the flat surface of the medical gymnasium with chair placed at both ends of the course. The research assistant who conducted the 6MWT was blinded to the group allocation. The participant was instructed to stand at the zero mark of the walk course, and then walk at their own pace, in order to cover as much ground as possible in a period of 6 minutes. They were allowed to stop and rest during the test in case of fatigue, but were instructed to resume walking as soon as they were able to do so. A pulse oximeter was used to monitor the oxygen saturation level (Model Lifeline Medical Devices, Haryana, India), The total walking distance covered during this period was measured and recorded in metres [16—18].

The estimated peak oxygen consumption was calculated from formulae derived from Duke Activity Status index (DASI) [19].

$$VO_{2peak} = (0.43 \times DASI) + 9.6 \text{ mL/kg/min} \quad [1]$$

$$\text{Metabolic equivalent} = VO_{2peak}/3.5 \text{ mL/kg/min} \quad [2]$$

Veteran's Specific Activity Questionnaire was also used to assess the activity level of these patients [20].

Cardiovascular-respiratory function

Resting arterial blood pressure (systolic and diastolic) was measured with Omron automatic blood pressure monitor (model HEM- 712 CLCN2; Omron Healthcare Inc.). This instrument was validated using an Accoson Mercury sphygmomanometer. Regular checks for consistency were done routinely every week. Patients were required to be seated for at least 20 minutes before the measurements were taken following standardized methods [16,21]. The average of two systolic and two diastolic blood pressure meaasurements were recorded respectively. The unit of measurement was mmHg. Resting heart rate was measured using Omron automatic blood pressure monitor while polar heart rate monitor was used to monitor the heart rate (beats/min) during the exercise.

A pulse oximeter (Model Lifeline Medical Devices, Haryana, India) was used to measure oxygen saturation level (%) of the patients. Resting respiratory rate (breaths/min) was determined by observing the chest excursions. Borg's scale of perceived exertion was used to assess rate of perceived exertion as a measure of level of fatigue and dyspnoea.

Data analysis

SPSS version 17 (SPSS Inc., Chicago IL, USA) was used to analyse the data. Descriptive statistics (mean, standard error of the mean) were computed for all study variables as appropriate. Independent t test was used to analyse between-group differences while paired t test was used to analyse within-group differences over time in all the parametric variables in this study. Wilcoxon signed rank test was used to analyse nonparametric data of New York Heart Association class within the groups. The level of significance was set at $p < 0.05$.

Results

A total of 199 individuals (107 men, 92 women) fulfilled all eligibility criteria, of whom only 80 gave their consent; 69 reported for the study and were randomized into the control group and exercise group with intention to treat (Fig. 1). Three patients were denied participation because they showed some signs of decompensation during baseline assessment. The total number of patients that completed the study was 51 (28 in the exercise group, 23 in the control group). Twenty-five of these individuals were in NYHA Class II and 26 were in Class III.

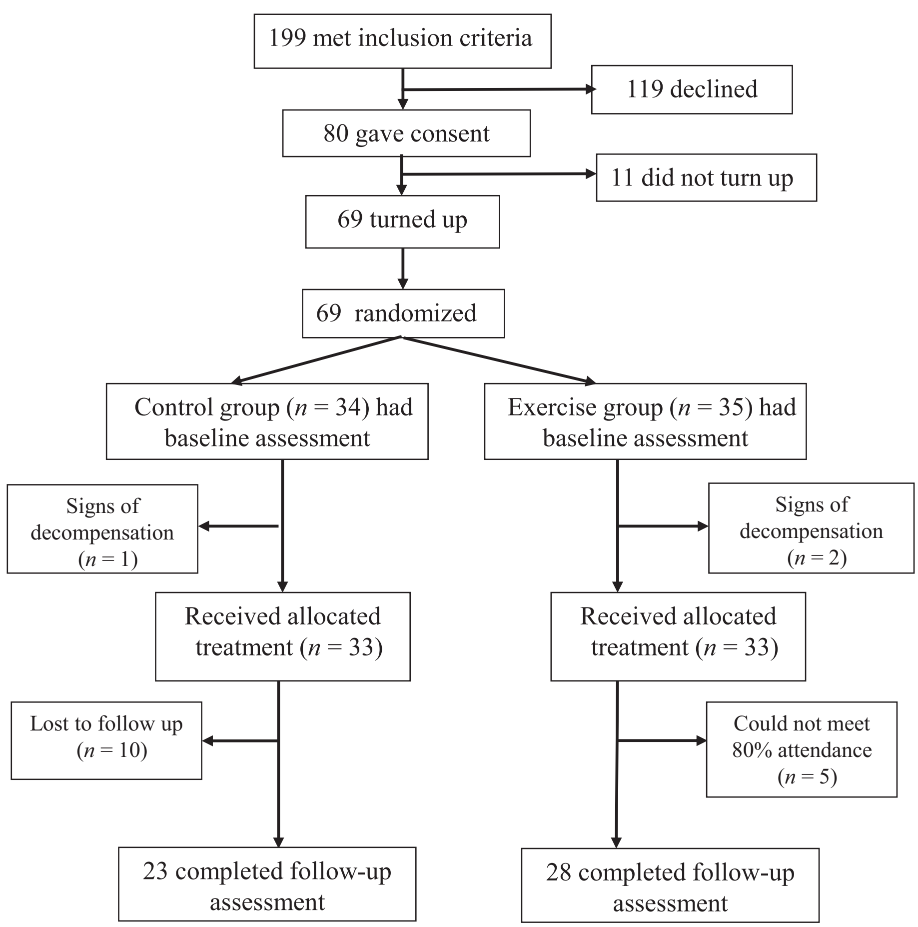

Figure 1. Study flow chart. A total of 51 patients completed the study.

Table 1 Physical characteristics of patients in both groups as a whole, and in the exercise and control groups individually.

Physical characteristics	Both groups Mean ± SEM ($N = 51$)	Control group Mean ± SEM ($n = 23$)	Exercise group Mean ± SEM ($n = 28$)	t	p
Age (y)	54.0 ± 1.6	51.5 ± 2.6	56.1 ± 2.0	1.442	0.156
Height (m)	1.65 ± 0.01	1.65 ± 0.02	1.65 ± 0.02	−0.097	0.923
Weight (kg)	77.0 ± 2.0	75.1 ± 3.4	78.6 ± 2.4	0.867	0.390
Body mass index (kg/m^2)	28.6 ± 0.7	27.7 ± 1.3	29.1 ± 0.9	0.969	0.338

Level of significance: $p < 0.05$.
SEM = standard error of the mean.

Among the patients who completed the study, 32 (62.7%) had systolic biventricular HF secondary to hypertension and 19 (37.3%) had biventricular HF secondary to dilated cardiomyopathy. None of the patients that participated showed adverse cardiac response to the training program and no severe long-term adverse events occurred.

Physical characteristics of the patients

Table 1 shows the physical characteristics of patients in the two groups. There was no significant difference in the age, height, weight, body mass index, distance walked in 6 minutes (6MWD), or classification according to NYHA standard between the two groups ($p > 0.05$).

Table 2 shows comparisons of functional walking capacity. There was a significant reduction in the functional capacity as measured by peak oxygen consumption as estimated by DASI ($p = 0.002$) in the control group. The change in 6MWD, however, was not statistically significant ($p = 0.168$). Among the controls, 13 patients were in NYHA Class II and 10 in Class III at baseline. After the 12-week study period, 15 patients were in Class II with 8 patients were in Class III. This change was not statistically significant ($p = 0.157$).

In the exercise group, there were significant improvements in the 6MWD ($p < 0.001$) and peak oxygen consumption as estimated by DASI ($p < 0.001$). Twelve patients were in Class II and 16 patients were in Class III prior to the exercise intervention. After the 12 weeks of exercise training, 14 patients were in NYHA Class I, 13 patients were in Class II, and only 3 patients were in Class III. This change was statistically significant.

A comparison between the groups showed no significant difference at baseline in all the variables of functional capacity but significant differences were observed after the intervention period ($p < 0.05$). Table 3 shows the mean changes in 6MWD, estimated peak oxygen consumption and activity level in the control and exercise groups after 12 weeks of intervention. There was a significant difference in mean changes in the 6MWD, estimated oxygen consumption, and activity level ($p < 0.001$) between the two groups.

Fig. 2 shows the comparison of changes in selected cardiorespiratory variables between patients in the control and exercise groups after 12 weeks of the study. There were significant difference in mean changes in the resting heart rate ($p = 0.030$), rate of perceived exertion, and resting respiratory rate ($p = 0.004$) while a significant difference in change was observed in oxygen saturation ($p < 0.001$) between the two groups, in favour of the exercise group. No significant change was observed in the resting diastolic blood pressure ($p = 0.105$) or resting systolic blood pressure ($p = 0.085$) after the 12 weeks of intervention.

Discussion

This study investigated the effects of aerobic and resistance exercise training on functional walking capacity and

Table 2 Within-group analysis of outcome variables.

Variables	Control group		t value/z value	p	Exercise group		t value/z value	p
	Pretest Mean ± SEM (a)	Post-test Mean ± SEM (b)			Pretest Mean ± SEM (c)	Post-test Mean ± SEM (d)		
6MWD (m)	404.0 ± 6.9	399.0 ± 12.1	1.482	0.168	414.1 ± 8.8	448.8 ± 6.6	−5.871	< 0.001**
PVO_2-DASI (mL/kg/min)	12.7 ± 0.2	12.2 ± 0.2	3.495	0.002*	12.8 ± 0.2	15.0 ± 0.2	−13.426	< 0.001**
PVO_2-VSAQ (mL/kg/min)	14.9 ± 0.5	14.1 ± 0.5	1.344	0.209	13.8 ± 0.4	21.9 ± 0.5	−16.156	< 0.001**
NYHA class	13/2; 10/3	15/2; 8/3	1.414	0.157	12/2; 16/3	14/1; 13/2; 2/3	−4.817	<0.001**

*$p \le 0.05$; **$p \le 0.001$.
6MWD = distance walked in 6 minutes; NYHA class = New York Heart Association class; PVO_2-DASI = peak oxygen consumption estimated from the Duke Activity Status Index questionnaire; PVO_2-VSAQ = peak oxygen consumption estimated from the Veteran's Specific Activity Questionnaire; SEM = standard error of the mean.

Table 3 Between-group comparison of change scores of functional walking capacity, estimated peak oxygen consumption and activity level after 12 weeks of exercise training.

Variables	Control group	Exercise group	t	p
Δ 6MWD (m)	−5.5 ± 3.7	34.8 ± 5.9	4.278	< 0.001
Δ in PVO_2 DASI (mL/kg/min)	−0.5 ± 0.1	2.2 ± 0.2	12.252	< 0.001
Δ VSAQ (metabolic equivalents)	−0.3 ± 0.2	2.2 ± 0.2	9.290	< 0.001

Δ 6MWD = change in 6-minute walk distance; Δ PVO_2 DASI = change in peak oxygen consumption as estimated from the Duke Activity Status Index questionnaire; Δ VSAQ = change in activity level as measured by the Veteran's Specific Activity Questionnaire.

activity level of Nigerians with chronic biventricular HF. In recent years, it has become evident that peripheral skeletal abnormalities are responsible for exercise intolerance and limitation seen in many patients with chronic HF [3,5]. The results of this study demonstrated beneficial effects of aerobic and resistance training on functional walking capacity and activity level of Nigerians with stable biventricular HF.

Methodological considerations

Some of the limitations encountered were that some of the patients with chronic HF were unwilling to participate in the study due to the fear of worsening conditions with exercise. Many of these patients came from other parts of the country to attend the cardiology clinic in Lagos and so were unable to stay in Lagos for thrice weekly appointments for a period of 12 weeks. These factors affected the number of patients who volunteered to participate for the study. Larson et al [22] in their study compared maximal, submaximal, and endurance exercise protocols in assessing the effects of exercise training in congestive HF and concluded that although maximal cycle tests are commonly used in clinical work, submaximal and endurance exercise tests might be preferable for evaluating new treatment regimens in this population as they are easy to perform, reproducible, and reflect daily tasks better than the maximal cycle test in this population. Some of the sophisticated equipment that could be used as a "gold standard" for cardiopulmonary exercise testing was not readily accessible in Nigeria, thus the need to use readily available and inexpensive outcome measures for the study, to make it reproducible in other parts of the country. Another limitation observed in this study is the use of DASI to estimate oxygen consumption, which is a measure of functional capacity of these patients. This may underestimate the oxygen consumption, and because this was the first study of its kind in Nigeria, it is advisable that further study should incorporate the use of cardiopulmonary exercise testing to assess oxygen consumption.

The 6MWT, one of the outcome measures used in this study, is a widely used measure of functional exercise capacity in individuals with cardiovascular, cardiopulmonary, and other chronic diseases. It has advantages over laboratory-based tests of exercise tolerance as it more closely resembles the ability to perform activities of daily living and does not require sophisticated equipment [23]. The 6MWT evaluates the global and integrated responses of all the systems involved during exercise, including the pulmonary and cardiovascular systems, systemic circulation, peripheral circulation, blood, neuromuscular units, and muscle metabolism [23,24].

The 6MWD shows moderate to good correlation with the peak oxygen uptake measured during an incremental cycle ergometry test in patients with moderate to severe chronic obstructive pulmonary disease [25,26] and congestive HF [27,28]. It is frequently used as an outcome measure in cardiopulmonary and cardiovascular rehabilitation and as

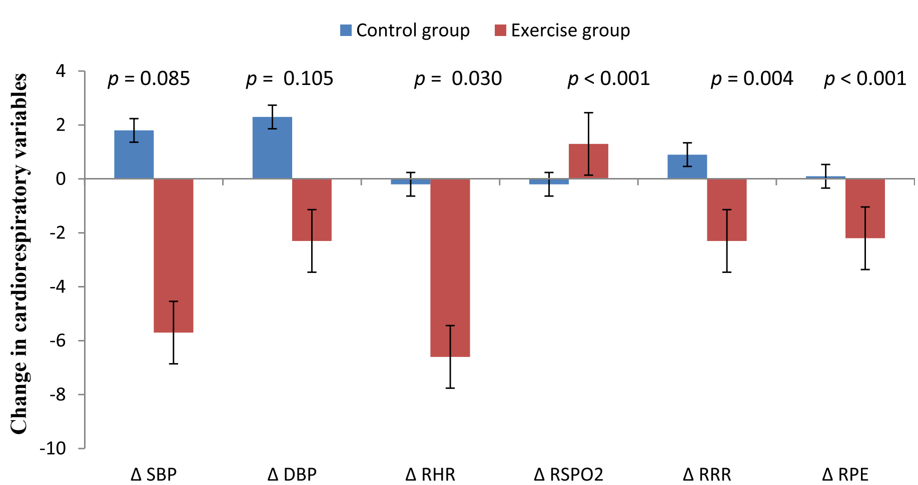

Figure 2. Between-group comparisons of change scores in cardiorespiratory variables. RDBP = resting diastolic blood pressure (mmHg); RHR = resting heart rate (beats/min); RPE = rate of perceived exertion (modified Borg scale); RRR = resting respiratory rate (breaths/min); RSBP = resting systolic blood pressure (mmHg); $RSPO_2$ = resting blood oxygen saturation (%).

an assessment tool in the selection of patients for lung and heart surgery [28,29].

Physical characteristics of patients in the control and exercise groups

This study showed no significant differences in age, height, weight, body mass index, or 6MWD at baseline between control and exercise groups. The age of the individuals with HF who participated in this study were comparable with other studies done in Nigeria [30,31]. This result also supported the finding of Kengne et al [32], who reported that HF in Africa occurs mostly in the 5^{th}–6^{th} decade of life. Thirty-three (55%) of the patients that participated in this study were females; this finding is consistent with the result of Mbakwem et al [31]. They reported that 52.1% of their study population was female.

Effects of exercise training on blood pressure

In this study, exercise training brought about a significant reduction in resting systolic blood pressure compared with the control group. This finding is in agreement with the result of Whelton et al [33], who reported that among three ethnic groups, black participants had significantly greater reductions in resting systolic blood pressure and Asian participants had significantly greater reductions in diastolic blood pressure compared with white participants. This result also supported the Kelley [34] study that reported a small but significant reduction of blood pressure after exercise intervention.

Effects of exercise training on functional walking capacity

This study showed a significant increase in 6MWD and estimated peak oxygen uptake in the exercise group after 12 weeks of training. No significant increase was observed in the measure of functional walking capacity in the control group. This finding shows that exercise training had a significant effect in improving walking capacity of patients in the exercise group. Similar results were observed by other researchers [35–37]. The improvement observed in the walking capacity and increase in the estimated peak oxygen consumption as assessed by DASI could be attributed to partial reversal of physical de-conditioning which is an invariable concomitant of this condition. Deconditioning may directly or synergistically (with cardiac dysfunction) worsen many of the adverse organ systemic changes that occur in HF. Mechanisms behind improved peak oxygen uptake and improvement in the 6MWD as observed in this study may be due to reversal of peripheral abnormalities such as endothelial dysfunction, skeletal muscle wasting and ventilation inefficiency seen in HF. In chronic HF, normal mechanisms of vasodilation to exercise are blunted, rather chronic vasoconstriction are seen. This chronic vasoconstriction leads to chronic hypoperfusion with impaired neurovascular response, which becomes more prominent as the severity of cardiac dysfunction increases [38]. The improvement observed in the functional capacity of these patients after the exercise training may be attributed to a reduction in blood pressure and improvement in oxygen saturation after 12 weeks of exercise training. All of these physiological changes result in an increased functional capacity and increase in activity level that directly improved the quality of life of these patients.

Effects of exercise training on activity level

The Veteran's Specific Activity Questionnaire was administered to assess the activity level. This study showed a significant improvement in the activity level of patients in the exercise group, but not the control group. The increase in activity level noted in this study may further explain the significant increase in oxygen consumption observed in this study because oxygen and other nutrients are readily made available for the muscles for optimal functioning.

Conclusion

This study shows that supervised and structured exercise training improves function walking capacity and activity level of individuals with biventricular HF. It is therefore recommended that patients with chronic systolic biventricular HF who are willing to commence exercise are advised to consult their health care providers for necessary medical and physiotherapy assessment for exercise prescription before they enrol for exercise training. Eligible patients must be subjected to a structured and supervised training within a hospital setting. Exercise training should be incorporated as part of the standard treatment of patients with chronic HF especially individuals with biventricular HF in Nigeria. For easy accessibility, cardiac rehabilitation centres should be domiciled in all the teaching and specialist hospitals in all the six geopolitical zones in Nigeria where exercise training will form core therapeutic intervention for these patients. Further research is needed to evaluate the effects of exercise training in the management of individuals with preserved ejection fraction (i.e., diastolic HF), the safety and efficacy of exercise training in acute HF and the effects of exercise training in children with HF.

Conflicts of interest

All contributing authors declare that they have no conflicts of interest.

Funding/support

No financial or material support of any kind was received for the work described in this article.

References

[1] Elahi M, Mahmood M, Shahbaz A, Malick N, Sajid J, Asopa S, et al. Current concepts underlying benefits of exercise training in congestive heart failure patients. Curr Cardiol Rev 2010;6:104–11.
[2] Fülster S, Tacke M, Sandek A, Ebner N, Tschöpe C, Doehner W, et al. Muscle wasting in patients with chronic heart failure:

results from the studies investigating comorbidities aggravating heart failure (SICA-HF). Eur Heart J 2013;34:512–9.
[3] Hunt SA, Abraham WT, Chin MH, Feldman AM, Francis GS, Ganiats TG, et al. 2009 Focused update incorporated into the ACC/AHA 2005 guidelines for the diagnosis and management of heart failure in adults: a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines. J Am Coll Cardiol 2009;53:e1–90.
[4] Adedoyin RA, Adesoye A. Incidence and pattern of cardiovascular disease in a Nigerian teaching hospital. Trop Doct 2005;35:104–6.
[5] Piña LP, Apstein CS, Balady GJ, Belardinelli R, Chaitman BR, Duscha BD, et al. Exercise and heart failure: a statement from the American Heart Association committee on exercise, rehabilitation, and prevention. Circulation 2003;107:1210–25.
[6] Van Tol BA, Huijsmans RJ, Kroon DW, Schothorst M, Kwakkel G. Effects of exercise training on cardiac performance, exercise capacity and quality of life in patients with heart failure: a meta-analysis. Eur J Heart Failure 2006;8:841–50.
[7] Mayosi BM. Contemporary trends in the epidemiology and management of cardiomyopathy and pericarditis in sub-Saharan Africa. Heart 2007;93:1176–83.
[8] Selig SE, Hare DL. Evidence-based approach to exercise prescription in chronic heart failure. Br J Sports Med 2007;41: 407–8.
[9] Giannuzzi P, Temporelli PL, Corra U, Tavazzi L. ELVD-CHF Study Group. Antiremodeling effect of long-term exercise training in patients with stable chronic heart failure: results of the Exercise in Left Ventricular Dysfunction and Chronic Heart Failure (ELVD-CHF) Trial. Circulation 2003;8:554–9.
[10] Downing J, Balady GJ. The role of exercise training in heart failure. J Am Coll Cardiol 2011;58:561–9.
[11] Tabet JY, Meurin P, Driss AB, Weber H, Renaud N, Grosdemouge A, et al. Benefits of exercise training in chronic heart failure. Arch Cardiovasc Dis 2009;102:721–30.
[12] Beckers P, Denollet J, Possemiers N, Wuyts F, Vrints C, Conraads V. Combined endurance-resistance training *vs.* endurance training in patients with chronic heart failure: a prospective randomized study. Eur Heart J 2008;29:1858–66.
[13] Eng J. Sample size estimation: How many individuals should be studied? Radiology 2003;227:309–13.
[14] Swedberg K, Cleland J, Dargie H, Drexler H, Follath F, Komajda M, et al. Guidelines for the diagnosis and treatment of chronic heart failure: executive summary: the Task Force for the Diagnosis and Treatment of Chronic Heart Failure of the European Society of Cardiology. Eur Heart J 2005;26: 1115–40.
[15] Borg GA. Psycho-physical basis of perceived exertion. Med Science Sports Exercise 1982;14:377–81.
[16] ATS Committee on Proficiency Standards for Clinical Pulmonary Function Laboratories. ATS statement: guidelines for the six-minute walk test. Am J Resp Critical Care Med 2002;166: 111–7.
[17] Anigbogu CN, Ajiboye O. Changes in cardiovascular response to six-minute walk test in some chronic heart failure patients. FASEB J 2010;24. 806.21.
[18] Olawale OA, Jaja SI, Anigbogu CN. Exercise training improves walking function in an African group of stroke survivors: a randomized controlled trial. Clin Rehabil 2011;25:442–50.
[19] Hlatky MA, Boineau RE, Higginbotham MB, Lee KL, Mark DB, Califf RM, et al. A brief self-administered questionnaire to determine functional capacity (The Duke Activity Status Index). Am J Cardiol 1989;64:651–4.
[20] Myers J, Do D, Herbert W, Ribi SLP, Froelicher VF. A nomogram to predict exercise capacity from a specific activity questionnaire and clinical data. Am J Cardiol 1994;73:591–6.
[21] Ajiboye OA, Anigbogu CN, Ajuluchukwu JN, Jaja SI. Therapeutic effects of exercise training on selected cardiopulmonary parameters and body composition of Nigerian with chronic heart failure (a preliminary study). Nig Q J Hosp Med 2013;23:295–301.
[22] Larsen AI, Aarsland T, Kristiansen M, Haugland A, Dickstein K. Assessing the effect of exercise training in men with heart failure; comparison of maximal, submaximal and endurance exercise protocols. Eur Heart J 2001;22:684–92.
[23] Solway S, Brooks D, Lacasse Y, Thomas S. A qualitative systematic overview of the measurement properties of functional walk tests used in the cardiorespiratory domain. Chest 2001;119:256–70.
[24] Olsson LG, Swedberg K, Clark AL, Witte KK, Cleland JG. Six minute corridor walk test as an outcome measure for the assessment of treatment in randomized, blinded intervention trials of chronic heart failure: a systematic review. Eur Heart J 2005;26:778–93.
[25] Carter R, Holiday DB, Stocks J, Grothues C, Tiep B. Predicting oxygen uptake for men and women with moderate to severe chronic obstructive pulmonary disease. Arch Phys Med Rehabil 2003;84:1158–64.
[26] Cahalin L, Pappagianopoulos P, Prevost S, Wain J, Ginns L. The relationship of the 6-min walk test to maximal oxygen consumption in transplant candidates with end stage lung disease. Chest 1995;108:452–9.
[27] Zugck C, Krüger C, Dürr S, Gerber SH, Haunstetter A, Hornig K, et al. Is the 6-minute walk test a reliable substitute for peak oxygen uptake in patients with dilated cardiomyopathy? Eur Heart J 2000;21:540–9.
[28] Kadikar A, Maurer J, Kesten S. The six-minute walk test: a guide to assessment for lung transplantation. J Heart Lung Transplant 1997;16:313–9.
[29] Roul G, Germain P, Bareiss P. Does the 6-minute walk test predict the prognosis in patients with NYHA class II or III chronic heart failure? Am Heart J 1998;36:449–57.
[30] Adebayo AK, Adebiyi AA, Oladapo OO, Ogah OS, Aje A, Falase AO. Characterisation of heart failure with normal ejection fraction in a tertiary hospital in Nigeria. BMC Cardiovascular Disorders 2009;9:1186–94.
[31] Mbakwem A, Aina F, Amadi C, Akinbode A, Mokwunyei J. Comparative analysis of the quality of life of heart failure patients in South Western Nigeria. World J Cardiovasc Dis 2013;3:146–53.
[32] Kengne AP, Amoah AG, Mbanya JC. Cardiovascular complication of diabetes mellitus in sub-Saharan Africa. Circulation 2005;112:3592–601.
[33] Whelton SP, Chin A, Xin X, He J. Effect of aerobic exercise on blood pressure: a meta-analysis of randomized, controlled trials. Ann Intern Med 2002;136:493–503.
[34] Kelley D. Paul Dudley White International Lecture. Our future society. A global challenge. Circulation 1999;95:2459–64.
[35] Maiorana A, O'Driscoll G, Dembo L. Effect of aerobic and resistance exercise training on vascular function in heart failure. Am J Physiol Heart Circ Physiol 2002;279:H1999–2005.
[36] Bocalini DS, dos Santos L, Serra AJ. Physical exercise improves functional capacity and quality of life in patients with heart failure. Clinics 2008;64:437–42.
[37] Hwang CL, Chien CL, Wu YT. Resistance training increases 6-minute walk distance in people with chronic heart failure: a systematic review. J Physiother 2010;56:87–96.
[38] Hambrecht R, Gielen S, Linke A, Fiehn E, Yu J, Walther C, et al. Effects of exercise training on left ventricular function and peripheral resistance in patients with chronic heart failure: a randomized trial. JAMA 2000;283:3095–101.