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Effect of Inspiratory Muscle Training on Maximal Inspiratory Pressure in Patients with Congestive Heart Failure

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Abstract

To evaluate the effect of inspiratory muscle training (IMT) on inspiratory muscle strength, and quality of life in patients with congestive heart failure.Background: Inspiratory muscle training is a technique that is designed to improve pulmonary function, level of dyspnea, inspiratory muscle strength and endurance, limb blood flow, six minutes walking distance, exercise tolerance, as well as health related quality of life in congestive heart failure patients.In our study we used maximal inspiratory pressure as a measure of the strength of inspiratory muscles. Methods: Thirty male patients were randomly selected from Cairo university hospitals (critical care department), their ages ranged from 50 to 65 years.

Index terms— Keywords: Congestive heart failure, Inspiratory muscles training, Maximal inspiratory pressure.

Background: Inspiratory muscle training is a technique that is designed to improve pulmonary function, level of dyspnea, inspiratory muscle strength and endurance, limb blood flow, six minutes walking distance, exercise tolerance, as well as health related quality of life in congestive heart failure patients.In our study we used maximal inspiratory pressure as a measure of the strength of inspiratory muscles.

Methods: Thirty male patients were randomly selected from Cairo university hospitals (critical care department), their ages ranged from 50 to 65 years. They were divided into two equal groups: study and control group ,fifteen patients for each group, each patient of the study group received both inspiratory muscles training for 30 min and routine chestphysical therapy for 15 min with frequency five sessions per week for one month, each patient of the control group received only routine chestphysical therapy for 15 min with frequency five sessions per week for one month, All patients are clinically and medically stable as they were on standard cardiac medications all over the study. Pre and post study maximal inspiratory pressure(PImax) and quality of life assessment was done for each patient of both groups.

Results: Despite the homogeneity between the study and control groupsas regard age, weight, height, quality of life and in baseline PImax(P-Value=NS) and despite significant improvement in PImax post treatment compared to pre treatment values in both groups (P value=0.0001 for study group and 0.01 for control group) this improvement was significantly higher in the study group compared to the control group (54.93±11.17 vs 46.8±9.26 cmH2O respectively, Pvalue=0.03). Quality of life Scoresalso showed signific-antimprovement post treatment when compared to pre treatment values in both study and control group (P value=0.001 for both groups) but this improvement was highlysignificant in study group when compared to control group(39.46±5.68 vs 53.4±8.63 respectively, Pvalue=0.0001).

1 Introduction

ongestive heart failure indicates not only an inability of the heart to maintainadequate oxygen delivery; it is also a systemic responseattempting to compensate for the inadequacy [1].

A characteristic feature of congestive heart failure (CHF) is reduced exercise tolerance. Several factors contributing to this have been identified, including alterations in central hemodynamics, skeletal muscle oxygen utilization and respiratory muscle dysfunction [2].

Diastolic heart failure (DHF) and systolic heart failure(SHF) are 2 clinical subsets of the syndrome of heart failurethat are most frequently encountered in clinical practice [3].Those forms of cardiac insufficiency which are due to inadequate diastolic filling of the heart (hypodiastolic failure) andthe far more common ones in which the heart fills adequately but does not empty to the normal extent (hyposystolic heart failure). However, confusions and controversies regarding the definitions, pathophysiology, prognosis and management of DHF and SHF continue [4].

Clinical manifestations can range from no symptoms to dyspnea,pulmonary edema, signs of right heart failure and exercise intolerance.Whereas diastolic dysfunction usually presents as a chronic condition, acutediastolic dysfunction producing acute pulmonary edema is not uncommon manifestation of acute myocardial ischemia or uncontrolled hypertension [5].

Patients with CHF are limited in their physical activity by fatigue and dyspnea, and it has been suggested that respiratory muscle weakness and deconditioning may be involved in the increased work of breathing during hyperpnea. Some of these patients show reduced maximal inspiratory pressure and endurance of inspiratory muscles. Abnormal ventilatory response to exercise, periodic breathing, and delayed oxygen uptake duringrecovery of maximal effort have also been associated with severity andpoor prognosis in CHF [6].

closing pressure, increased work of breathing, and greater oxygen consumption.Pulmonary rehabilitation may improve quality of life and exercise capacity in patients with chronic heart failure [1].

Respiratory muscle dysfunction may play a role in limiting exercise capacity; it has been proposedthat dyspnea is influenced by the central nervous system's perceptionof inspiratory motor output, a signal that increases with a reductionin respiratory muscle strength. The maximal inspiratory pressure andmaximal expiratory pressures, as well as respiratory muscle endurance, are reducedin patients suffering from CHF compared with age-matched normalsubjects. This reduction correlates with the degree of dyspnea [7].

Respiratory muscles, as other skeletal muscles can be trained. Both the structure and the functional characteristics of respiratory muscles may be modified in response to increased imposing loads or decrease follow inactivity. The structural, functional and metabolic changes of the respiratory muscles in response to training have proven to be effective in increasing the cross sectional area of fibers and power generation with a clear increase in contractile proteins. Clinically, the respiratory muscle training demonstrated to be effective in increasing strength and endurance of respiratory muscle in numerous diseases [8].

Generally, training theory suggests that gains in inspiratory muscle strength (force-generating capacity) can be achieved at intensities of 80% to 90% of maximum inspiratory pressure. Strength-endurance gains (maximal effective force that can be maintained) can be achieved at 60% to 80% of MIP, and gains in endurance (the ability to continue a dynamic task for a prolonged period) can be achieved at approximately 60% of peak pressure, which equates to high-intensity training regimens used in systemic exercise. However,earlier studies have suggested that quantitative improvements in work capacity following inspiratory muscle training regimens can occur with intensities as low as 40% of peak pressure [9].

The inspiratory pressure load provided by a pressure-threshold device does not modify airflow mechanics. Therefore, pressure-threshold training provides a quantified pressure challenge to the inspiratory muscles that is independent of airflow [10].

Maximum inspiratory pressure is a measure of the strength of inspiratory muscles, primarily the diaphragm, and allows for the assessment ofventilatory failure, restrictive lung disease, and respiratory muscle strength. The test is quick and noninvasive, but it is highly dependent on participant effort and coaching. The range of normal values is broad, and low values should be interpreted relative to the lower limit of normal values for age and sex [11].

II.

2 Patients and Methods

The study was conducted at Critical Care Medicine Department, Cairo University Hospitals.

3 III.

4 Patients

Thirty male patients with mean age (63.8±4.34) were recruited for the study from Critical Care Medicine Department with the all patients were diagnosed as congestive heart failure with left ventricular ejection fraction range from 30% to 45 % and their NYHA classes IIandIII.

? Inspiratory muscle weakness with maximal inspiratory pressure (PImax) <70% of predicted. It was calculated as: PImax = 126 -1.028 x age + 0.343 xwt (kg).

All patients are clinically and medically stable as they were on standard cardiac medications all over the study (diuretics, angiotensin converting enzyme (ACE) inhibitors, and glycosides etc ?).

5 a) Exclusion criteria

Patients who had met one of the following criteria were excluded from the study:

? Patients with chronic lung disorders, anemia or sever hypoxia. Fifteen patients were assigned as control group and they were subjected toroutinechest physical therapy alone for the same period as study group.

All patients of both groups were under medical treatment, and were asked to be on their normal activities. All the trained subjects received information regarding the benefits of the program. o Frequency: 5 times/week.

6 IV.

7 Instrumentations

8 d) Statistical procedure

In this study data collected were fed to the computer, manipulated and analyzed using (SPSS underpin, statistical package, version12.2011) the mean, standard deviation and mean difference were collected for all patients groups (training and control) The comparison was made by paired t-test to determined the probability levels for difference in mean value between the result observed before and after the period of one months in each group and Comparison between study and control group patients in all studied parameters made by independent t-test.

Wilcoxon matched pairs test for Quality of life questionnaire pre and post treatment in each group and the Mann-Whitney test results for the quality of life questionnaire pre and post treatment between 2 groups. Statistical significance was established at the conventional < 0.05 level.

9 VI.

10 Results

This study were conducted on thirty male patients diagnosed as Congestive heart failure, with NYHA classes II and III selected from Critical Care Medicine Department, Cairo University Hospitals, the patients were classified randomly into two groups, IMT group and control group. The IMT group patients received prescribed inspiratory muscle training and Chest physical therapy, while the control group patients received Chest physical therapy only.All patients were clinically and medically stable as they were on standard cardiac medications. The data were collected before and after four weeks period.

11 VII.

12 Demographic Data

There was no significant difference between both groups in their ages,weights, heights where their Pvalues were (0.67),(0.52), and (0.57) respectively. Table **??**

13 Maximal Inspiratory Pressure a) Comparison between pre and post study mean values in the two groups of patients Group (A)

There was a statistically significant higher value of PImax post study in comparison to its pre study value (54.93±11.17 vs 43.53± 12.17 cmH2O respectively,P-value=0.0001) and the percentage of improvement was 26.18%.Table (2 There was no significant difference between study and control group in pre treatment valuesPImax of (43.53±12.17 vs 43.06±9.94 cmH2O respectively, Pvalue=0.9), but the posttreatmentPImax was significantly higher in the study group compared to the control group (54.93±11.17 vs46.8±9.26 cmH2O respectively, Pvalue=0.03).Table **??**4 The mean value of the QOL score was significantly better post treatment when compared to pre treatment value(39.46±5.68 vs 67.73±9.12 respectively,Pvalue=0.001). Table (5) The mean value of the QOL score was significantly better post treatment when compared to pre treatment value(53.4±8.63 vs 68.4±8.32 respectively, P-value=0.001).Table (6) and Fig. (5). b) Comparison between study group(groupA) and control group(groupB)

There was no significant difference between study and control group in pre treatment values of QOL score(67.73±9.12 vs 68.4±8.32 respectively, Pvalue=0.85), while the post treatment QOL score was significantly better in the study group compared to the controlgroup(39.46±5.68 vs 53.4±8.63 respectively, Pvalue=0.0001). Table (7) and fig. (6).

14 Discussion

Congestive heart failure patients are limited in their physical activity by fatigue and dyspnea, and respiratory muscle weakness and deconditioning may be involved in the increased work of breathing during hyperpnea. Some of these patients show reduced maximal inspiratory pressure and endurance of inspiratory muscles, which are currently recognized as additional factors implicated in the limited exercise response and quality of life, as well as in their poor prognosis [6].

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Patients with chronic heart failure have a restrictive pattern of lung function due to the presence of pulmonary hypertension. This lung 'stiffness' increases the load on the inspiratory muscles and makes a significant contribution to their dyspnea. In addition, there is evidence of inspiratory muscle weakness that emerges as an independent predictor of prognosis in this group of patients [12].

A characteristic feature of congestive heart failure (CHF) is reduced exercise tolerance. Several factors contributing to this have been identified, including alterations in central hemodynamics, skeletal muscle oxygen utilization and respiratory muscle dysfunction [2].

Our study was performed on thirty CHF patientswith mean age (63.8±4.34), their NYHA classes II or III selected from Critical Care Medicine Department, Cairo University Hospitals. Measurements were applied for all patients pre and post study regarding: The results of our studyrevealed statistically significant improvementininspiratory muscle strength (measured as the PImax) in the study group when compared to control group and this may be explained by that the inspiratory muscles are morphologically and functionally skeletal muscles and, therefore, should respond to training in the same way as would any locomotor muscle if an appropriate physiological load is applied.

The aim of training is to induce increase in maximal inspiratory pressure which would lower the value of the ratio inspiratory pressure generated per breath to PImax (PI/PImax) and the tension-time index (TTI), thereby increasing endurance and decreasing the probability of fatigue Our study is in agreement with the study done by Laoutaris and his colleges in 2007 Whoevaluated the effects of inspiratory muscle training on inspiratory muscle strength, as well as on functional capacity, ventilatory responses to exercise, recovery oxygen uptake kinetics, and quality of life in patients with chronic heart failure and inspiratory muscle weakness .They studied thirty-two patients with CHF and weakness of inspiratory muscles (maximal inspiratory pressure <70% of predicted). The IMT resulted in a 15% increment inPImax, 17% increase in peak oxygen uptake(VO2), and 19% increase in the 6-min walk distance. Likewise, circulatory power (calculated as the product of Peak VO2 and Peak systolic pressure) increased and ventilatory oscillations were reduced [13] These resultswere supportedby another study by Laoutaris and his colleges in 2008 who investigated the benefits of inspiratory muscle training in patients with chronic heart failure. The trained patients significantly increased both maximum inspiratory pressure, and sustained maximum inspiratory pressure, Peak VO2 increased after training, as did the six-minute walking distance, and the quality of life score was also improved [14].

Also our study is in agreement with the study made by Stein R and his colleges in 2009 who investigated the benefits of inspiratory muscle training in patients with chronic heart failure. In this study the training group exercised at 30% of individual maximal inspiratory pressure for three months. All patients exercised seven times weekly for 12 weeks. The training group significantly increased maximum inspiratory pressure, and improves oxygen uptake efficiency slope (OUES). The high correlation between changes inPImax and OUES suggests that inspiratory muscle strength is an important determinant of OUES in these CHF patients [15]. Also the study made by Stephanie J. and his colleges in 2011Whodemonstrated that IMT improve inspiratory muscle strength measured as the maximal inspiratory pressure. These changes in inspiratory pressures were achieved in all participants who underwent an 8-week period of training at 80%, 60%, or 40% of each individual's MIP, with no changes in these indexes in the participants who acted as a control group. However, quantitative improvements in lung volumes, work capacity, were evident in the 80% of the training group [9].

The improvement in inspiratory muscle strength and respiratory function as well as cardiac function lead to improving not only inlife expectancy, symptoms, physical function,social function, role performance, pain and fatigue,but also in quality of life in this patients and this is in agreement with the study done by Laoutaris et al. in 2004 whoconducted arandomized controlled trial of IMT and reported significant improvements in dyspnea, exercise tolerance, quality of life in patients with chronic heart failure [16].

The study done byFabbri G. and his colleges in 2007 revealed thatimprovedhealth-related quality of life by managing symptoms than curing the disease is the primary goal in the treatment of patients with congestive heart failure. Assisting or encouragement of patients to adopt a positive attitude towards their health status is also one more important goal of treatment. Another approach that can significantly contribute to better quality of life is the improvement of hospital to home transition, although this is closely depending on the severity of the disease [17].

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The result of our study revealed statistically improvement in maximal inspiratory pressure and quality of life scores in patients in both control and study group but this improvement was statisticallysignificant higher in study group only. So, it is recommended to use inspiratory muscles training with chest physiotherapy in order to improve inspiratory muscle strength, cardiac muscle function and quality of life in patients with congestive heart

Figure 1:

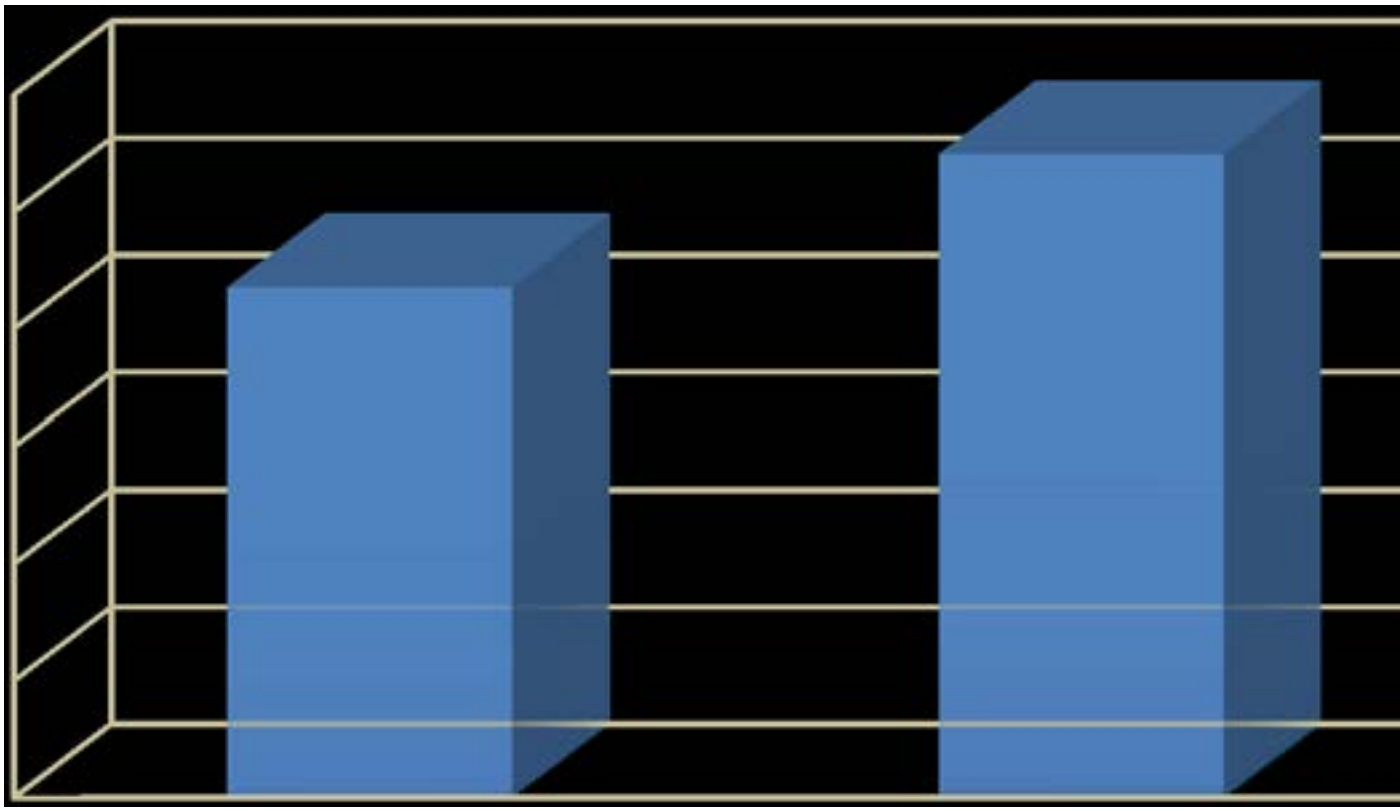
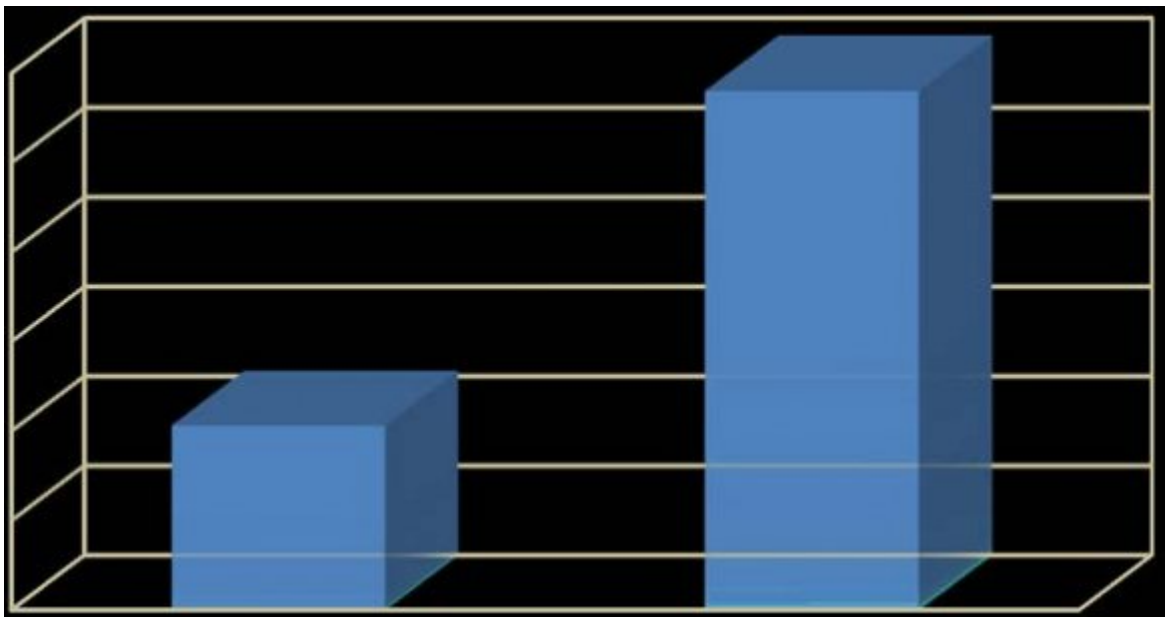


Figure 2:



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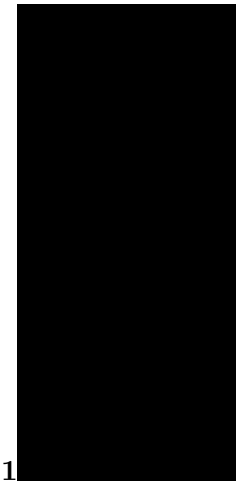


Figure 4: *Fig. 1 :

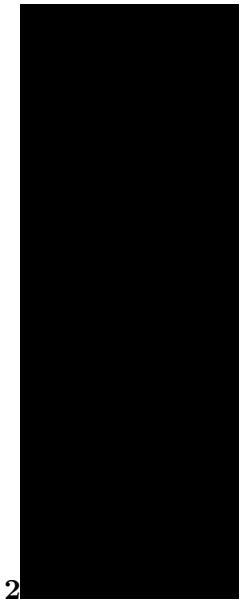
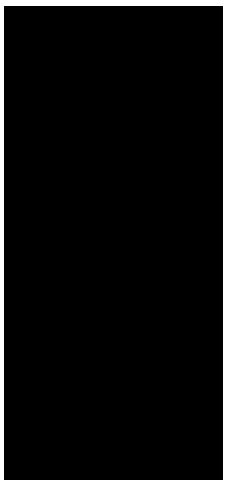


Figure 5: Fig. 2 :



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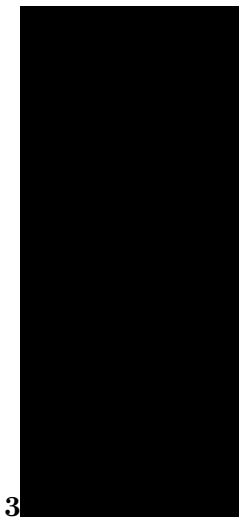

Figure 7: Fig. 3 :

Figure 8:

Figure 9:

Figure 10:

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Figure 11: Fig. 4 :

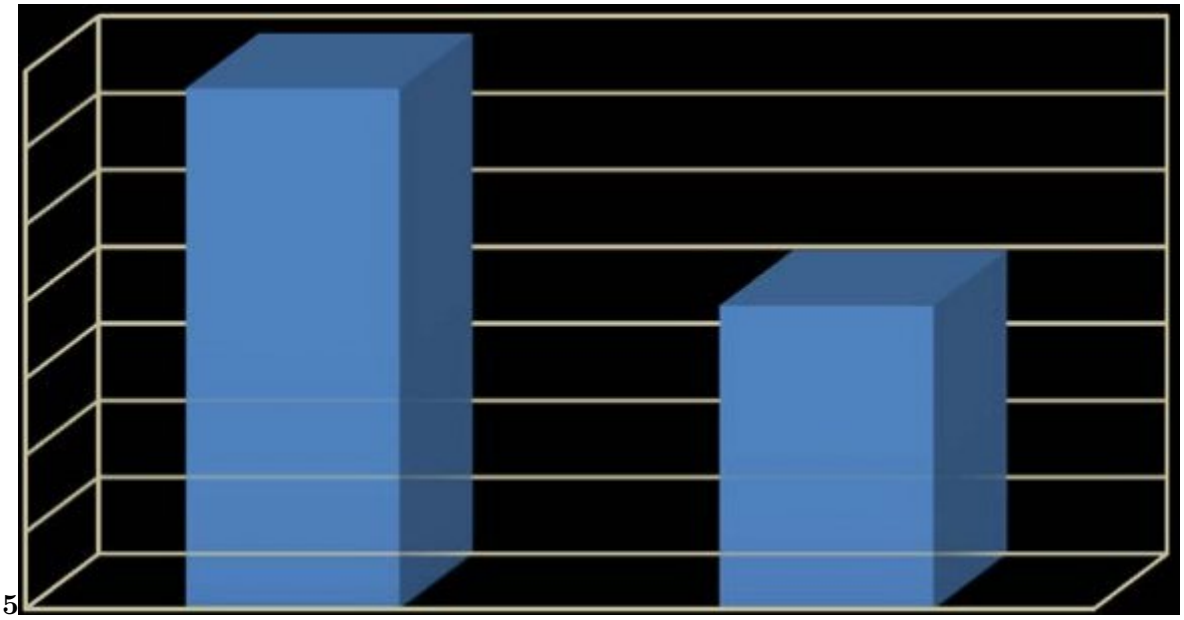

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Figure 12: F*Fig. 5 :

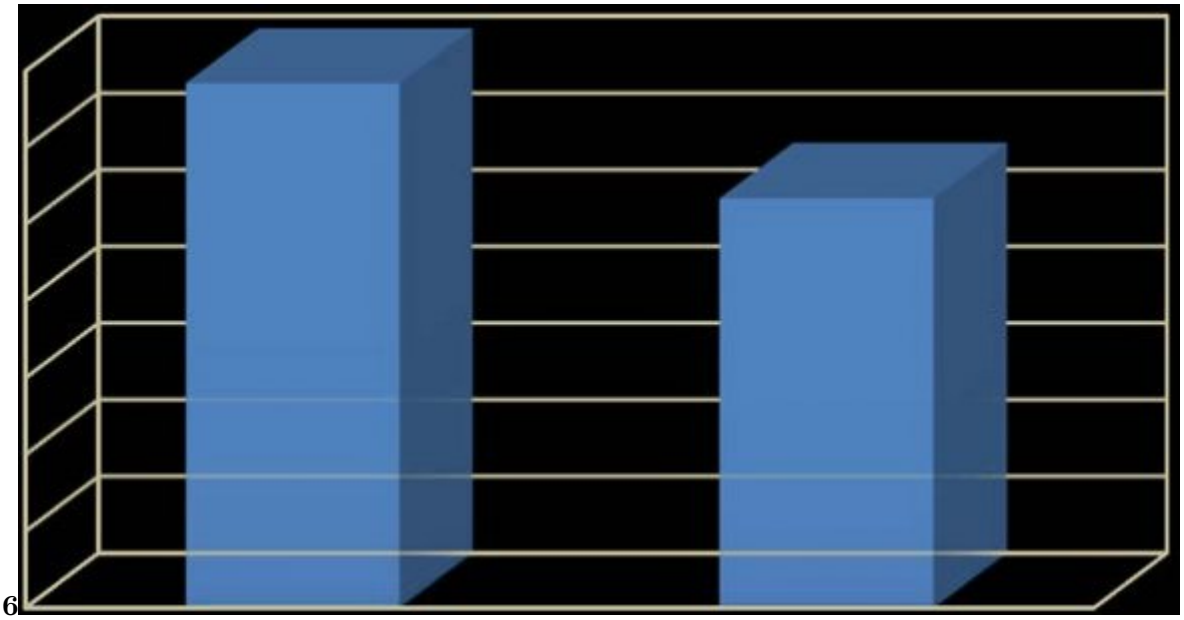

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Figure 13: Fig. 6 :

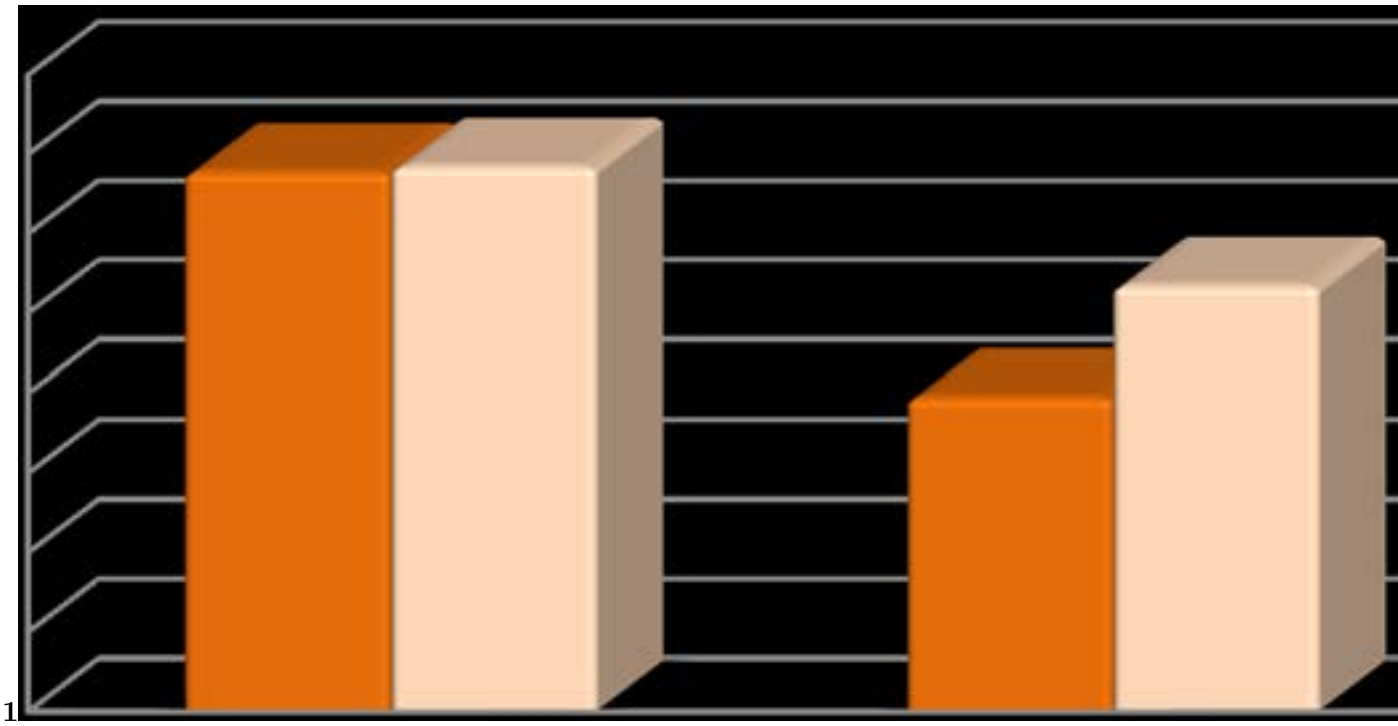

Figure 14: 1)

The patients were randomly divided (Block Randomization) into two equal groups:
Group (1): Inspiratory muscle training(IMT) group (Study Group)
Fifteen patients participated in inspiratory muscle training program using inspiratory muscle trainer and routinechest physical therapy (percussion, vibration, etc?) five times a week for one month. Periodic adjustment of the intensity of inspiratory muscle trainer was done throughout the training period.
Group (2): (Control group)

Figure 15: ?

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Items	Group A Mean	±SD	Group B Mean	±SD	P-value	
Age (yrs)	63.8	±4.34	63.06	±4.97	0.67	NS
Weight (Kg)	81.6	±5.72	82.93	±5.65	0.52	NS
Height (Cm)	167.86	±5.15	166.86	±4.56	0.57	NS

*SD: standard deviation, P: probability, NS:Non significant.

Figure 16: Table 1 :

2

Group A	Maximal inspiratory pressure					
	Mean (cmH 2 O)	±SD	Mean difference	Percentage of improvement	P-value	
Pre treatment Post treatment	43.53 54.93	±12.17 ±11.17	11.4	26.18 %	0.0001	S

Figure 17: Table 2 :

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Group B	Maximal inspiratory pressure Mean (cmH 2 O)	±SD	Mean difference	Percentage of improvement	P-value	
Pre treatment Post treatment	43.06 46.8	±9.94 ±9.26	3.73	8.66 %	0. 01	S

*[Note: *SD: standard deviation, P: probability, S: significant.]*

Figure 18: Table 3 :

5

Group A	Quality of life questionnaire Mean ±SD		P-value	
Pre treatment	67.73	±9.12		
Post treatment	39.46	±5.68	0.001	S

Figure 19: Table 5 :

6

Group B	Quality of life questionnaire Mean ±SD		P-value	
Pre treatment	68.4	±8.32		
Post treatment	53.4	±8.63	0.001	S

*[Note: *SD: standard deviation, P: probability, S: significant.]*

Figure 20: Table 6 :

7

	Quality of life questionnaire			
	Pre treatment(mean±SD)		Pos treatment(mean±SD)	
Study Group	67.73±9.12		39.46±5.68	
Control Group	68.4±8.32		53.4±8.63	
P-value	0.85	NS	0.0001	S

[Note: P: probability, NS: non-significant, S: significant.]

Figure 21: Table 7 :

failure as this may decrease the debilitating effect of chronic heart failure as well as the functional and medical dependence. [1]

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