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ORIGINAL ARTICLE

Impact of Cardiac Rehabilitation, including Deep Breathing, on Endurance Level in Patients with Heart Failure

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Abstract

Background: Heart failure (HF) is a morbid illness with a high mortality rate. Patients with HF necessitate a cardiac rehabilitation (CR) program that is a planned, lasting care, which is highly cost-effective in lowering hospital admissions and improving quality of life. **Objective:** This study aimed to compare the effects of diaphragmatic breathing and incentive spirometry on endurance levels in patients with mild heart failure. **Materials and Methods:** An experimental study, single-blinded design. Forty-five patients (25 males and 20 females) diagnosed with mild HF were nominated from the cardiac unit in King Abdulaziz University Hospital, Jeddah, KSA. The age range was 45–75, and subjects were randomly allocated to three equal groups: the diaphragmatic breathing (DB) group, the incentive spirometer group, and the control group. They were evaluated pre- and post-cardiac rehabilitation. **Results:** The results displayed a statistically significant increase in the six-minute walk test (6MWT) post-intervention compared to pre-intervention in the DB group ($p = 0.03$), indicating the efficacy of DB based on 6MWT results. However, there was a significant improvement in the rating of perceived exertion on the Borg scale post-intervention compared to pre-intervention in DB ($p = 0.01$). As well, there was a statistically significant improvement in oxygen saturation post-intervention in the control group. Indicating the efficacy of training on oxygen saturation. **Conclusion:** The results revealed a significant effect of the DB on hemodynamic indices and an improvement in cardiac function.

Keywords: Heart Failure; Cardiac Rehabilitation; Diaphragmatic Breathing; Incentive Spirometer

Introduction

Heart failure (HF) is an eternal ailment where the heart is unable to drive adequate blood and oxygen to meet the body's needs. Mild HF symptoms include exhaustion or dyspnea during climbing stairs or walking uphill. Conversely, light physical activity is done with no symptoms. Exercise training initiates muscle strength and improves exercise capacity, which is vital in HF treatment. Cardiac rehabilitation (CR) is important due to its physiological benefits, including increasing the maximum amount of oxygen (VO_2max), coronary circulation, and endothelial function. Awareness of the importance of CR needs to be enhanced [1].

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Cardiac rehabilitation's primary objectives include enhancing prognosis by reducing morbidity and mortality, restoring exercise capacity and quality of life (QOL), preventing disease progression through the correction of risk factors, improving pharmacological, social, and professional status, and improving the patient's self-care skills [2]. CR for acute mild HF showed better prognosis, increased drug compliance, initiated tobacco cessation in smokers, and reduced readmission and acute mild HF recurrence. CR health benefits following acute mild HF are significant, centering on relapse and death. Correcting cardiovascular risk factors, improving drug compliance, and conducting frequent follow-up are vital [3]. Consistent CR was not associated with a better prognosis beyond six months after discharge [4].

Circulatory system diseases are among the most serious medical conditions in both developing and developed countries. Incidence of this condition, which is currently the top cause of mortality worldwide, is predicted to continually increase up to 23.3 million cases in 2030 [1]. HF is a common serious disease with a negative prognosis. It is described as the heart muscle's inability to pump sufficient oxygen and blood to the peripheral tissues, resulting in an insufficient supply of tissue energy [2]. The most frequent HF causes are coronary artery disease (CAD), diabetes, and hypertension; although, it has been found that hypertension and diabetes are higher risk factors in older women than CAD and smoking are in older males [3]. According to the above, HF patients experience fatigue and dyspnea on exertion and, in more advanced HF, even during rest [2]. It's important to realize that, in patients with HF, increasing breathing effort, which worsens dyspnea and restricts everyday activities, may result in impaired strength and endurance of the respiratory muscles [4].

Cardiac rehabilitation is a planned interference aiming to improve CAD clinical signs. The diverse CR forms, including moderate intensity continuous training (MICT), high intensity interval training (HIIT), Nordic walking (NW), and home-based cardiac rehabilitation (HBCR), taming exercise capacity, quality of life (QOL), and declining disease rates and death [2].

Exercises can improve oxygen saturation and QOL in people with HF, according to a systematic review study that included 27 studies [1]. However, exercise plans must encourage sedentary patients to start and sustain a dynamic routine, therefore reducing the risk of CVD in the future [5]. Exercise training (ET), which can result in muscle hypertrophy, increased muscular and subsequently improved exercise capacity, is one of the most essential components of cardiac rehabilitation, which is a crucial aspect of the treatment strategies for HF. In addition, ET programs have regularly been used in the CR of HF patients, using wide-ranging, continuous or intermittent, aerobic or resistance exercise protocols at varying intensities [2].

Deep breathing exercises are used to improve breathing and functional performance. It supports ventilation and oxygenation by enhancing the function of the respiratory muscles [1]. Additionally, positioning and breathing exercises can be performed to minimize effort and improve respiratory muscle performance. Tolerable physical activity can be controlled to enhance tissue perfusion and promote circulation. Patients with HF are advised to participate in regular physical activity or exercise, as it is both safe and effective [1]. As well, the incentive spirometer (IS) is a device used to elevate trans-pulmonary pressure and inspiratory volumes, enhance the performance of the inspiratory muscles, and restore or enhance the normal pattern of lung inflation in patients with respiratory problems [6]. Hence, offers visual feedback and promotes deep inspiratory effort eaching total lung capacity (TLC). These two methods are easy to complete and depend on the patient's participation [7]. However, there is still a need for a current, systematic review and meta-analysis of all clinical trials focusing on how ET affects specific clinical and functional outcomes of CR [2].

A limited number of studies have been conducted on deep breathing exercises with HF patients, and none have examined the effects of incentive spirometers. Thus, the present study objective was to combine these two methods to compare the effects of diaphragmatic breathing and incentive spirometer exercise on the endurance level in patients with mild HF in Jeddah, Saudi Arabia.

Heart failure is described as the heart muscle's inability to supply the peripheral tissues with sufficient blood and oxygen, resulting in an inadequate supply of tissue energy [2]. Patients with both acute and chronic HF were, on average, between 57 and 60 years old, according to a national multi-center survey conducted in Saudi Arabia that has a 10-year younger median age than the developed nations like the United States, Japan, and Europe. The reasons are diverse, but important risk factors for HF and CAD include a high prevalence of diabetes mellitus and hypertension. Socioeconomic change and the consumption of high-calorie foods are the primary causes of the rise in obesity. Other reasons include a high prevalence of smoking [8]. Cardiovascular rehabilitation should be a targeted intervention utilizing standard procedures tailored to the specific needs of cardiovascular patients. A systematic review of 27 studies revealed that deep breathing exercises, motion-activated range of motion, and physical activity can all increase oxygenation [5]. Acute myocardial infarction (AMI), post-myocardial re-vascularization or heart transplants, stable chronic angina, and chronic HF are all indicated for CR [7]. A review shows exercise therapy in congestive HF patients. The summary of results involving exercise training or electric muscle stimulation with acute decompensating HF mentions the safety and benefits of early mobility via exercise; hence, it must be put into practice since ICU admission if not medically contraindicated [9].

Preceding studies have almost exclusively focused on incentive spirometer management with coronary artery bypass graft, cardiac, and thoracic surgeries, but no trials have explained its impact in patients with HF [6]. Exercise tests on a cycle or treadmill are not recommended for patients with HF who are elderly, weak, or seriously disabled, since they may not accurately assess their ability to carry out daily tasks. For individuals with chronic pulmonary diseases, walking tests have proven to be effective as indicators of progress. The 6-minute walk test (6MWT) was given six times over the course of three months to 18 patients with chronic HF and 25 patients with chronic pulmonary disorders. The 6MWT, according to the authors, is a valuable indicator of physical capacity [8]. Endurance assessment showed that the 6MWT distance was significantly increased ($p < 0.01$), and 6MWT detects the possible values of walking as an objective measure of exercise capacity in patients with chronic HF [10].

Mostly, there are numerous techniques for both healthy and ill patients to boost their cardiorespiratory endurance. Along with structured ET programs, a lifestyle approach can be used to encourage physical activity. The former strategy encourages regular daily activities, such as brisk walking, using the stairs instead of the elevator, doing more household chores and gardening, and participating in active leisure activities. Both strategies have been proposed for CHF, but only the organized physical activity (ET) strategy will be covered in the current paper (as lifestyle changes are presented extensively elsewhere) [5]. To achieve the intended results while keeping a fair degree of risk control, it is essential to identify the right and sufficient amount of training intensity. Since there is no accepted standard for recommending exercise in CHF, a personalized strategy involving rigorous clinical examination and consideration of behavioral traits, individual goals, and preferences is advised [11].

Several aspects highlight the differences in training methods. Eight variables need to be considered: type (endurance, resistance, and strength); intensity (aerobic and anaerobic); control (supervised and unsupervised); application (systemic, regional, and respiratory muscle); and setting (hospital/center- and home-based). Three diverse exercise modes have been planned in various combinations: continuous and intermittent aerobic endurance, power/resistance, and respiratory [12]. Continuous aerobic exercise is often carried out in steady-state conditions, allowing patients to complete lengthy exercise sessions of 45 to 60 minutes at moderate to high exercise intensities, thereby yielding aerobic energy. Owing to its well-established status, proven efficacy, and safety, it is the most highly advised mode of instruction in the guidelines. Since it is simple to teach and practice via cycle ergometers or treadmills, it is widely recognized [13].

Recommendations include starting slowly and gradually increasing intensity for more deconditioned individuals (at low intensities for 5-10 minutes, twice weekly). If endured, exercise sessions are added more frequently, with a goal of 20 to 60 minutes, three to five days/week, at moderate to high intensity, and in endless programs [14]. Heart rate (HR), HR reserve (HRR = difference between the basal and peak HR), and rating of perceived exertion (RPE) have been proposed as indirect methods to monitor work during stress tests or a 6 MWT because the cardiopulmonary stress test is not routinely performed in clinical practice. It is advised to use a "training HRR range" of 40: 70% HRR and 10/20-14/20 of RPE. It has recently been demonstrated that periods of continuous exercise are less effective than interval (or intermittent) training for enhancing exercise capacity. The patient is asked to alternate short bursts of moderate-high intensity exercise (50:100% max exercise capacity) with longer recovery (80–60 s), conducted at low or no effort, as opposed to the continuous training regimen [15].

Physical activity stimulates the circulatory system via the rising oxygen demand of muscles. Steady exercise training improves cardiovascular functions by increasing both the heart capacity and blood flow. By raising the ejection fraction, the efficiency of the cardiac muscle is improved, and resting HR is lowered. Additionally, exercises improve vessel wall flexibility and stimulate dilation, thereby reducing both peripheral resistance and blood pressure [16]. Altered HR to steady exercise comprises both physical and functional adaptations. An increased number of skeletal muscle capillaries (angiogenesis) improves oxygen delivery to tissues, which is crucial for improving exercise capacity [17]. Researchers concluded that the exercise dosing for patients with heart disease differs in customary and present training interventions, comprising high-intensity interval training (HITT) [18].

The progressive increase in exercise intensity slowly improves both cardiopulmonary function and reserve. The physiological changes may occur through increased cardiopulmonary function, stimulation of stagnated blood flow in the body, enhanced skeletal muscle oxygen uptake capacity, improved peripheral blood flow, and increased endurance[19]. The stimulated weight loss and reduced adiposity, blood lipids, and BP, besides improvement in glycemic control, depression, QOL, and lifestyle, including diet and physical activity [20,21]. The inclusive, multifactorial daily life interventions, including vegetarian diets and psycho-social adaptation, had a major influence, including lowered cardio-metabolic risk and improved the psycho-social well-being in patients with chronic CVD [22]. The present study was conducted to compare diaphragmatic breathing and incentive spirometer use on the endurance level in patients with mild heart failure in Jeddah, Saudi Arabia.

Materials and Methods

Forty-five patients with mild heart failure, whose ages ranged from 45 to 75 years, were selected from the cardiac inpatient unit of King Abdulaziz University Hospital (KAUH) in Jeddah. However, exclusion criteria included patients with moderate & severe HF, unstable angina pectoris at the moment of selection or during the program, complex ventricular arrhythmia, uncontrolled arrhythmia, congestive decompensated heart failure, uncontrolled high blood pressure, and cerebrovascular accident. Serious hemodynamic disturbances during the intervention (e.g., shock, severe uncontrolled blood pressure). Complications affecting hemodynamic state, such as neuromuscular disorders, bleeding, smoking, chronic obstructive pulmonary disease, renal dysfunction requiring dialysis, and a history of previous open heart or pulmonary surgery. Aneurysm or cardiovascular instability, complete heart block dependent on an external cardiac pacemaker. Symptoms of influenza or fever during the evaluation for the 7days before the evaluation, and lack of intellectual function.

The study design was a quasi-experimental study. Where a random sample was included from the patients, three equal groups (each group with n = 15) were created. The first group participated in DB and a range of motion exercise. The second group had IS training and a range of motion exercises. The third group was designated as the control group and received aerobic exercises, strengthening exercises, locomotion training, and marching balance training on stairs. Program. The research team evaluated the degree of endurance pre- and post-intervention. However, the standard exercise program involved strengthening exercises, functional exercises, stair climbing, bed mobility, and walking. The session duration was 30 minutes, three times a week [10].

The Scientific Research Ethical Committee of King Abdulaziz University Hospital (KAUH) in Jeddah, Saudi Arabia, received the IRB approval on September 1, 2024, from the research team and approved this study. All patients signed consent forms preceding participation in the study.

Measurements

Assessing the endurance level pre- and post-intervention for in-patients diagnosed with acute HF, these measures included:

- **Six-minute walk test (6MWT):** A well-tolerated test for determining functional ability [19]. The American Thoracic Society's statement provides detailed instructions on methods. This is used to assess the prognosis without the need for specialized equipment [20]. The 6MWT is a valid and reliable method for assessing functional ability in phase II/III CR. An effect of 6% was noted over the three walks; still, it is unknown if this will be reserved (Table 1) [21]. The 6MWT should ideally be completed on a hard surface, a straight, flat corridor that is at least 30 meters long. The patient must be relaxed, take their medications as prescribed, and wear comfortable clothing and shoes. The supervisor noted resting oxygen saturation, heart rate, blood pressure, and a dyspnea and tiredness rating on the Borg scale. The patient is prepared to start the test once they have grasped the instructions. Every 3 meters on the walking route must be indicated, and it's a good idea to put cones in the turnarounds. The participants in the test must move at an appropriate pace, but they are free to pause or slow down if needed and then resume their pace as soon as they feel ready. The supervisor is constantly present, encouraging the patient with platitudes such as "You are doing well" and "Keep up the excellent job." As a conclusion, the supervisor again notes the dyspnea and tiredness scores on the Borg scale, and may also measure arterial blood pressure, heart rate, and oxygen saturation. The 6MWD is computed after the number of laps and the added distance are recorded [19].
- **Quality of life (QOL)** as measured by the Minnesota living with HF questionnaire (MLHFQ): The MLHFQ is a direct indicator of one of the two ultimate outcomes of public interest; its principal benefit is as a therapy efficacy measure (Table 2). In general, substantially smaller studies are required to identify a significant effect when a device is predicted to mitigate the negative effects of HF than are necessary to detect a significant decline in death, the alternative end outcome. The impact of various HF treatment devices has been and can still be studied using the MLHFQ. However, the scoring procedure was based on an assessment that aims to quantify (provide a reliable and valid numeric score) the opposing effects of HF on a patient's life, guiding healthcare and measuring the outcome. The 21 questions measure the importance of disease signs and symptoms. Shortness of breath, fatigue, peripheral edema, and frequently occurring depressive symptoms. Other questions inquire about how common physical and social activities, such as walking, climbing stairs, housework, the need for relaxation and sleep, work, going away from home, participating in activities with a family member or friend, leisure activities, sexual activity,

and diet, are. Concentration, memory, absence of self-control, and feelings of burdensomeness to others. To evaluate the total negative impacts of HF on patients' lives, treatment side effects, hospitalization, and medical charges. The responses range from 0 (no), 1 (very little) to 5 (greatly) [22].

- **New York Heart Association (NYHA):** The Simple functional classification of HF dates back almost a century. It is a cornerstone of clinical documentation, trial enrollment, and candidacy for therapies in HF since its use is established in both guidelines and modern practice. It strongly correlates with both exercise capacity and prognosis. It's also widely utilized in routine clinical practice; it's simple and very helpful[20]. A functional outcome measure's validity and reliability for use in a research experiment. In addition to investigating strengths and limitations, the authors conclude that the NYHA is a valid assessment of functional states, which differs from capacity or performance [23].
- **Target Heart rate (THR):** HF is a measure to evaluate the efficacy of interventions because a higher-than-normal resting heart rate is linked to a lower left ventricular ejection fraction (LVEF) and a higher relative risk of HF [25]. Heart rate (HR) is used to calculate exercise intensity via the Karvonen formula, which reflects the level of difficulty of exercise. Because heart rate is easily measured with a small instrument and can even be measured remotely, the Karvonen formula is frequently used in physical training and rehabilitation [14].
  - Target heart rate range is calculated as: HRR = (HRR x desired training intensity) + HRrest (resting HR)
  - Heart rate reserve is calculated as: HRR = HRmax - HRrest [15].
  - Maximum heart rate is calculated as: HRmax = 220 - age, (HR when exerting physical effort to the maximum) [14].
- **Rating of perceived exertion (RPE) scale:** is simple, applicable to occupational health and safety procedures [24]. It is reliable in rating exertion and validated against HR. Used for assessing patients' level of physical effort, exertion, dyspnea, and fatigue during physical activity. The scale (Table 3) includes increased HR, breathing rate, or increased respiration, increased sweating, and muscle fatigue. Simple numerical lists make up the scale. Applicants were requested to level their exertion during the activity using a scale that accounts for all physical stress, fatigue, and sensations. As well as ignore any individual aspect of exertion (leg pain or shortness of breath) and concentrate on the overall sense of exertion. RPE can be used once or repeatedly; it just takes a few seconds to complete. The participant is instructed to circle or check the number that, overall during the past 24 hours, best describes breathlessness [18].

Procedures

Diaphragmatic breathing (DB): The muscle used for breathing most effectively is the diaphragm. The goal of diaphragmatic breathing is to ensure proper use of the diaphragm. By lowering heart rate and blood pressure and promoting relaxation, this breathing method has many positive effects on the body. It helps to use the diaphragm correctly while breathing for its strengthening. This correct use of the diaphragm decreases the quality of breathing by slowing the breathing rate, reduces the need for oxygen, and helps breathing that requires less effort and energy[16].

The procedures: Instruct the patient to:

- Place the patient on his or her back, with the knees bent and the head elevated, on a flat surface or in bed. Put a pillow beneath the knees to support the legs.
- Put one hand on the upper chest and the other just below the ribs. This will cause your diaphragm to move as you breathe, which you will be able to feel.
- Slowly inhale through your nose to make your abdomen move out, which will make your hand rise. Keep your hand as still as you can on your chest.
- Tightening the patient's abdominal muscles so that the abdomen moves in, causing the hands to lower as exhaustion through pursed lips. The hand on the upper chest should be as still as possible [17].

Incentive spirometer (IS): It's a simple piece of plastic exercise tool for medicinal purposes. An IS helps strengthen the lungs, maintain lung inflation, and clear the chest and lungs of mucus and other secretions. After surgery or a serious disease, it helps return the oxygen level to normal by using it at least ten times every hour[18

Procedure: Instruct the patient to perform the following steps:

- Sit on the bed's edge as much as the patient can in bed, sitting up if he/she can't.
- Hold the IS in an upright position.
- Put the mouthpiece inside the mouth and close the lips tightly.
- Inhale as slowly and deeply as the patient can. A yellow piston will be seen rising toward the top of the column. The yellow piston should reach the blue-outlined region.
- Hold your breath for at least five seconds, or as long as the patient can, allowing a slow exhale, allowing the piston to slowly descend to the bottom of the column.

- Every hour the patient is awake, he or she repeats the first five steps at least ten times while taking a brief moment to rest.
- Put the yellow indicator on the IS side to display the patient's best breath as he/she takes deep, calm breaths, using the indicator as a goal to strive for.
- Deeply cough to empty the patient's lungs after each set of 10 deep breaths. If there is a surgical incision, firmly press a pillow or towel that has been rolled up against the incision while coughing to provide support. Once the patient can safely get out of bed, go for regular, brief walks and practice coughing [18].

Data Analysis: The Data collected were reviewed and manually coded. The numerical codes were input into the computer for statistical analysis using the Statistical Package for the Social Sciences, Version 23 (SPSS 23) for Windows.

- *Descriptive statistics:* Quantitative data were presented as means and standard deviations (mean ± SD), and qualitative data were expressed as numbers and percentages.
- *Analytical statistics:* Chi-square test (X2) as used for comparing qualitative (non-numeric) data. Student's "t "-test for comparing quantitative data of 2 independent samples of normally distributed data. One-way ANOVA test for comparing quantitative data of more than 2 independent samples of normally distributed data**.** The coefficient interval was set to 95%. The significance level was set in line with the following probability (P) values: $p < 0.05$ was considered statistically significant.

Results

The main aim of the study was to compare the effects of DB and IS on the endurance level in patients with HF. This experimental study was conducted at KAUH, Jeddah, KSA. The study included 45 patients with HF, aged between 45 and 75. Both genders were included. The ability to perform deep breathing exercises and use an incentive spirometer.

The main results of the study were as follows:

Demographic and clinical data: insignificant difference between the 3 studied groups with regard to their age and gender. There was an insignificant difference between the 3 studied groups with regard to their weight, height, and BMI (Table 1).

Table 2 showed a non-significant difference between the 3 studied groups regarding the side (p-value > 0.05). Besides, a non-significant difference between the

TABLE 1: COMPARISON OF ANTHROPOMETRIC MEASUREMENTS DISTRIBUTION OF THE STUDIED GROUPS

		Mean	SD	Min.	Max.	f	p-value	DB vs IS	DB vs C	IS vs C
Weight	DB	87.2	8.4	73	101	0.69	0.49	0.33	0.26	0.79
	IS	82.5	10.8	70	108					
	C	81.1	13.5	52	103					
Height	DB	165.3	4.2	157	173	0.86	0.42	0.36	0.67	0.21
	IS	163.2	3.8	155	169					
	C	166.4	5.2	154	176					
BMI	DB	30.8	2.6	25.4	38.6	1.00	0.37	0.55	0.19	0.40
	IS	29.8	2.7	24.6	35.5					
	C	28.2	4.0	17.7	35.3					

DB: diaphragmatic breathing, IS: incentive spirometer, C: control group.

TABLE 2: COMPARISON OF HF QUALITY OF LIFE SCORES IN THE STUDIED GROUPS

		Mean	SD	Min.	Max.	f	p-value	DB vs IS	DB vs C	IS vs C
Physical score	DB	12.70	3.17	9	20.0	0.34	0.40	0.34	0.21	0.65
	IS	15.00	5.10	2.00	20.01					
	C	16.30	6.80	2.00	26.01					
Emotional score	DB	3.50	1.66	0.40	7.01	3.19	0.00	0.01	0.02	0.55
	IS	7.50	3.20	0.50	13.02					
	C	6.50	2.00	2.00	09.00					
Total score	DB	27.59	6.09	20.00	45.01	2.39	0.03	0.07	0.01	0.64
	IS	36.69	13.84	8.00	53.00					
	C	39.59	12.46	15.00	51.00					

DB: diaphragmatic breathing, IS: incentive spirometer, C: control group.

TABLE 3: CLINICAL DATA BEFORE AND AFTER TRAINING IN RELATION TO GENDER IN THE STUDIED GROUPS

		♂		♀		Test of Sign.	p-value
		Mean	SD	Mean	SD		
HR	pre	98.49	11.13	94.01	10.34	0.99	0.15
	post	78.71	8.91	96.01	6.58	0.99	0.17
Test of sign.	-0.05		-0.05				
p-value	0.94		0.94				
O_2 sat %	pre	93.49	1.49	95.01	1.12	-0.57	0.45
	post	95.38	1.02	96.41	0.99	-0.03	0.85
Test of sign.	-2.49		-2.49				
p-value	0.02		0.02				
6MWT	pre	89.55	42.31	66.66	42.76	1.45	0.05
	post	138.10	62.14	89.67	64.00	2.04	0.04
Test of sign.	-2.68		-2.68				
p-value	0.011		0.011				
RPE	pre	3.38	0.99	5.01	0.98	-1.56	0.02
	post	3.38	0.97	3.91	0.77	-1.60	0.01
Test of sign.	2.98		2.97				
p-value	0.005		0.005				

Male: ♂, Female: ♀

3 studied groups regarding the presence of associated comorbidities or their type (p-value > 0.05).

The results revealed an insignificant difference between the 3 studied groups with regard to their HF type and NYHA classification of HF severity (p-value > 0.05), indicating a homogenous distribution of clinical data of the studied groups (Table 2).

Table 3 showed that despite higher target HR in the 3 groups, this difference was significant in the DB group compared to the control group (p-value < 0.05), with no significant difference between the DB group and the IS group. There was an insignificant difference between the 3 studied groups regarding their HR before and after training (p-value > 0.05).

A statistically significant improvement in O_2 saturation after training in the control group. However, there was an insignificant difference between the diaphragmatic breathing and incentive spirometer groups with regard to their O_2 saturation before and after training (p-value > 0.05).

A statistically significant increased 6MWT after than before training in deep diaphragmatic breathing training (p-value 0.029). Despite the increased 6MWT after incentive spirometer training and standard National Guard Cardiac Rehabilitation Program training, this increase was non-significant for each of the 2 intervention methods (p-value > 0.05). There was statistically significant improvement in rating perceived exertion (RPE) scale after than before in deep DB training (p-value 0.006). A decreased RPE scale after IS training and control group training, but this decrease was non-significant for each of the 2 intervention methods (p > 0.05) (Table 4).

Correlation: In the present study, there was statistically significant improvement in 6MWT performance and Ten Borg Rating of perceived exertion (RPE) scale after deep diaphragmatic breathing training than before (p < 0.05) in both males and females. There was no significant difference between the clinical parameters after training between males and females. There was a statistically significant association between improvement in THR and female gender in the deep breathing training group (p-value 0.044). No significant variance in clinical parameters after training between males and females.

The results displayed a statistically significant association between improvement in target heart rate (THR) and BMI in the control group (p = 0.05) and a significant association between improvement in O_2 saturation and BMI in the BB group (p = 0.02). Then, there was no significant change in clinical parameters after training between those with a BMI of less than 30 and those with a BMI of more than 30. A statistically significant improvement in THR in the BB group, regardless of the side of HF. Otherwise, there was no significant difference between the clinical parameters after training between right and left-sided HF. There was an absence of significant association between clinical variables and type of HF, except for THR, O_2 saturation, and 6MWT. There was an absence of a significant association between clinical variables and the NYHA grade of HF, except for THR.

TABLE 4: CLINICAL DATA AFTER TRAINING IN RELATION TO GENDER IN THE STUDIED GROUPS

		DB		IS		Control		Test of Sign.	p-value
		Mean	SD	Mean	SD	Mean	SD		
HR	♂	82.60	4.48	100.19	6.15	106.39	10.56	4.21	0.03
	♀	87.00	1.54	97.00	11.70	97.79	6.72	0.01	0.98
Test of sign.		-1.63		0.48		1.37			
p-value		0.13		0.63		0.19			
O_2 sat %	♂	85.03	0.96	96.79	0.99	98.00	1.23	3.94	0.03
	♀	86.22	0.50	96.39	0.99	96.19	0.63	0.03	0.96
Test of sign.		-1.83		0.44		1.44			
p-value		0.09		0.61		0.18			
6MWT	♂	138.60	58.70	131.39	58.48	117.00	73.29	0.36	0.69
	♀	87.56	87.56	85.79	79.67	115.00	67.03	0.18	0.83
Test of sign.		0.90		1.01		0.03			
p-value		0.42		0.33		0.96			
RPE	♂	3.00	0.81	3.59	0.79	3.79	0.99	1.06	0.36
	♀	3.56	0.57	3.79	0.83	4.00	0.97	0.15	0.85
Test of sign.		-1.46		-0.36		-0.26			
p-value		0.18		0.71		0.78			
THR	♂	127.72	4.73	133.61	8.09	129.33	4.46	2.26	0.13
	♀	130.52	5.08	134.39	5.77	129.13	1.79	4.33	0.03
Test of sign.		-0.69		-0.14		0.06			
p-value		0.52		0.87		0.93			

Male: ♂, Female: ♀

Discussion

In cardiac rehabilitation protocols, customized exercise plans are developed to suit each patient's specific needs, abilities, and medical history. The goal is to strengthen the heart and improve endurance and heart health in a safe, monitored environment. Endurance training comprising isotonic and regular exercises for large muscles has been suggested to be included in rehabilitation strategies for patients with HF. These regimens in cardiac outpatients are classically executed at moderate intensities for at least 30 min, and known to be associated with an augmented maximum aerobic capacity (VO_2 max) of 11–36% [25].

Quality of life (QOL) was noted as more significantly improved in patients experiencing a combined home-based program of interval and resistance exercises than in patients who maintained their usual daily activity. QOL improvements and functional capacity assessed by 6MWT were also more significant in a patient group who endured aerobic exercises in comparison with a control group of patients with HF [26].

With aging, HF incidence is likely to rise to about 12%. Moreover, at present, it is estimated that around 8 million adults will be diagnosed with HF by 2030. The HF predictable all-cause death rate is 8% and 25% for 30-d and 1-year periods, in that order. Additionally, ageing patients with HF experience a higher rate of comorbidities and hospital readmissions [27].

Present medical policies praise appropriate exercises as a complementary treatment for patients with HF, as well as the regular drugs. For instance, it was shown that dyspnea-related low-exercise tolerance was effectively improved by respiratory muscle training in patients with HF. The respiratory muscle exercises include a machine-assisted routine, such as inspiratory muscle training (IMT). The non-machine-assisted respiratory training included breathing exercises. Machine-assisted respiratory training benefits patients with HF, adjusting their maximal inspiratory pressure (MIP), which is an important factor in improving inspiratory muscle strength, dyspnea, and hence walking distance [28]. One systematic review revealed that IMT effectively improved exercise capacity in patients with HF, as assessed by 6MWT. Additionally, when executed at higher intensities, IMT not only improved 6MWT totals but also enhanced peak oxygen uptake (VO_2 peak) [29]. Six-minute walk test distance is sensitive to health status variations and is reactive to exercises and interferences that increase 6MW distance, similarly improve QOL, and decrease weakness [30].

The present study results were reinforced by a study by Sadek et al. (2018), as they stated that their trial was done on 40 patients with heart disease who were candidates for coronary artery bypass graft (CABG) surgery. They selected their participants using convenience sampling and then randomly divided them into two groups. A day prior to surgery, one group was taught how to execute deep breathing (DB) while the other group was educated about the use of an incentive spirometer (IS) [30]. Both groups were similar regarding demographic data. Likewise, Zerang et al. (2022) stated that of the 40 patients, 20 (50%) were in the DB group and 20 (50%) in the IS group. The mean age of patients in the DB and IS groups was 65.4 ± 7.12 and 62.8 ± 7.22 years, respectively, but this difference was not statistically significant ($p = 0.2$). It should be noted that all patients in both groups were married ($p = 1$) [31].

There was no significant difference between the three studied groups regarding the presence of associated comorbidities or their type (p-value > 0.05). Consistent with our results, Malik et al. (2019) reported no statistically significant difference between the two studied groups concerning co-morbidities [6].

The present study showed that there was an insignificant difference between the 3 studied groups with regard to their HF type and NYHA classification of HF severity (p-value > 0.05); this indicates a homogenous distribution of clinical data of the studied groups. The results were reinforced by a study of Barkhordari et al. (2022), who mentioned that the research was conducted in a randomized controlled way on a total of 56 patients to define the impacts of breathing exercises on dyspnea and sleep quality in patients with HF. There was an insignificant difference between the experimental and control groups with regard to their NYHA classification [32].

Outcome and rationale: IS a tool for measuring the amount of inspired air into the lungs. The IS measures the inhaled air volume for evaluating the inspiratory efforts via optical feedback. Due to the absence of known side effects, the IS can be beneficial in therapy. When a patient learns using IS, it is easy and requires no help. Moreover, the optical signals endorse obedience [33]. So M et al. (2012) divided the subjects into two groups, the IS group and the DB group. These two exercise groups considerably improved the functional capacity ($p < 0.05$) [34]. According to Forzano et al. (2024), exercise training decreased muscular sympathetic nerve activity ($p < 0.001$) and QOL ($p < 0.01$) in all groups; nevertheless, the occurrence of sleep apnea [35].

The results of our study showed an insignificant difference between the 3 studied groups with regard to their HR pre and post intervention (p-value > 0.05); this indicates a homogenous distribution of baseline data of the studied groups with a similar non-significant effect of the 3 intervention methods on the heart rate. Numerous trials have revealed that diaphragmatic exercise lowers both heart rate and arterial blood pressure. This breathing encourages the vagus nerve (parasympathetic), which diminishes the "fight or flight" response, triggering anxiety or tension [36,37].

In the present study, there was a statistically significant improvement in O_2 saturation after training in the control group. This indicates good efficacy of the standard KAUH Cardiac Rehabilitation Program training on oxygen saturation. However, there was an insignificant difference between the diaphragmatic breathing and incentive spirometer groups with regard to their O_2 saturation before and after training (p-value >0.05); this indicates a similar non-significant effect of diaphragmatic breathing training and incentive spirometer methods on the oxygen saturation %. In the study of Barkhordari-Sharifabad et al. (2022), the mean arterial SaO_2 in the IS group was significantly higher than that in the DB group ($p < 0.05$). Conversely, there was no significant difference between the two groups regarding the mean arterial SaO_2 on the first and second days after the intervention [32]. DB had no significant effect on arterial blood gases (arterial blood SaO_2 percentage, partial pressure of carbon dioxide (PCO_2), and partial pressure of oxygen (PaO_2) in patients undergoing CABG surgery [38]. However, the results of a study by Moradyan et al. (2012) showed significantly higher arterial blood SaO_2 and PaO_2 in the experimental group in comparison to the controls on the third day after surgery. In other words, patients who completed organized breathing exercises had a better oxygen delivery status compared to those who underwent usual hospital routines, and appreciated quicker improved oxygen delivery and returning to pre-operative level[39]. Zhang et al. (2024) studied deep breathing effects on improving oxygen delivery in patients experiencing CABG, showing that mean arterial oxygen pressure and arterial blood SaO_2 in the experimental group were significantly higher than in controls on the second day after surgery [40].

The present study showed a statistically significant increase in 6MWT after training in deep diaphragmatic breathing training (p-value 0.029). This indicates good efficacy of deep diaphragmatic breathing training on the results of 6MWT. Despite the increased 6MWT after incentive spirometer training and standard National Guard Cardiac Rehabilitation Program training, this increase was non-significant for each of the 2 intervention methods (p-value > 0.05). There was statistically significant improvement in rating perceived exertion (RPE) scale after than before in deep DB training (p-value 0.006). This indicates good efficacy of DB training on the perceived exertion. Despite decreased RPE scale after IS training and control group training, this decrease was non-significant for each of the 2 intervention methods ($p > 0.05$). HR and LVEF are significant signs of cardiac function. Exercise capacity affects cardiac function; assessment is done by 6MWT and peak oxygen uptake (VO_2) scores [41]. The consequences were reinforced by the study of Gondko et al. (2024), as they described that the paired t-test displayed a statistically significant improvement in all the pulmonary function parameters, 6MWD in the IS group ($p < 0.05$) [42].

In the present study, there was a statistically significant improvement in 6MWT performance and Ten Borg Rating of perceived exertion (RPE) scale after deep diaphragmatic breathing training compared to before ($p < 0.05$) in both males and females. There was no significant difference between the clinical parameters after training between males and females. There was a statistically significant association between improvement in THR and female gender in the deep breathing training group (p-value 0.044). Otherwise, there was no significant variance among clinical parameters after training between males and females. This indicates the absence of a significant association between clinical variables and gender. While in the study of Antunes-Correa et al. (2010), exercise training produced a similar reduction in resting Muscle sympathetic nerve activity (MSNA) ($p = 0.000002$) in men and women with HF. Peak VO_2 was similarly increased in men and women with HF ($p = 0.0003$) [43]. Previous investigators have stated that VO_2max is significantly lower in women than in men [44]. Several anatomical and physiological sex alterations between women and men could clarify these alterations in women compared to men: (i) minor Lt ventricular chamber and therefore, lower stroke volume; (ii) lower diastolic compliance; (iii) women display superior occurrence of obesity; (iv) lower hemoglobin levels and more likely to suffer from iron deficiency; and (v) lesser lean mass [45].

Study Limitations

Time constraints led to difficulty in providing patients with mild heart failure, a small number of stable cases, and a few patients were unable to participate in the 6MWT to avoid the risk of falling. The lack of similar previous comparative clinical studies was a limitation.

Recommendations/Future Study

First, the effectiveness of multiple intervention plans must be considered. Second, reassessing the QOL questionnaire in advanced phases of improvement during interventions in cardiac outpatient rehabilitation. The results will be evident in QOL improvement in different aspects of the patient's life. The last important recommendation is applying more clinical research to patients with HF.

Conclusion

The results showed superiority of DB on hemodynamic indices and general progress in cardiac function in old HF patients compared to IS.

Ethical Considerations

This study was reviewed and approved by the research ethics committee at King Abdullah International Medical Research Center (KAIMRC), Jeddah, KSA ID SPJ-101-06.

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تأثير إعادة تأهيل القلب بما في ذلك التنفس العميق على مستوى التحمل لدى مرضى قصور القلب الخفيف

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المستخلص:

الخلفية: قصور القلب هو مرض مرضي مع ارتفاع معدل الوفيات. يحتاج المرضى المصابون بالتردد العالي إلى إعادة تأهيل القلب وهي رعاية مخططة ودائمة ، وهي فعالة من حيث التكلفة في تقليل دخول المستشفى وتحسين نوعية الحياة. الهدف: كان الهدف من الدراسة هو مقارنة آثار التنفس الحجابي ومقياس التنفس الحوافز على مستوى التحمل لدى مرضى قصور القلب الخفيف. الأساليب: دراسة تجريبية ، تصميم أحادي التعمية. تم ترشيح خمسة وأربعين مريضا تم تشخيص إصابتهم بهبوط القلب الخفيف من وحدة القلب في مستشفى الملك عبد العزيز الجامعي ، جدة ، المملكة العربية السعودية ، وتم توزيع الأشخاص بشكل عشوائي على ثلاث مجموعات متساوية: التنفس بالحجاب الحاجز ، ومقياس التنفس الحوافز ، والمجموعة الضابطة. تم تقييمهم قبل وبعد إعادة تأهيل القلب. النتائج: أظهرت النتائج ارتفاعا معتدا به إحصائيا في اختبار المشي لمدة ست دقائق بعد التدخل مقارنة بمرحلة ما قبل التدخل في مجموعة التنفس بالحجاب الحاجز ، مما يدل على فعالية التنفس الحجاب الحاجز بناء على النتائج على الرغم من وجود تحسن معتد به في تصنيف المجهود المدرك لمقياس بورغ بعد التدخل مقارنة بفترة ما قبل التدخل في التنفس الحجاب الحاجز بالإضافة إلى ذلك ، كان هناك تحسن معتد به إحصائيا في تشبع الأكسجين بعد التدخل في المجموعة الضابطة. الإشارة إلى فعالية التدريب على تشبع الأكسجين. الخلاصة: كشفت النتائج عن تأثير التنفس الحجاب الحاجز الكبير على مؤشرات ديناميكا الدم وتحسين وظائف القلب.

الكلمات المفتاحية: قصور القلب ، إعادة تأهيل القلب ، التنفس الحجابي ومقياس التنفس التحفيزي