EFFICACY OF DIFFERENT AEROBIC TRAINING INTENSITIES ON VENTRICULAR REMODELING PARAMETERSIN CHRONIC HEART FAILURE PATIENTS.

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Abstract

Exercise intolerance is a symptom of heart failure and associated with increased disability and mortality. Cardiacremodeling is manifested clinically as changes in size, shape, and function of the heart. Exercise training has been shown to induce reverse remodeling in stable CHF patients. This study was aimed to determine the efficacy of different aerobic exercise training intensities on left ventricular remodeling,and Quality of Life (Minnesota Living With Heart Failure Questionnaire)in chronic heart failure patients. Forty five eligible male patients with chronic heart failure secondary to ischemic heart disease were selected from National Heart Institute, heart failure outpatient clinic. Their ages ranged from 50-60 years old and their ejection fraction ranged from 30-40%, they were randomly assigned into threeequal groups: **HIT Group:** High Intensity aerobic Training.**(n=15) MIT Group:** moderate Intensity aerobic Training..**(n=15)LIT Group:** low Intensity aerobic Training. (**n=15)** in the form of bicycle ergometer exercise for the lower limbs three times /week for three months Before and after intervention, the following parameters were obtained: Echocardiograph parameter (EF%, LVEDD,LVESD,FS) and (MLWHFQ).The results revealed greater improvement in **HIT group** (in EF%, and MLWHF).

Keywords: chronic heart failure, ventricular remodeling, aerobic exercises, Quality of Life.

INTRODUCTION:

Heart failure (HF) is a growing syndrome related to significant morbidity and mortality. The prevalence of HF is 1–2% in developed countries and is expected to rise in the next decadesdue to the ageing population and advances in treatment of cardiovascular diseases that often precede HFA further relevant increase by nearly 50% is predicted until 2030**(Magnussen C &Blankenberg S .,2018) and (Brugts et al,. 2018)**.

Exercise intolerance and peripheral skeletal muscle myopathy are the most important clinical and physical symptoms of CHF**(Papathanasiou et al., 2008).**

Exercise intolerance, which causes progressive functional deterioration in addition to physical impairments in patients with chronic heart failure also exhibit psychological challenges. Controlled clinical trials have also shown that exercise training programs improve aerobic capacity, delay onset of anaerobic metabolism, and improve autonomic balance. Furthermore, improvements in exercise capacity can led to increased metabolism, strength, and vitality and significant reductions in depressive symptoms. **(Lorraine et al., 2017).**

Aerobic exercise training is a well-established non pharmacological tool improving the CHF's pathophysiological, clinical, and prognostic picture, and prescription of an adequate training intensity is crucial to obtain both exercise-induced benefits and a reasonable control of exercise related risk. However, clarity is still lacking regarding the definition of exercise intensity domains and the lower and upper intensity limits of prescriptible aerobic exercise in CHF patients (**Carvalhoand Mezzani 2011).**

It was concluded that aerobic exercise training reverses ventricular remodeling in clinically stable individuals with HF. Therefore the current study was conducted to compare between high intensity training and moderate intensity training for chronic heart failure patients.**(Haykowsky et al., 2007 andZwisler et al ., 2008)** .

MATERIALS AND METHODS:

Subjects:

Forty five male patients with chronic heart failure(Class II and III according to NYHA classification) secondary to ischemic heart disease were selected from the outpatient heart failure clinic National Heart Institute (NHI) All patients were referred and carefully examined by their cardiologist, their ages ranged from 50 to 60 years old.

They were randomly assigned into three equal groups, with age, weight; height matched values. Body Mass Index (BMI) ranged from 25-29.9. All patients had the same risk factors. This study was started from December 2016 till May 2018. **HIT Group**included 15 patients who received high intensity aerobic training and **MIT group**included 15 patients who received moderate intensity aerobic training program **LIT Group** included 15 patients who received low Intensity aerobic Training.

Assessment:

Echocardiography:

M-mode, two dimensional and pulsed Doppler echocardiography examinations was performed with an ultrasound system; a two-dimensional mechanical sector scanner (2.5 MHZ imaging transducer connected to Hewlett- Packard Sons Doppler flow analyzer). Each patient was examined in the supine, left lateral position, according to the standards of the American Society of Echocardiograph.**(Ulbrich et al, 2016).** Ejection fraction(EF) ,left ventricular end diastolic dimension (LVEDD) ,left ventricular end systolic dimension(LVESD) ,fraction shortening (FS%)were recorded before and after training program.

Quality of life:

Minnesota living with Heart Failure Questionnaire (MLHFQ)was used to assess patient perception of the degree to which CHF and its treatment influences physical symptoms, physical and social functions and psychological components of living .Answers were given by choosing a score between 0 (no impairment) and 5 (very much impaired). The total score is the sum of the all items and the possible total score ranges from zero to 105**(Adebayo, *et al.,2017).***

Symptom limited exercise test: It was used to determine Maximum Heart Rate (Max HR), Brief explanation of the procedures was done. Patients were also instructed to avoid any strenuous activity for 24 hours prior to testing and to avoid eating a heavy meal, coffee or cigarettes within 2 to 3 hours of testing.**(Ekblom-Bak; et al 2014) (Mehani. et al ,2013).**

Patients first pedaled at work rate of 30 W without any added load for 1min. The work rate was then increased by 30 watts/3min up until the patient could no longer maintain the required pedal cadence. Their symptom-limited maximum heart rate was recorded during the final 15s of the 3rd min of each stage. Patients were given maximal encouragement to perform to exhaustion (**Nelson.,et al 2000**).

Exercise test was terminated with a cool down stage in which the patient pedals the bicycle for a brief period against zero resistance**(Chatterjee et al., 2013).**

Treatment procedures:

All patients groups performed a supervised individual training program based on the results of exercise tolerance testing, they were trained using heart rate range or reserve method (**Karvonen's method**); training heart rate (THR=HRrest + (HRmax – HRrest) 55-85% This formula is the most accurate one (**Kennedy et al .,2012)**.The study groups of patients shared in different aerobic intensities training program as following **(HIT) Group:** they received High Intensity aerobic Training (75-85%HRR) in the form of bicycle ergometer exercise. **(MIT) Group:** they received moderate Intensity aerobic Training(65-75%HRR) in the form of bicycle ergometer exercise. **(LIT) Group:** they received low Intensity aerobic Training (55-65%HRR) in the form of bicycle ergometer exercise. The duration of the session was 20 min.(at the beginning of the training) and gradually increased till reach 45 min (at the end of 3 months of training).Every session began with warming up exercise in form of active stretching exercise and quite walking for 5 minutes.

Then the active phase lasted for (10-35 min) at the end of 3 months. Cooling down in the form of slow pedaling with no resistance applied for all patients after finishing the session for 5 minutes. Patients closely monitored using ECG telemetry. The training was three times/week for three months.

Data collection

Statistical analysis

Descriptive statistics for all parameters in the form of

Mean and standard deviation of [Demographic and clinical characteristics [ejection fraction(EF) left ventricular internal dimensions (LVEDD ,LVESD),fraction shortening (FS%), and quality of life (Minnesota living with HF questionnaire (MLHFQ)) ,were evaluated. Inferential statistics in the form of Paired t-student test to compare between pre and post-treatment within each study group for the tested variables (LVEDD, LVESD, EF, FS, MLWHF,and BNP).

One way analysis of variance (ANOVA-test) to compare among high, moderate and low groups for demographic data , LVEDD, LVESD, EF, FS, and MLWHF variables. Post hoc multiple comparison test (LSD) between pairs of groups for post-treatment of the tested variables which F was significant from ANOVA test.

Significant level: all statistical analyses were significant at 0.05 level of probability ($P \leq 0.05$).

Results:

Table (1) and Figure (1) represent the mean values of LVEDD within each group. In high intensity group, the mean values of LVEDD were 6.47 ±0.74 pre-treatmentand 5.87 ±0.64 post-treatment. In moderate intensity group, the mean values of LVEDD were 6.27 ±0.59 pre-treatment and 5.93 ±0.60 post-treatment. In low intensity group, the mean values of LVEDD were 6.27 ±0.59 before training and 6.00 ±0.65 after training. Paired t-test revealed that there were significant differences between pre- and post-LVEDD within high intensity group (P=0.0001; P<0.05), moderate intensity group (P=0.019; P<0.05) and low intensity group (P=0.041; P<0.05) with percentage of improvement was (9.27, 5.26 and 4.17%, respectively). The statistical analysis by one-way analysis of variance (ANOVA test) revealed that there was no significant differences (P>0.05) in pre- and post-LVEDD among high, moderate and low groups.

Table (1) Comparison between pre- and post-LVEDD within high, moderate and low intensity groups

Items	**LVEDD**			

	HIT group	MIT group	LIT group	F Value	P Value	
Pre-treatment (Mean ±SD)	6.47 ±0.74	6.27 ±0.59	6.27 ±0.59	0.477	0.624	**NS**
Post-treatment (Mean ±SD)	5.87 ±0.64	5.93 ±0.60	6.00 ±0.65	0.168	0.846	**NS**
Mean difference	0.60	0.34	0.27			
Improvement percentage	9.27%	5.26%	4.17%			
t-value	4.583	2.646	2.256			
P-value	0.0001	0.019	0.041			
Significance(P<0.05)	**S**	**S**	**S**			

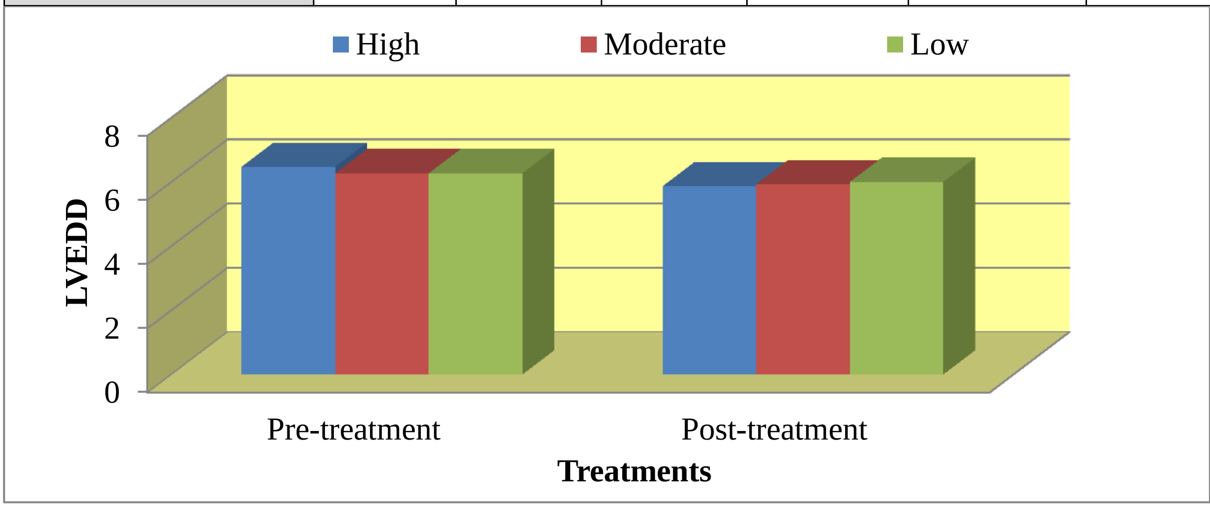

Fig. (1) Show mean values of pre- and post-LVEDD among high, moderate and low groups

Table(2) and Figure (2)represent the mean values of LVESD within each group. In high intensity group, the mean values of LVESD were 5.07 ±0.79 pre-treatmentand 4.33 ±0.48 post-treatment. In moderate intensity group, the mean values of LVESD were 4.93 ±0.70pre-treatment and 4.27 ±0.59 post-treatment. In low intensity group, the mean values of LVESD were

4.26 ±0.59pre-treatment and 3.78 ±0.47 post-treatment. The statistical analysis by paired t-test revealed that there were significant differences between pre- and post-LVESD values within high intensity group (P=0.0001; P<0.05), moderate intensity group (P=0.0001; P<0.05) and low intensity group (P=0.029; P<0.05) with percentage of improvement (14.60, 13.39 and 11.27%, respectively). The statistical analysis by one-way analysis of variance (ANOVA test) revealed that there were no significant differences (P>0.05) in pre- and post-LVESD among high, moderate and low intensity groups.

Table (2): Comparison between pre- and post-LVESD within high, moderate and low intensity groups

Items	**LVESD**					
	High group	**Moderate group**	**Low group**	**F value**	**P value**	

Pre-treatment (Mean ±SD)	5.07 ±0.79	4.93 ±0.70	4.26 ±0.59	0.164	0.849	NS
Post-treatment (Mean ±SD)	4.33 ±0.48	4.27 ±0.59	3.78 ±0.47	0.071	0.932	NS
Mean difference	0.74	0.66	0.48			
Improvement percentage	14.60%	13.39%	11.27%			
t-value	6.205	5.292	3.398			
P-value	0.0001	0.0001	0.029			
Significance (P<0.05)	**S**	**S**	**S**			

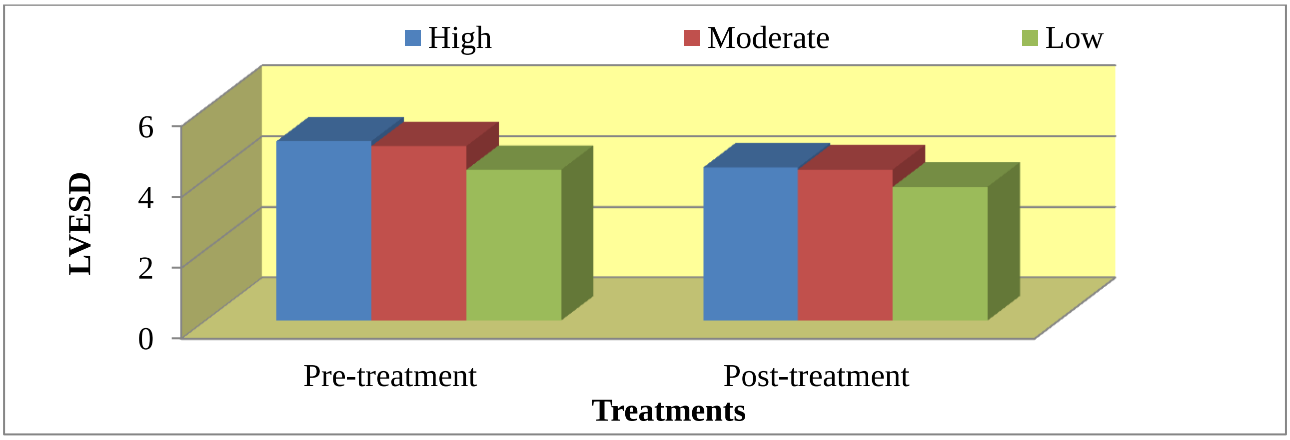

Figure (2) Show mean values of pre- and post-LVESD among high, moderate and low intensity groups

Table (3) and Figure (3)represent the mean values of EF within each group. In high intensity group, the mean values of EF %were 37.00 ±1.85 pre-treatmentand 45.73 ±2.76 post-treatment. In moderate intensity group, the mean values of EF % were 37.27 ±3.01pre-treatment and

42.87 ±2.72 post-treatment. In low intensity group, the mean values of EF% were 37.27 ±3.01pre-treatment and 42.00 ±2.64 post-treatment. The statistical analysis by paired t-test revealed that there were significant differences between pre- and post-EF% within high intensity group (P=0.0001; P<0.05), moderate intensity group (P=0.0001; P<0.05) and low intensity group (P=0.0001; P<0.05) with percentage of improvement (23.60, 15.03 and 12.69%, respectively).

Table (3): Comparison of pre- and post-EF %among high, moderate and low intensity group.

Items	**EF%**					
	High group	**Moderate group**	**Low group**	**F value**	**P value**	
Pre-treatment (Mean ±SD)	37.00 ±1.85	37.27 ±3.01	37.27 ±3.01	0.049	0.952	NS
Post-treatment (Mean ±SD)	45.73 ±2.76	42.87 ±2.72	42.00 ±2.64	7.792	0.001	S
Mean difference	8.73	5.60	4.73			
Improvement percentage	23.60%	15.03%	12.69%			
t-value	14.245	23.82	20.744			
P-value	0.0001	0.0001	0.0001			
Significance (P<0.05)	**S**	**S**	**S**			

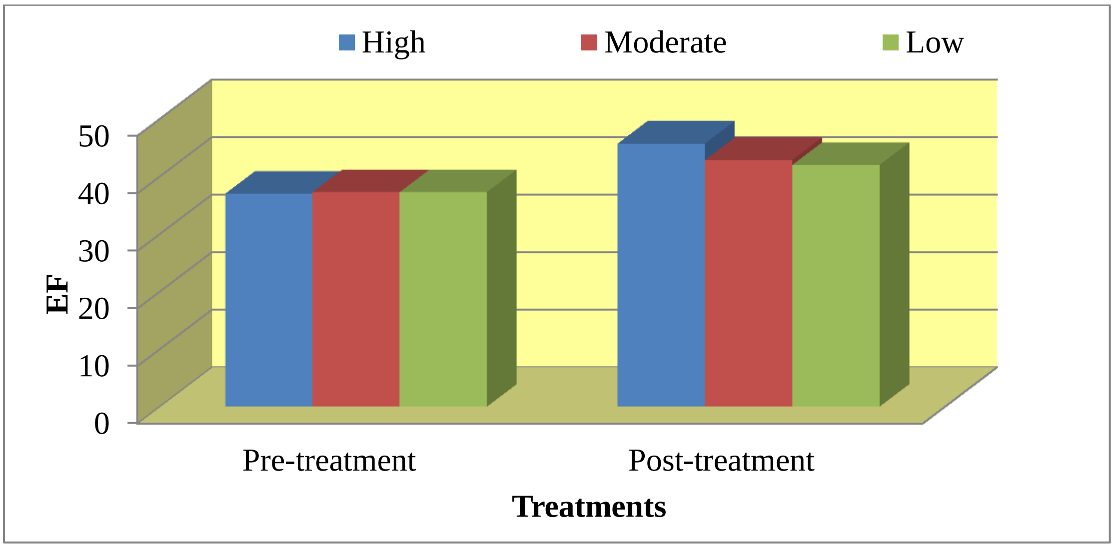

Figure (3): Show mean values of pre- and post-EF% among high, moderate and low intensity groups.

Table (4) represents Post hoc multiple comparison test (LSD) between pairs of groups for post-EF%. There were significant differences between post-high with post-moderate (P=0.006; P<0.05) and post-high intensity with post-low intensity (P=0.001; P<0.05), while, no difference between post-moderate intensity and post-low intensity (P=0.386; P>0.05). From Post hoc, the high group recorded the best group for EF%.

Table (4): Post-hoc multiple comparison test (LSD) for EF%.

Groups		**Post-EF**			
		Means	**High group**	**Moderate group**	**Low group**
Post-EF	**High group**	45.73 ±2.76	-	0.006*	0.001*
	Moderate group	42.87 ±2.72		-	0.386
	Low group	42.00 ±2.64			-

Table (5) and Figure (4) represent the mean values of FS within each group. In high intensity group, the mean values of FS were 19.47 ±2.72

pre-treatmentand 22.60 ±2.32 post-treatment. In moderate intensity group, the mean values of FS were 20.80 ±2.62pre-treatment and 23.82 ±3.03post-treatment. In low intensity group, the mean values of FS were 20.80 ±2.62 pre-treatment and 22.62 ±3.45 post-treatment. The statistical analysis by paired t-test revealed that there were significant differences between pre- and post-FS within high intensity group (P=0.0001; P<0.05), moderate intensity group (P=0.0001; P<0.05) and low intensity group (P=0.0001; P<0.05) with percentage of improvement (16.07, 14.52 and 8.75%, respectively).**Table (5):** Comparison between pre- and post-FS within high, moderate and low groups

Items	**FS**					
	High group	**Moderate group**	**Low group**	**F value**	**Pvalue**	
Pre-treatment (Mean ±SD)	19.47 ±2.72	20.80 ±2.62	20.80 ±2.62	1.259	0.294	NS
Post-treatment (Mean ±SD)	22.60 ±2.32	23.82 ±3.03	22.62 ±3.45	0.829	0.443	NS
Mean difference	3.13	3.02	1.82			
Improvement percentage	16.07%	14.52%	8.75%			
t-value	6.714	8.082	4.677			
P-value	0.0001	0.0001	0.0001			
Significance (P<0.05)	**S**	**S**	**S**			

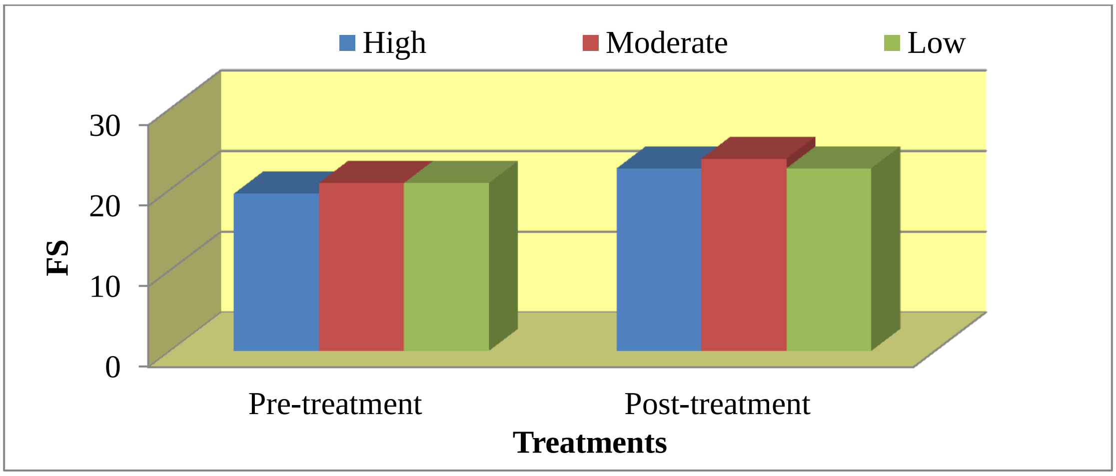

Figure (4): Show mean values of pre- and post-FS among high, moderate and low intensity groups.

Table (6) and Figure (5) represent the mean values of MLWHF within each group. In high intensity group, the mean values of MLWHF were 74.00 ±4.30 pre-treatmentand 25.67 ±3.20 post-treatment. In moderate intensity group, the mean values of MLWHF were 72.00 ±4.55pre-treatment and 25.67 ±3.71post-treatment. In low intensity group, the mean values of MLWHF were 70.00 ±4.43 pre-treatment and 41.67 ±3.71 for post-treatment. The statistical analysis by paired t-test revealed that there were significant differences between pre- and post-MLWHF within high group (P=0.0001; P<0.05), moderate group (P=0.0001; P<0.05) and low group (P=0.0001; P<0.05) with percentage of improvement (65.31, 64.35 and 40.47%, respectively).

Table (7) represents Post hoc multiple comparison test (LSD) between pairs of groups for post-MLWHF. There were significant differences between post-high with post-low (P=0.0001; P<0.05) and post-moderate with post-low (P=0.0001; P<0.05), while, no difference between post-high and post-moderate (P=1.000; P>0.05). From Post hoc, the high group recorded the best group for MLWHF.

Table (6): Comparison between pre- and post-MLWHF within high, moderate and low intensity groups

Items	MLWHF					
	High group	**Moderate group**	**Low group**	**F value**	**P value**	
Pre-treatment (Mean ±SD)	74.00 ±4.30	72.00 ±4.55	70.00 ±4.43	3.000	0.061	NS
Post-treatment (Mean ±SD)	25.67 ±3.20	25.67 ±3.71	41.67 ±3.71	30.434	0.0001	S
Mean difference	48.33	46.33	28.33			
Improvement percentage	65.31%	64.35%	40.47%			
t-value	45.854	32.633	19.956			
P-value	0.0001	0.0001	0.0001			
Significance (P<0.05)	S	S	S			

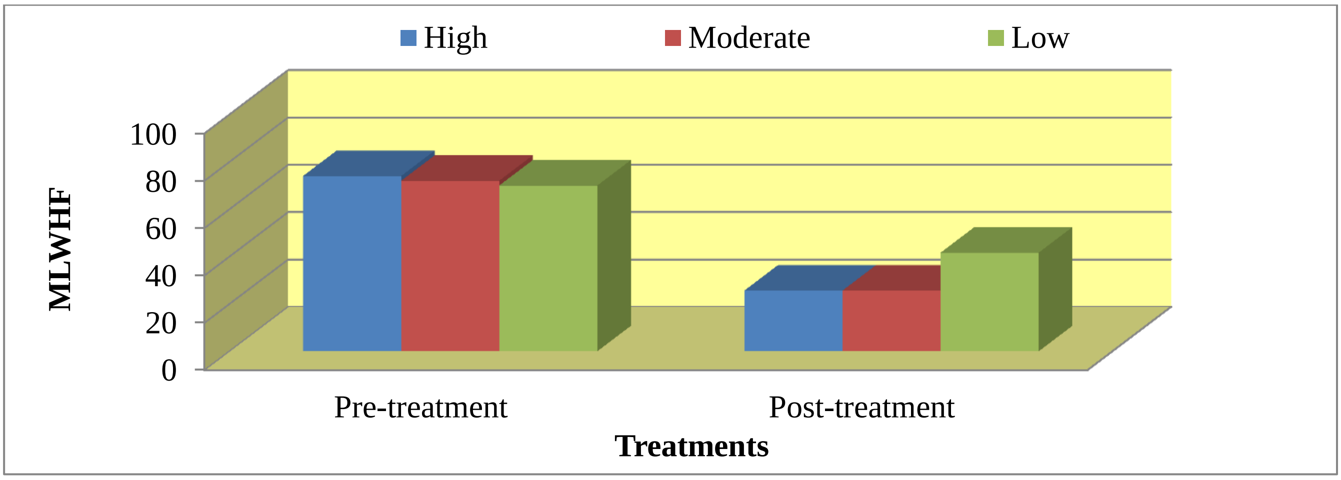

Figure (6): Show mean values of pre- and post-MLWHF among high, moderate and low intensity groups.

Table (7): Post-hoc multiple comparison test (LSD) for MLWHF.

Groups		Post-MLWHF			
		Means	**High group**	**Moderate group**	**Low group**
Post-MLWHF	**High group**	25.67 ±3.20	-	1.000	0.0001*
	Moderate group	25.67 ±3.71		-	0.0001*
	Low group	41.67 ±3.71			-

Discussion:

Exercise training (ET) is generally recommended in stable heart failure outpatients in addition to optimal medical treatment. The main assumption is that ET could benefit exercise capacity and QOL, mainly by increasing peak oxygen uptake (VO2). It is also stated that ET could induce left ventricular remodeling, alteration in cardiac volumes and an augmented left ventricular ejection fraction (LVEF). Furthermore, prognosis towards morbidity and mortality has been shown to improve**.**

(Cornelis et al., 2016).

The effect of ET on QOL is already stated long time before and therefore it is more interesting and important to compare different exercise modalities to clarify which ET modality is most effective**. (Cornelis et al., 2016).**

For Echocardiograph the results of the present study revealed percent of improvement in EF% between pre- and post within high intensity group moderate intensity group and low intensity group as (23.60, 15.03 and 12.69%, respectively).and the results of the study revealed also improvement in EF% inbetween post-high intensity and post-moderate intensity also between post-high intensity and post-low intensity , while, no difference between post-moderate intensity and post-low intensity so, the high intensity group recorded the best group for EF.

For measurement of QOL through Minnesota questionnaire there were improvement between pre- and post-MLWHF within high group, moderate group and low group with percentage of improvement (65.31, 64.35 and 40.47%, respectively). the results of the study revealed also improvement in MLWHF between post-high intensity and post-low intensity, also between post-moderate intensity and post-low intensity while, no difference between post-high intensity and post-moderate intensity so, the high intensity group recorded the best group for MLWHF.

The present study was supported by **Benetti et al., 2010** who studied the effect of 12 weeks of high-intensity physical training at 85% maximum heart rate versus moderate-intensity training at 75% maximum heart rate on cardiorespiratory fitness and quality of life after myocardial infarction ,they found that with regard to quality of life there is a significant improvement QOL in high intensity group than moderate intensity group with a significant impact of exercise intensity on QOL improvement.($p <$ 0.05). There was also a significant improvement of cardiopulmonary fitness (VO2peak) with a significant difference between both groups on favor of high intensity group.

It was demonstrated that patients who do high intensity aerobic exercises attain better cardiorespiratory fitness and QOL than those who do moderate intensity exercises and those who are sedentary. Apparently, for healthy subjects and patients with CAD, the greater the capacity to exercise, the greater the protection against death even in the presence of other risk factors. It is understandable that daily problems and other intervening events resulting from the chronic disease need to be addressed in the context of the individual's interaction and adaptation to the disease and the environment, aiming for a better QOL. Besides the physiological benefits on CAD, physical exercise interventions provided good social integration and easy access to information and education on the disease, which might have improved QOL perception in patients undergoing cardiac rehabilitation (**Benetti et al., 2010).**

Meta-analyses by (**ismail,et al 2013)** confirmed the result of our study, aerobic exercise probably produces the greatest improvements in peak oxygen consumption (VO_2) and left ventricular ejection fraction . Endothelial function and serum levels of natriuretic peptides and proinflammatory cytokines are also improved with exercise training. A search (1985 to 2012) was conducted for exercise-based rehabilitation trials in heart failure, high-intensity training in exercise groups compared with control groups, equating to a 23% improvement from baseline.

The HF-ACTION (''Heart Failure: A Controlled Trial Investigating Outcomes of Exercise Training'') trial also showed that greater physiological and clinical benefits seem likely in patients with heart failure who adhere to a higher volume of exercise **(Lorraine et al., 2017).**

Also, greatly confirmed with **Kemi and Wisløff 2010**who compared between continuous moderate-intensity, and high-intensity exercise training programs that each lasted 3 months and found that The aerobic high-intensity exercise training program increased V□O_2max by 46%, which was paralleled by reduced left ventricular dilatation and mass; and increased ejection fraction (from 0.28 to 0.38), stroke volume, and systolic and diastolic flow; and motion parameters, as well as reduced levels of pro–brain natriuretic peptide .Moreover, quality of life also increased with the exercise training program. In contrast, moderate-intensity exercise training induced only a 14% increase in V□O_2max, but had no effect on the measured cardiac parameters, apart from a small effect on diastolic filling pressure. Blood pressure was not affected by exercise training. family physician according.

(Helgerudetal., 2007) studied effect of high intensity (90-95% HRmax) and moderate intensity (70-85% HRmax) exercises on VO2max in 40 healthy, physically active and non-smoking subjects. The subjects exercised three times a week for eight weeks. At the end of the intervention period, a significant increase in VO2max was observed in the individuals who did high-intensity physical exercises compared with those of moderate and low intensities26. This increase in functional capacity may be considered a modifiable protection factor, since each 1-MET increment in cardiorespiratory fitness was associated with a 12% reduction in cardiovascular mortality.

Marchionni et al., 2003 added to the evidence that an eight-week program of physical exercises at 70%-85% HRmax, performed either at home or in the hospital, improved the subjective QOL perception and tolerance to exercise among post-AMI patients of all age groups.

It was suggested that the antiremodeling effect of exercise training may be due to the reduction in vasoconstrictive hormones or a decline in homodynamic loading, reduction of resting plasma angiotensin II, aldesterone, vasopressin, atrial natriuretic peptide, brain natriuretic peptide and, catecholamine levels. Training is also associated with improved sympathovagal balance, coupled with the decline in vasoconstrictive neurohrmones which can reduce the vascular load that may attenuate LV remodeling. So, aerobic training is an inexpensive and effective nondrug, non-device, non surgical intervention that reverses ventricular remodeling and improves peak VO2 in clinically stable heart failure patients. (**Passion et al., 2006).**

Finding of increased EF after aerobic training is likely attributable to enhanced preload, myocardial contractility, and vascular reserve.The results obtained in the present study suggested that high intensity training and continuous moderate aerobic training improves systolic function ,left ventricular dimension , and quality of life significantly with a significant difference between both groups regarding systolic and quality of life in chronic heart failure .These results suggested that HIT was an effective strategy to reverse cardiac dysfunction and it is feasible and safe as a part of cardiac rehabilitation in chronic heart failure.**Haykowsky et al,.2007.**

Conclusion

High intensity aerobic training is superior to moderate and low exercise regarding improvement of left ventricular function and quality of life with no difference between both groups in left ventricular internal dimensions.

Conflict of Interest

The authors have declared no conflict of interest.

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The author would thank all participants.

Authors Contributions

All authors contributed equally in all parts of this study.

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