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Effects of Therapeutic Exercises on the Quality of Life and Upper Limb Muscle Strength of Individuals with Bi-Ventricular Heart Failure

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Abstract

Background: Despite remarkable progress in heart failure management, fatigue, Breathlessness, exercise intolerance and muscle wasting remain the hallmarks of the disease leading to impaired quality of life (QoL) and capacity for activities of daily living (ADLs). This study aimed to examine the effects of exercise training on the health-related quality of life and upper limb strength of individuals with bi-ventricular heart failure (BVF).

Methods: Sixty-six subjects with chronic BVF in Class II and III of the New York Heart Association were recruited from a Nigerian tertiary Hospital and randomized into two groups, the Exercise and the Control groups. Both groups were on their prescribed medications and underwent education/counselling sessions. The exercise group performed aerobic and resistance training three times a week for 12 weeks while the control group did not engage in any exercise training. The quality of life of the subjects was assessed using the Kansas City Cardiomyopathy Questionnaire (KCCQ) and SF-36 questionnaire. The hand dynamometer and One Repetition Maximum (1RM) were used to determine the handgrip and upper limb strengths. Data were analysed using the SPSS Package version 22 and presented using descriptive statistics of Mean ± SEM. The level of significance was set at $p < 0.05$.

Results: The results showed that the exercise group experienced significant improvement in all domains of QoL, upper limb strength and grip strength while the control group only showed significant improvement in the Knowledge and Perception domains.

Conclusion: It can be concluded that therapeutic exercise positively impacts the general health and symptoms experienced by individuals with Chronic Bi-ventricular heart failure. This suggests that exercise training should be considered a beneficial intervention for improving QoL and muscle strength of individuals with bi-ventricular heart failure.

Keywords: Exercise training; Bi-ventricular heart failure; Quality of life; Muscle strength

Introduction

Cardiovascular disease remains a major global health concern affecting both developed and developing countries; In 2010, cardiovascular diseases accounted for a significant proportion of all deaths in the United States of America, emphasizing the urgent need for effective prevention and treatment strategies, especially for heart failure, which poses a substantial burden on healthcare systems worldwide [1-4].

Heart failure in Africa presents unique characteristics, often affecting individuals at a relatively young age, with a higher incidence during the 5th and 6th decades of life . While research on heart failure in Sub-Saharan Africa is limited, available evidence suggests that the prevalence and rate of hospital admissions for heart failure are comparable to global figures, but the underlying pathophysiology and aetiologies differ. Non-ischemic causes, such as hypertensive heart disease, rheumatic heart disease, and cardiomyopathy, account for over 75% of heart failure cases in many developing countries, particularly in Sub-Saharan Africa , attributed to climate, genetic factors, and socioeconomic disparities . Heart failure is characterized by the heart's inability to pump sufficient blood to meet the body's energy demands, leading to symptoms like fatigue and dyspnea, initially occurring during exertion and later even at rest [5-10]. As the most prevalent cardiovascular disease, heart failure is a major health problem in Nigeria and a leading cause of sudden cardiac death. Despite progress in therapeutic approaches to chronic heart failure (CHF), exercise intolerance remains a hallmark of the disease [9].

To address the rising prevalence of heart failure and its associated symptoms, it is imperative to identify optimum pharmacologic and nonpharmacologic therapies aimed at reducing symptoms and improving physiological and psychological functioning, ultimately enhancing overall quality of life [10]. While substantial progress has been made in pharmacological treatment, the number of people affected by heart failure continues to rise annually, with many patients experiencing dyspnea, fatigue, diminished exercise capacity, and a poor quality of life [11].

While data on heart failure in developing countries, including Nigeria, may not be as robust as in Western societies, several trends are evident. Causes of heart failure tend to be predominantly non-ischemic, with patients presenting at a younger age. Outcomes are often worse in regions with limited healthcare resources and isolated right heart failure and biventricular heart failure are more prevalent. Various factors, such as a lack of universally agreed definition, challenges in definitive diagnosis, pollution, and limited healthcare resources, have been postulated to contribute to these trends [6].

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Despite the relevance of exercise training as a potential intervention for heart failure, there is a lack of studies in Nigeria focusing on the effects of exercise training on patients with biventricular heart failure of non-ischemic origin. Consequently, supervised exercise training has not been part of the management of this condition in Nigeria. Addressing these knowledge gaps, we hope to contribute valuable insights that may inform the development of effective therapeutic strategies to improve the well-being and outcomes of individuals with biventricular heart failure in Nigeria.

Methods

Subject selection

The participants in this study were recruited from the population of chronic heart failure patients undergoing treatment at the cardiology clinic of a tertiary hospital in Lagos, Nigeria. Specifically, individuals in Class II and III of the New York Heart Association (NYHA) classification were included. The study took place in the medical gymnasium of the Physiotherapy department within the same institution (Table 1).

Table 1: Physical characteristics of subjects in both, exercise and control groups.

Physical Characteristics	Both Groups Mean ± SEM	Control Group	Exercise Group	t-value	p-value
	N = 51	Mean ± SEM	Mean ± SEM		
		N = 23	N = 28		
Age (years)	54.0 ± 1.6	51.5 ± 2.6	56.1 ± 2.0	1.442	0.156
Height (meters)	1.65 ± 0.01	1.65 ± 0.02	1.65 ± 0.02	-0.097	0.923
Weight (kilograms)	77.0 ± 2.0	75.1 ± 3.4	78.6 ± 2.4	0.867	0.39
Body mass index (kg/m2)	28.6 ± 0.7	27.7 ± 1.3	29.1 ± 0.9	0.969	0.338

Instruments Used: Various instruments were employed for data collection in this study as reported in the earlier publications [12,13].

Study design: A randomized controlled trial design was employed, and a computer-generated random-number sequence in blocks of 10 was used to ensure consistent distribution of patients into both the control (CG) and exercise training (EG) groups. Outcomes were measured at baseline and after 12 weeks [13]. Inclusion Criteria, Exclusion criteria, ethical approval and study procedures (Tables 2 and 3).

Resistance training: Strength training for upper limbs involved the use of dumbbells, hand dynamometer, and sandbags of known weights. Subjects performed three sets of 10 repetitions at 50% of one repetition maximum (1RM) for four major muscle groups in upper limbs from the 1st to the 6th week. From the 7th to the 12th week, the intensity was increased to 60% of 1RM. The 20-minute strength/resistance training also included light upper-body exercises (hand grip, flexion, extension, adduction, and abduction at the shoulder joints at 10 repetitions of 20-25% of 1RM). Exercises like a reciprocal pulley was also included. The intensity was monitored using the Polar heart rate monitor and the modified Borg scale of perceived exertion. Resistance exercises were performed three times weekly for twelve weeks, with subjects resting for at least 10 minutes after each training set and observing a one-minute recovery period following each muscle group exercise (Table 4).

Assessment of quality of life

Two quality of life instruments were used to assess the response of the subjects to management in this study. They were Kansas City for Cardiomyopathy Questionnaire (KCCQ) a 23-items disease specific questionnaire was analysed in 9 domains and SF-36, a 36-items health related QoL questionnaire with 8 domains providing information about several areas of quality of life.

Table 2: Pre-test and Post-test assessment of quality of Life (KCCQ) in the control and exercise groups.

Kansas Domains	Control Pre- test Mean Rank (a)	Group Post-test Mean Rank (b)	Z- value (a&b)	P-value (a&b)	Exercise Pre- test Mean Rank (c)	Group Post-test Mean Rank (d)	Z-value (c&d)	P- Value. (c&d)
QoL –KANSAS	95.6±17.2	94.1±18.6	-0.357	0.721	99.2±12.5	118.2± 9.1	-4.625	<0.001**
Activity limitation	20.1±4.7	20.4±4.5	-0 .777	0.437	19.1± 4.1	13.7 ± 2.6	-4.637	< 0.001**
General symptoms	2.9±1.5	2.9±1.1	<0.001	1	2.3±1.2	1.1 ± 0.3	-3.674	<0.001**
Swelling	3.3±1.7	2.9±1.5	-1.537	0.124	3.3 ± 1.8	1.8±0.4	-3.548	< 0.001**
Fatigue	6.2±2.9	6±2.8	-0.503	0.615	4.9 ± 2.4	1.9 ± 1.0	-4.567	< 0.001**
Dyspnoea	6.4±2.9	6.3± 2.9	-0.46	0.646	5.8 ± 2.9	1.8 ± 0.7	-4.661	< 0.001**
Knowledge	6.4±2.4	7.4±1.8	-3.63	0.001**	6. 9 ± 2.2	9.5 ± 0.9	-4.319	< 0.001**
Perception	2.3 ±1.4	1.9 ±1.8	-2.714	0.007*	4.5 ± 0.6	1.6±0.6	-4.702	< 0.001**
Mood	2.8 ±1.1	2.9±1.3	-0.449	0.653	3.0 ± 1.0	1.4 ± 0.6	-4.443	<0.001**
Participation restriction	12.2 ±3.6	11.9 ± 4	-0.613	0.54	13.1± 3.4	8.0 ± 2.1	-4.646	< 0.001**

Table 3: Pre-test and post-test assessment of health related quality of life as measured by (SF-36) within and between the control and exercise groups using Wilcoxon rank test and Mann-Whitney U respectively.

SF-36 Domains	Control	Group			Exercise	Group	Z-value	P– value	Z-value	P– value	Z-value	P – value
	Pre-test	Post-test	Z-value	P- value	Pre-test	Post-test	(c&d)		(a&c)	(a&c)	(b&d)	(b&d)
	Mean Rank	Mean Rank (b)			Mean Rank	Mean Rank		(c&d)				
	(a)		(a&b)	(a&b)	(c)	(d)						
General Health	19.4±3.8	19.6±4	0.17	0.865	18. 4 ± 3.1	27.7 ± 4.0	-3.998	< 0.001**	-0.385	0.699	-2.427	0.015*
Physical function	20.6±3.6	20.3 ±4.3	-0.213	0.832	21.7 ± 3.0	25.1 ± 2.3	-4.086	< 0.001**	-0.894	0.371	-3.177	0.001**
Role physical	14.8 ± 3	14.2 ±3.7	0.711	.0.477	13.8 ± 3.4	17.4 ± 3.4	-4.091	< 0.001**	-0.651	0.515	-2.334	0.020*
Role emotion	11.5 ± 3	11.3 ± 3.4	0.541	0.589	10.3 ± 3.7	13.3 ± 2.7	-4.113	< 0.001**	-0.994	0.321	-1.694	0.09
Social function	8.5 ± 1.5	6.5 ± 3	0.001	1	6.0 ± 1.2	8.6 ± 1.4	-4.32	< 0.001**	-0.983	0.325	-3.558	<0.001**
Bodily Pain	7.2 ± 1.7	6.6 ± 1.6	0.211	0.226	6.4 ± 1.3	3.5 ± 2.0	-4.563	< 0.001**	-1.967	0-049	-3.985	<0.001**
Vitality	12.5 ± 2.5	11.9 ± 2.1	0.471	0.638	13.4 ± 2.5	15.4 ± 2.0	-3.506	< 0.001**	-0.798	0.425	-3.917	<0.001**
Mental Health	18.3 ± 3.6	17.2 ± 2.9	1.208	.0.227	18.8 ± 2.8	20.5 ± 3.0	3.452	0.002*	-0.765	0.445	-3.072	0.002*

Kansas city cardiomyopathy questionnaire (kccq)

The QoL of each subject in the control and exercise groups was assessed at baseline and at 6th and 12th week for the exercise group and at baseline and 12th week for the control of the study period. This was done using a self-administered, 23-item questionnaire, the Kansas City Cardiomyopathy Questionnaire (KCCQ) developed to provide a better description of health-related quality of life (HRQoL) in patients with chronic heart failure regardless of aetiology. Each item has a five-, six- or seven-point Likert scale. The questionnaire was analysed in 9 domains of HRQoL (Figures 3 and 4) (14). The overall QoL of the subjects studied was assessed according to their groups. The domains assessed were activity limitation, general symptoms, swelling, fatigue, dyspnoea, knowledge, perception, and mood and participation restriction/ lifestyle. The overall QoL is taking as the sum of these domains' scores with lower scores indicating lower symptom burden and better quality of life except the overall QoL and knowledge domains where higher scores indicate better QoL. Scaling responses included a range of 5-7 options including: 'Extremely Limited' to 'Not at all Limited', 'Much worse' to 'I've had no symptoms', 'Every morning' to 'Never over the past 2 weeks', 'Extremely bothersome' to "Not at all bothersome", "Not at all sure" to "Completely sure" and "Severely limited" to " Did not limit at all" This instrument had been found to be a valid and reliable way of measuring HRQoL of people with heart failure [14 -16].

36-item short form health survey (sf-36)

The 36-Item short form health survey (SF-36) is a self-administered 36-item questionnaire developed in a generic form to assess the general health of individuals with health challenges. The SF-36 consists of 8 domains. These domains include General function, Physical function, Role physical, Role emotion, Social function, Bodily pain, Vitality and Mental health. Higher scores in all the domains except the Bodily pain domain implied better quality of life. The SF-36 has been extensively validated and used in patients with many diseases including coronary artery disease and CHF [17].

Analysis

Statistical Package for Social Sciences (SPSS version-22) was used to analyse the data. Descriptive statistics (e.g., mean, standard error of mean, frequency distributions, and percentages) were computed for all study variables. Independent *t*-test was used to analyse group differences while paired t-test was used to analyse pre-tests and post-tests differences in all the parametric variables in this study. Mann-Whitney U test was used to analyse the group differences while the Wilcoxon test was used to rank the pre-test and post-test differences in all the non-parametric variables in this study. Level of significance was set at $P < 0.05$.

Figure 1: 1a and 1b showing patients performing aerobic exercise and one repetition maximum during the training.

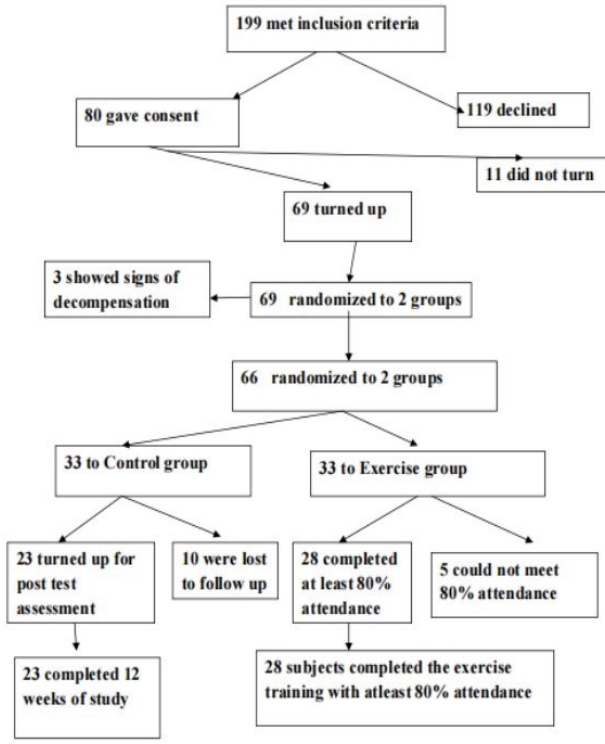


Figure 2: Flow chart showing patients' responses during the study.

Results

All the subjects that met inclusion criteria were 199 (male- 107, female -92) out of which only 80 gave their consent, 69 reported for the study and were consecutively randomized into control group and exercise group with intention to treat. Three patients were denied participation because they showed some signs of de-compensation during baseline assessment. Twenty-three (23) out of 33 subjects in CG reported for post-test assessment while 28 out of 33 subjects in EG completed at least 80% attendance. The total number of subjects that completed the study were 51 (25 in class 11; 26 in class 111 of NYHA). Twenty-three (23) (male-11, female- 12) were in CG and 28 (male-11, female-17) were in EG. Among the subjects that completed the study, 32 (62.7%) had biventricular heart failure secondary to hypertension, 19 (37.3%) had biventricular heart failure secondary to dilated cardiomyopathy (DCM). None of the subjects that participated showed adverse cardiac response to the training program. No severe long-term adverse events occurred either (Figure 2).

Discussion

This study evaluated the effects of aerobic and resistance exercise training on the health-related quality of life of Nigerians with bi-ventricular heart failure. In recent years, it has become evident that peripheral skeletal abnormalities are responsible for exercise intolerance and limitation seen in many patients with CHF [4,8]. The results of this study demonstrated that therapeutic exercise training improved the health-related quality of life of Nigerians with stable bi-ventricular failure.

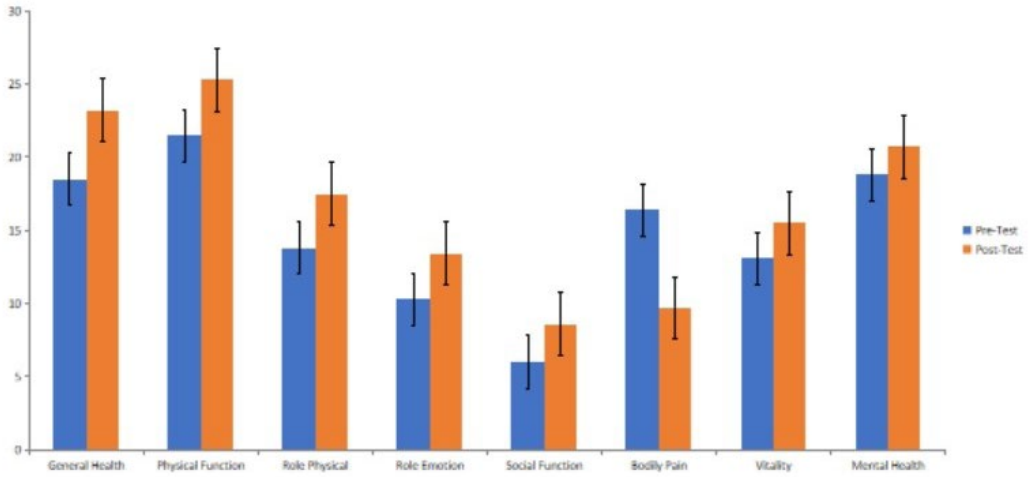
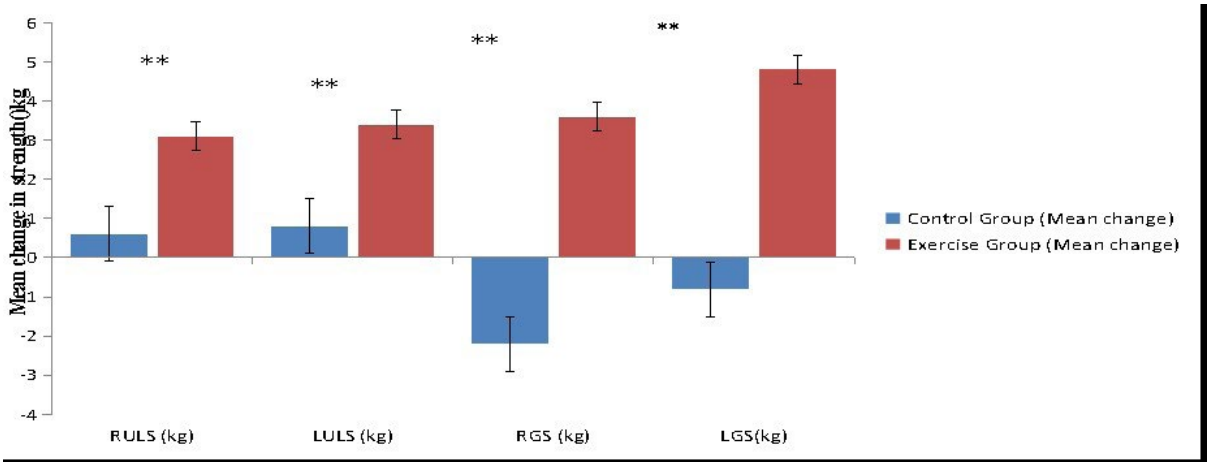


Figure 3: Pre-test and post-test assessment of HRQoL as measured within the exercise group using Wilcoxon rank test.



** - p < 0.01 RULS -Right Upper Limb Strength; LULS – Left Upper Limb Strength; RGS – Right Grip Strength; LGS– Left Grip Strength.

Figure 4: Comparison of changes in muscle strength and grip strength variables between subjects in control and exercise groups after 12 weeks of study.

Shows comparison of changes in upper limb muscle strength and grip strength variables between subjects in control and exercise groups after 12 weeks of study.

There were significant differences in general muscle strength in the right upper limb ($p < 0.001$), left upper limb ($p < 0.001$), right upper limb grip strength ($p = 0.001$) and left grip strength ($p = 0.007$). Subjects in EG had significant greater muscle strength and Grip strength than the control group after the study.

Physical characteristics of subjects in the control and exercise groups

The result of this study shows no significant differences in age, height, weight, body mass index and six-minute walk distance at baseline between control and exercise groups. The age of the individual with heart failure that participated in this study were comparable with other studies done in Nigeria [3, 7, 16]. This result also supported the finding of Kengne *et al*., (2005) who reported that HF in Africa occurs mostly between 5th to 6thdecade of life. Thirty-three (55%) of the subjects that participated in this study were females, this finding is also consistent with the result of Mbakwem *et al*., 2013 who reported that 52.1% of their study population was females.

Effects of exercise training on quality of life

In this study, the combination of aerobic and resistance exercise had significant improvement in all 8 domains of SF-36 HRQoL and 9 domains of KCCQ (disease-specific QoL) of subjects in the EG. In the control group, significant improvement was observed only in the knowledge and perception domains as measured by KCCQ, the other 15 domains of the quality of life did not improve significantly [18-20]. These findings agree with other investigators and assume an important context since studies have demonstrated a strong association between recurrent cardiovascular events and psychosocial problems such as depression, anxiety and social isolation [21]. It has been reported that HF significantly decreases health-related quality of life (HRQOL), especially in the areas of physical functioning and vitality [22]. Lack of improvement in HRQOL after discharge from the hospital has been reported to be a powerful predictor of rehospitalization and mortality [23].

Women with HF have consistently been found to have poorer HRQOL than men [24]. Ethnic differences also have been found, with Mexican Hispanics reporting better HRQOL than other ethnic groups in the United States [25]. Other determinants of poor HRQOL include depression, younger age, higher body mass index (BMI), and greater symptom burden.

Effects of exercise training on muscle strength

The results of the study demonstrate that exercise training had a significant positive impact on muscle strength in individuals with stable bi-ventricular heart failure. The participants who underwent exercise training showed substantial increases in both right (21.8%) and left (22.2%) upper limb muscle strength, as well as grip strength in the right (12.7%) and left (18.3%) hand. In contrast, no significant improvement in muscle and grip strengths was observed in the control group. Chronic heart failure often presents with myopathy syndrome, which can range from mild muscle weakness to severe cachexia. Incorporating resistance (strength) training into the management of patients with heart failure aims to partially reverse muscle wasting and weakness, ultimately enhancing their ability to perform activities of daily living (ADLs) and overall quality of life. It is well-established that moderate-intensity strength training can lead to improvements in aerobic capacity, partly through enhancing skeletal muscle mitochondrial ATP production rates (Figure 1). The observed increase in muscle strength and the potential for increased muscle mass in this study could translate into enhanced physical activity levels for the participants. This, in turn, may improve their ability to perform ADLs and lead to an overall improvement in their quality of life. Similar results were observed by Maiorana et al (2002), [19, 26]. The improvement could be attributed to partial reversal of physical de-conditioning which is an invariable concomitant of this condition. De-conditioning may directly or synergistically (with cardiac dysfunction) worsen many of the adverse organ systemic changes that occur in heart failure. Mechanisms behind this improvement may be due to reversal of peripheral abnormalities such as endothelial dysfunction, skeletal muscle wasting and ventilation inefficiency seen in heart failure.

Strengthening the upper limbs of patients with heart failure holds particular importance. These individuals often face challenges related to muscle weakness in their upper limbs, which can affect their ability to perform daily tasks. Any intervention that can increase the strength of these limbs may contribute to reducing oxidative stress and levels of fatigue experienced by these patients [27]. Consequently, this improvement in strength may lead to increased oxidative capacity in these individuals during physical activities [12,13, 28] . Hulsmann M et al., 2004 reported muscle strength as one of the major predictors of survival in acute congestive heart failure. Furthermore, the reduction in cardiovascular load during exercise is influenced by the percentage of muscle mass utilized. By increasing the strength of specific muscle groups, the percentage of muscle mass engaged in lifting a certain weight decrease, thus lowering the cardiovascular load. This adaptation could be associated with an increase in mitochondrial density, reflecting an enhancement in the oxidative capacity of the trained skeletal muscles.

In conclusion, the findings of this study underscore the positive effects of exercise training on muscle strength in patients with stable bi-ventricular heart failure. The increase in muscle strength observed in the upper limbs may have implications for the patients' daily functioning, overall physical activity levels, and ultimately, their quality of life. These results support the integration of exercise training, particularly strength training, as an essential component of the management of individuals with heart failure, to optimize their functional capacity and well-being.

Conclusion

It can be concluded that therapeutic exercise positively impacts the general health and symptoms experienced by individuals with Chronic Bi-ventricular heart failure. This suggests that exercise training should be considered a beneficial intervention for improving and muscle strength of individuals with bi-ventricular heart failure.

Conflict of Interest

The authors declare no conflict of interest.

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