ORIGINAL ARTICLE

Pulmonary Function Responses to Active Cycle Breathing Techniques in Heart Failure Patients at the University Teaching Hospital (UTH), Lusaka, Zambia

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ABSTRACT

Chronic heart failure patients experience restrictive respiratory dysfunction, resulting in alterations of FEV_1, FVC and FEV_1/FVC as demonstrated in exercise intolerance, dyspnoea and poor quality of life (QoL). Active Cycle of Breathing Techniques (ACBT) is traditionally used by Physiotherapists in the management of respiratory conditions. The aim of this study was to investigate the physiological effects of ACBT on pulmonary function in stable heart failure (HF) patients (New York Heart Association Functional class II and III) at the University Teaching Hospital (UTH) in Lusaka, Zambia.

Methods*:* This prospective cohort study investigated the pulmonary function response to ACBT in heart failure patients at UTH Lusaka, Zambia. A Minnesota questionnaire was used to collect anthropometric and QoL data; respiratory function tests were done by a handheld spirometer at baseline, 6 weeks and 12 weeks. ACBT were conducted on 3 days of the week for a total of 12 weeks. STATA version 11.2 was used for data analysis.

Results*:* A total of 23 patients, mean age 54.0 years (range 25-77), participated in the study. The lung function volumes were reduced at baseline as expected (FVC = 2.9L, FEV_1 = 2.0L and FEV_1/FVC = 70.1%). There was hardly any change at 6 weeks (FVC = 2.7 L, FEV_1 = 1.9 L and FEV_1/FVC = 70.2 %). There was a slight increase in the means at 12 weeks (FVC = 2.8L, FEV_1= 2.0 L and FEV_1/FVC = 73.0%) which was statistically insignificant ($p= 0.73$). However there was a statistically significant improvement in quality of life at both 6 and 12 weeks of intervention (($p< 0.0001$).

Conclusion: ACBT exercises facilitate modest increases in ventilatory function but significantly improve HF related symptoms, greatly improving the quality of life in heart failure patients.

INTRODUCTION

Chronic heart failure is associated with mild to moderate restrictive or obstructive changes in pulmonary function [1], which are caused by structural, functional and biological alterations [2]. About 50% of severe heart failure patients are said to have restrictive airway dysfunction and reduced lung compliance, secondary to heart enlargement, lung parenchyma stiffness and congestion [3], contributing to a reduction in Forced Vital Capacity (FVC) and Forced Expiratory Volume in one second (FEV_1), however, FEV_1/FVC ratio remains normal or increases [4]. The patients experience dyspnea, cough, fatigue, reduced respiratory muscle mass, and fluid retention [5], resulting in a 30-50% reduction in their

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functional capacity [6]. HF patients are classified according to the NYHA functional class and severity, based on symptoms and physical activity. HF Patients in NYHA functional class II have slight limitation of physical activity, comfortable at rest, but ordinary physical activity results in fatigue, palpitation or dyspnea; NYHA III patients on the other hand, have marked limitation of physical activity, they are comfortable at rest, but less than ordinary activity results in fatigue, palpitation or dyspnea.

Generally, these patients are often characterized by exercise intolerance associated with poor prognostic effects such as increase in morbidity, mortality and poor quality of life despite advanced pharmacological intervention [7]. Stable heart failure patients may tolerate an amount of exercise [8] which is said to lower disease progression if properly implemented [9].The traditional use of ACBT has been documented in many studies [7]; [10]; [11], where ACBT are taken for clearance of bronchial secretions, lung function improvement and strengthening of the respiratory muscles. While the benefits of these exercises have been documented elsewhere, there is limited information in the Zambian population on the effects of ACBT on lung volumes in HF. This study investigated the physiological effects of ACBT on pulmonary function in HF patients.

METHODS

This prospective cohort study determined the pulmonary function response to ACBT in HF NYHA function class II and III from the Cardiology Outpatient Clinic of the UTH. The data was collected using a portable Spirometer (DATOSPIR- 70, SN117- B696), weighing scale, wall stadiometer (SECA 220, manufacturer) and an administered Minnesota questionnaire. A pre-test was done on 5 randomly selected HF patients. Analysis of data was done using repeated measure Analysis of Variance (ANOVA) in STATA version 11 and summarized using descriptive statistics. All values were expressed as the mean ± SD (standard deviation). A value of $P < 0.05$ was considered significant in all cases comparing baseline, 6 weeks and 12 weeks.

ACBT Exercise Protocol

Thirty minutes of supervised ACBT exercise per session were given to the participants in a sitting position; this was done on 3 days of the week for a period of 12 weeks. The exercises comprised; breathing control exercises to promote relaxation of the lungs and pulmonary muscles. Participants took gentle, quiet and relaxed breaths; these were repeated 4 - 5 times in sitting position. Thoracic expansions involving deep inspiration combined with 3 - 4 seconds breath- holding before passively exhaling were also done. Finally Forced Expiration Techniques (Huffing) were done.

Ethical approval was obtained from the Biomedical Research Ethics Committee at the University of Zambia (Ref No 014-03-14).

RESULTS

Main Demographic information and physical characteristics

The total sample size consisted of 23 cardiac patients, mean age was 54.0 years (range 25-77); 16 (69.6%) were females and 7 (30.4%) were males. The mean BMI for males was 25.5 kg/m^2 and 26.1kg/m^2 for females which remained relatively unchanged at 6 weeks and 12 weeks (Table 1). The comorbidities (n=23) in this study were as follows; chronic obstructive pulmonary diseases 2 (8.6%); hypertension 11 (47.8%); diabetes 3 (13.0%); retroviral disease 4 (17.4%); myocardial infarction 2 (8.6%) and sickle cell anemia 1 (4.3%).

Table 1: Basic characteristics of participants by sex

Variable (n=23)	**Male**			**Female**		
Number	7			16		
Mean age (range)	59.3(40-76 years)			51.4(25-77 years)		
Height(meter) (SD)	1.7 (0.1)			1.6 (0.1)		
Duration	Baseline	Week 6	Week12	Baseline	Week 6	Week12
Weight (kg)	72.6(18.8)	75.4(15.2)	75.0(15.4)	65.4(18.9)	66.0(18.7)	65.7(18.6)
BMI (kg/m$^{2)}$	24.0 (3.0)	24.4 (2.8)	24.2 (2.5)	26.1 (6.7)	26.2 (6.3)	26.1(6.3)

LUNG FUNCTION TESTS

At baseline the mean FVC was 2.7 ± 1.1 liters, FEV1 was 1.9 ± 0.7L, and FEV$_1$/FVC was 70.1 ± 14.7%. There was no significant change in mean parameters at 6 weeks.

However there was a slight increase in the means at 12 weeks; FVC was 2.8 ± 1.1L, FEV_1 was 2.0 ± 0.8 L and FEV_1/FVC was 73.0 ± 13.6%. One way repeated measure ANOVA computed to estimate the change from baseline to 12 weeks of ACBT showed no significant difference (Table 2). The percentage change from baseline to 12 weeks in the FVC was 3.6%, FEV_1 was 5.3% and FEV_1/FVC was 4.0% (Table 3).

Table 2: Summary of clinical lung volumes

Variables	Units	Mean (SD) baseline	Range	Mean (SD) 6 weeks	Range	Mean (SD) 12 weeks	Range	P Value For ANOVA
FVC	L	2.7 (1.1)	1.1-5.4	2.7 (1.0)	1.2-4.8	2.8 (1.1)	1.1-4.8	0.70
FEV_1	L	1.9 (0.7)	0.6-3.8	1.9 (0.7)	1.0-3.6	2.0 (0.8)	0.8-3.4	0.43
FEV_1/FVC	%	70.1(14.7)	40.1-94.4	70.1 (12.0)	40-80	73.0 (13.6)	30-94.3	0.49

Table 3: Percent change in FVC, FEV_1 and FEV_1/FVC

Variable	baseline	Week 6		Week 12	
		Measure (L)	% change	measure	% change
FVC (L)	2.70	2.74	2.1	2.80	3.6
FEV_1 (L)	1.9	1.9	0.0	2.0	5.3
FEV_1/FVC %	70.1%	70.1%	0.0	73.0%	4.0

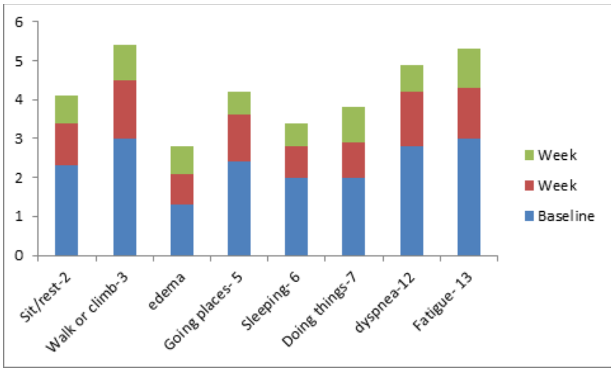
Table 3 shows the percentage changes in lung volumes from baseline to 12 weeks

Quality of life for participants after 12 weeks of ACBT

The quality of life measure was desegregated into three domains namely, 1) Physical factors, 2) Psycho-Social factors and 3) Mental/emotional factors, each of which had different weightings as per the Minnesota questionnaire.

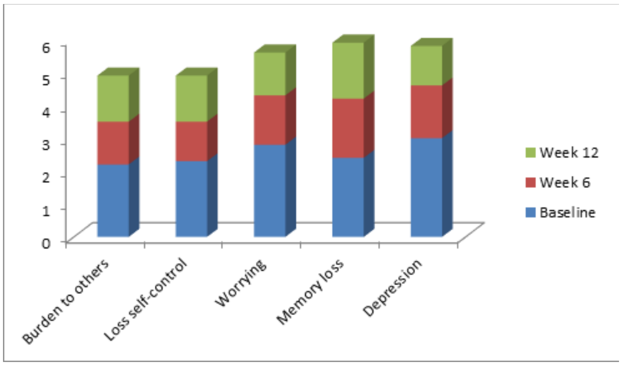
The physical factors domain included; sitting to rest during activity, ability to walk or climb stairs, house chores, oedema, going places, sleeping at night, shortness of breath and fatiguability. At baseline physical factor scores were high averaging 17.9 scores out of the maximum of 40 scores. A reduction in scores was noted at 6 weeks (9.4 out of 40) and at 12 weeks (6.1 out of 40). This reduction in the scores showed a statistically significant improvement of quality of life ($p < 0.001$) (figure 1).

Figure 1: Physical factors of Quality of life in Heart Failure Patients



The mental/emotion domain included the perception of being a burden to others, worrying, memory loss and depression. At baseline scores averaged 12.7 out of 25. This reduced to 7.4 out of 25 at 6 weeks and 7.0 out of 25 at 12 weeks. These changes were statistically significant ($p < 0.001$) (Figure 2).

Figure 2: Mental/ Emotional dimension of Quality of Life



The psychosocial domain included, working, earning a living, recreation, sexual difficulty, eating less food, hospital admission, side effects and hospital cost. The psycho-social domain baseline scores averaged 14.1 out of a maximum of 40 scores. This score improved significantly at 6 weeks when the average score recorded was 8.5 out of 40 ($p < 0.01$). It further improved to 7.2 out of 40 ($p < 0.01$) at 12 weeks, demonstrating improved quality of life (Figure 3). Statistical comparisons of the changes in the 3 domains of quality of life compared showed significant differences at different times and are summarized in (Table 4)

Figure 3: Socio-psychological factors of quality of life

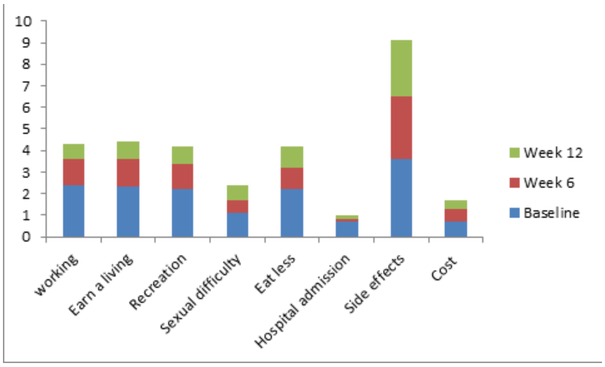


Table 4: Change in quality of life dimension measurements from baseline to 12 weeks

Factor	Variables	Baseline score	Week 6 score	Week 12 score	P-value
Physical	Sit or rest, walk or climb, swelling, going to places, sleeping at night, doing things with friends, shortness of breath	17.9	9.4	6.1	**P< 0.001**
Emotional/ Mental	Burden to others, loss of self- control, worrying, memory loss and depression	12.7	7.4	7.0	**P< 0.002**
Socio-psychological	House work, earning a living, recreation, sexual difficulty, eating less food, hospital admission, side effects and cost	14.1	8.5	7.2	**P< 0.001**

DISCUSSION

Our study has demonstrated that ACBT have a modest effect on lung volumes but have an appreciable effect on the quality of life. ACBT is a cycle of breathing techniques routinely used in respiratory disorders [12] for clearance of bronchial secretions and strengthening of the respiratory muscles [10]. It also facilitates improvement in cardiorespiratory symptoms in conditions such as heart failure [7]. Physiologically ACBT promote maximum air entry by reducing bronchospasms, utilizes collateral ventilation and exerts force on adjacent collapsed alveoli for re-expansion [10]. In addition, thoracic expansion and inspiratory holds used result in redistribution of gas between the lung segments and improved ventilatory function [13]. The increase in lung compliance and reduction in lung resistance is said to result from the release of prostaglandins and surfactant in the alveolar space during maximum deflation of the lungs [14].

The mean age of participants in this study was 54.0 years (range 25-77) similar to that reported in two studies done in Tanzania [15] and [16]. These reported that the age related prevalence of heart failure in Africa tends to occur at around the 5th and 6th decade due to rheumatic heart disease (RHD) and hypertension which occur at a tender age among blacks [16] in contrast to developed countries where the prevalence of heart failure peaks much later. Low life expectancy also contributes which currently stands at 54 years in Zambia [17], with very few people surviving beyond the 7th decade. Anatomically, 40-50 years is the age when pulmonary function starts declining causing structural changes of the chest wall and thoracic spine deformities [18].

Heart Failure is until now considered a condition best treated by bed rest in some areas including Zambia [19]. The perception of risk during exercise is said to be high [6] and the beneficial effects of exercise remain unappreciated [19]. However, benefits of exercise by stable HF patients are well documented and; they include improved lung volumes, functional capacity and health related quality of life [20]. Evidence suggests that these benefits are mainly due to the effects of exercise training on peripheral skeletal muscles and circulation rather than on the myocardium [21]and[2].

Respiratory Function parameters

The increase seen in lung parameters though modest may still be attributed to ACBT. At baseline FVC averaged 2.7L from the predicted 5L demonstrating impairment of the compliance of lungs and chest wall [22]. At six weeks post ACBT intervention the FVC remained the same; however, there was a marginal average increase of FVC of 0.1L at 12 weeks. This change was statistically insignificant. However this small increase in mean FVC values may be attributed to the effects of ACBT which increase depth of breathing, muscle strength and oxygenation [23] these are mechanisms for reducing dyspnea and improving quality of life [24].

The FEV_1, the volume of air that the patient exhales in the first second of forced expiration, was recorded at an average of 1.9L. The predicted FEV_1 for this patient population was 4.0- 4.2 L. This suggested an increase in airway resistance or a reduction in elastic lung recoil [22]. However the mean FEV_1 marginally increased to 2.0L at 12 weeks (p=0.43); this was brought about by the reduction in bronchospasms [14].

The FEV_1/FVC ratio, the proportion of the vital capacity exhaled in the first second, was 70% at baseline (predicted was 70-80%) demonstrating a normal ratio. In this study FVC and FEV_1 decreased in parallel while the ratio remained normal, suggesting a restrictive pathophysiological mechanism [3]. At 12 weeks post intervention the ratio increased to 73.0%. The increase in this study was small and statistically insignificant. However this trend to increase the lung volume parameters showed the potential of ACBT exercises to increase ventilatory function and improving quality of life [11]. This supports the current findings [24].

QUALITY OF LIFE (QoL)

QoL was also studied as a way of assessing the impact of ACBT on physical, psycho-social and emotional/mental dimensions; it was measured using a reliable and valid Minnesota Questionnaire [25].

Physical factors

At baseline, most of the patients had considerable physical impairment. There was improvement in physical symptoms noted at 6 weeks of ACBT and this was more marked at 12 weeks at which time they reported ability to better endure physical activity. The magnitude of these changes attained statistical significance (p<0.001). Similar findings were reported in previous studies [25; 26; 27]. These findings are worth noting as they occur in the presence of small insignificant increases in the lung volumes reported in this study. Collins (2005) and Hough (2001) also reported an improvement in patient's quality of life.

Socio-psychological factors

The parameters considered under socio-psychological factors also showed improvement at 6 weeks and was marked at 12 weeks. This is similar to what was reported by (Keteyan, 2010). The study showed improvement in the health status of participants and they reported a 15% reduction of hospital admissions. Similar findings have also been reported in other studies (Belardinelli et al., 2000).

Mental/Emotional Factors

Heart failure is accompanied by significant emotional/mental symptoms which are considerable determinants of one's quality of life. Depression especially is a serious medical condition which interferes with performance [30]. In heart failure outpatients the prevalence of depression is said to range from 13 to 48% [31]. At baseline, a considerable number of patients showed emotional/mental symptoms. These were noted to improve at 6 weeks and were marked at 12 weeks of the intervention at which time the patients reported a reduction in dependence and depression. These findings are similar to those of (Li, 2002). Substantial amount of research has shown that ACBT exercises can be of benefit to heart failure patients in overcoming HF related symptoms in order to minimize Government expenditure through hospital admissions and drugs (Collin, 2005 and Patel, 2008).

LIMITATIONS

The confounder component of the multidisciplinary management like drugs maybe said to have played a part, in this study however, we would say much of the improvement was caused by the effects of ACBT because these patients exhibited poor quality of life at baseline despite being on pharmacological intervention for a very long time.

CONCLUSIONS AND RECOMMENDATIONS

This study showed the importance of physical exercise in the treatment of heart failure. The benefits are seen even in mild exercises such as the ACBT. While the improvements in pulmonary function parameters may be small, the accompanying changes in quality of life are considerably significant. ACBT exercises in Physiotherapy should therefore be recommended as additional therapy to pharmacological intervention in HF.

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