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Efficacy of high intensity versus moderate intensity aerobic training on ventricular remodeling and quality of life in chronic heart failure patients

Moustafa Ibrahim Ahmed Elnaggar[2], Zeinab Mohamed Helmy[1], Heba Ahmed Ali Abdeen[1], Mervat Abdel Rahman Mohamed[2], Rania Nabil Hanna[2] and Abeer Ahmed Abdel Hamid[1]

[1]Faculty of physical Therapy, Cairo University, **Egypt.**
[2]National Heart Institute Cairo University, **Egypt.**

***Correspondence:** mosneggar2014@gmail.com **Accepted:02 Nov**. 2018 **Published online:28** Nov. 2018

Exercise intolerance is a symptom of heart failure and associated with increased disability and mortality.Cardiac remodeling involves changes that 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 aimed to determine the efficacy of high intensity Versus Moderate Intensity aerobic exerciseson left ventricular remodeling, and Quality Of Life QOL (MLWHF Questionnaire)in patients with chronic heart failure.Thirty 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 two groups: Group A: received High Intensity aerobic Training in the form of bicycle ergometer exercise for the lower limbs three times/week for three months(n=15).Group B:received moderate Intensity aerobic Training in the form of bicycle ergometer exercise for the lower limbs three times /week for three months(n=15).Before and after intervention, the following measures were obtained: Echocardiograph parameter (EF%, and left ventricular internal dimension), and (MLWHFQ). The results revealed greater improvement in EF% in group A, with significant different (23.6% versus15.03%.*P*<0.001), LVEDD and LVESD significantly improved in both groups with no significant difference between groups, (MLWHFQ) improved significantly in both groups with significant improvement in group A (*P*<0.0001).The study concluded that the high intensity aerobic training is the best improvement in parameters of EF%, and QOL in selected CHF.

Keywords: Chronic heart failure, ventricular remodeling, aerobic exercises, quality of life.

INTRODUCTION

Heart failure (HF) is a growing epidemic related to significant morbidity and mortality and The prevalence of HF is 1-2% in developed countries and is expected to rise in the next decadesdue to the ageing population and success in treating cardiovascular diseases that often precede HFA further relevant increase by nearly 50% is predicted until 2030 (Magnussen and Blankenberg, 2018 and Brugts et al., 2018). Exercise intolerance and peripheral skeletal muscle myopathy are two of 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, 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 in this patient population led to increased metabolism, strength, and vitality and significant reductions in depressive symptoms (Evangelista et al., 2017). Heart failure exercise studies by exercise intensity indicate that the magnitude of gain in cardiorespiratory fitness is greater with increasing exercise intensity (Ismail et al., 2013). 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 (Evangelista 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 and Zwisler et al., 2008).

MATERIALS AND METHODS

Subject:

Thirty male patients with chronic heart failure (Class II and III according to NYHA classification) secondary to ischemic heart disease were referred and carefully examined by their cardiologist from the outpatient heart failure clinic in the National Heart Institute (NHI), their age were range from 50 to 60 years old. They were assigned into two groups equally in numbers, Group (A) included 15 patients who received high intensity aerobic training and group (B) included 15 patients who received moderate intensity aerobic training program, the period of training for both groups was three times per week for twelve weeks .This study was approved by Ethical committee of faculty of physical therapy, Cairo university, Egypt with approval No.: P.T. REC/012/001406.

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 Echocardio graph (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:

It was measured using Minnesota living with Heart Failure Questionnaire (MLHFQ) to assesses 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 and 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. Participants were given maximal encouragement to perform to exhaustion (Nelson et al.,2000).Exercise test finished 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:

Thirty patients participated in the study. The

patients were randomly assigned into two groups. Group A (The high intensity training group) consisted of 15 patients who received high intensity training program for 3 days/week (day another day) for 12 weeks. Group B (the moderate intensity training group) consisted of 15 patients who received moderate intensity training program for 3 days/week (day another day) for 12 weeks. Both group performed a supervised training program at Physical Therapy Department of National Heart Institute based on the results of symptom limited exercise test. They were trained using heart rate range or reserve method (Karvonen'smethod); training heart rate [THR=HRrest+(HRmax-HRrest) %] (Casillas et al., 2017) as following groupA High Intensity aerobic Training (75-85%HRR) in the form of bicycle ergometer exercise and Group B moderate Intensity aerobic Training (65-75%HRR) in the form of bicycle ergometer exercise., both groups started with training at 50%of peak heart rate ,till reaching (75-85%for group A 60-75% for group B) at the end of 12 weeks. For both groups each exercise training session included three phases; warm up phase composed of an initial 5minat30% of the target heart rate. Conditioning phase started with 10 min, gradually prolonged up till 30 min at the end of the 12 weeks, finally, cool down phase for 5 min with intensity decreased gradually to 30% of target heart rate.

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 and LVESD), fraction shortening (FS %), and quality of life (SF-36, Minnesota living with HF questionnaire (MLHFQ)], were evaluated. Inferential statistics in the form of Paired t-test to examine the characteristics (EF, LVEDD, LVESD, FS% and MLHFQ) pre and post training in each group and Independent t-test to compare between the two groups regarding (EF,LVEDD, LVESD, FS%, and MLHFQ) pre and post training. The level of significance was at $P \leq 0.05$.

RESULTS

Demographic and clinical characteristics of patients. In the baseline (pre-training) evaluation, results revealed that there were non-significant differences between the two groups with regard to demographic characteristics and clinical parameters where (P>0.05), Table (1) and figure (1).Table (2) and Figure (2) represented the comparative mean values of pre- and post-LVEDD between high intensity and moderate intensity groups. The mean values of LVEDD pre-treatment were 6.47±0.74in high intensity group and 6.27 ±0.59in moderate intensity group. Whereas, the mean values of post-treatment LVEDD were 5.87±0.64in high intensity group and 5.93±0.60 in moderate intensity group. The statistical analysis by independent t-test revealed that there were no significant difference in pre-LVEDD (P=0.624; P>0.05) and in post-LVEDD (P=0.846; P>0.05) between high intensity group and moderate intensity group

Table (3) and Figure (3) represented the comparative mean values of pre- and post-LVESD between high intensity and moderate intensity groups. The mean values of LVESD pre-treatment were 5.07±0.79 in high intensity group and 4.93±0.70in moderate intensity group. Whereas, the mean values of post-treatment LVESD were4.33±0.48in high intensity group and4.27±0.59in moderate intensity group. The statistical analysis by independent t-test revealed that there were no significant difference in pre-LVESD (P=0.849; P>0.05) and in post-LVESD (P=0.932; P>0.05) between high intensity group and moderate intensity group. Table (4) and Figure (4) represented the comparative mean values of pre- and post-EF% between high intensity and moderate intensity groups. The mean values of EF% pre-treatment were 37.00±1.85in high intensity group and 37.27 ±3.01in moderate intensity group. Whereas, the mean values of post-treatment EF% were 45.73 ±2.76 in high intensity group and42.87±2.72 in moderate intensity group. The statistical analysis by independent t-test revealed that there were no significant difference in pre-EF% (P=0.952; P>0.05) while, a significant difference in post-EF% (P=0.001; P<0.05) between high intensity group and moderate intensity group.

Table (5) and Figure (5) represented the comparative mean values of pre- and post-FS between high intensity and moderate intensity groups. The mean values of FS pre-treatment were 19.47±2.72in high intensity group and 20.80±2.62in moderate intensity group. Whereas, the mean values of post-treatment FS were 22.60±2.32 in high intensity group and 23.82±3.03 in moderate intensity group. The statistical analysis by independent t-test revealed that there were no significant difference in pre-FS (P=0.294; P>0.05) and in post-FS (P=0.443; P>0.05) between high intensity group and moderate intensity group.

Table (1): Comparison of demographic data among high and moderate groups.

Items	Age (year)	Weight (kg)	Height (cm)	BMI (kg/m^2)	NYHA	Duration of infarction
High group	54.33 ±2.35	83.53 ±7.74	172.40 ±6.66	28.09 ±1.70	2.00 ±0.00	4.67 ±0.90
Moderate group	52.53 ±3.46	80.00 ±6.84	171.13 ±5.05	27.29 ±1.63	2.00 ±0.00	4.53 ±0.91
t-value	0.133	1.252	0.252	1.173	0.000	0.107
P-value	0.876	0.296	0.778	0.320	1.000	0.889
Significance	NS	NS	NS	NS	NS	NS

SD: standard deviation; P-value: probability; S: significant and NS: non-significant

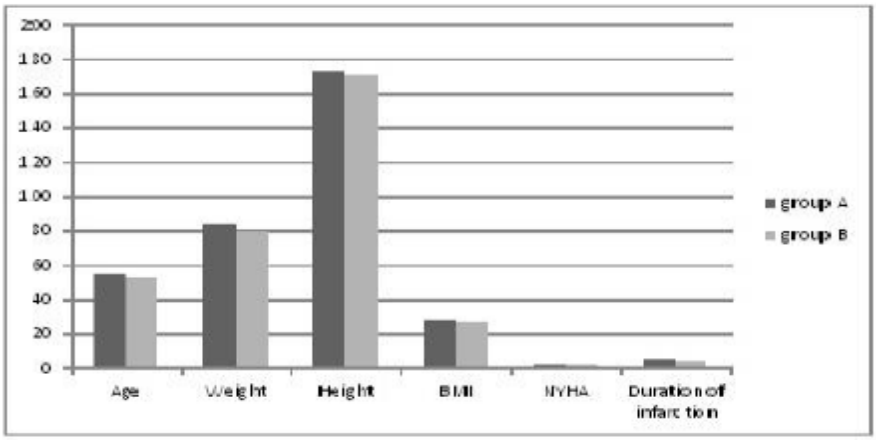
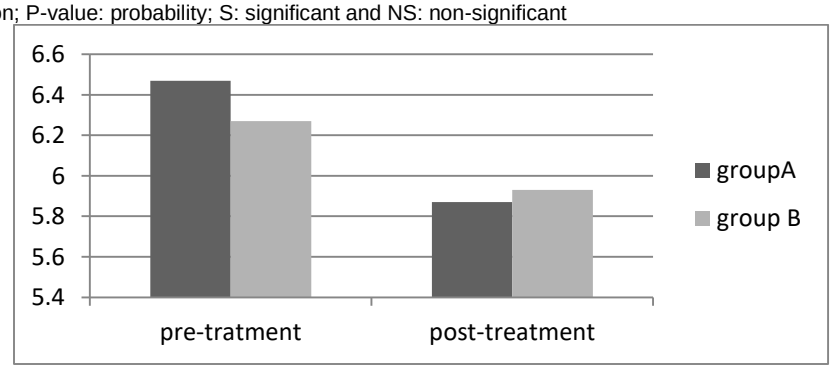


Figure (1): Represent the mean values data among high and moderate groups.

Table (2): Comparison between pre- and post- LVEDD within high and moderate groups.

Items	High group	Moderate group	t-value	P-value	Significance (P<0.05)
Pre-treatment (Mean ±SD)	6.47 ±0.74	6.27 ±0.59	0.477	0.624	NS
Post-treatment (Mean ±SD)	5.87 ±0.64	5.93 ±0.60	0.168	0.846	NS
Mean difference	0.60	0.34			
Improvement percentage	9.27%	5.26%			
t-value	4.583	2.646			
P-value	0.0001	0.019			
Significance (P<0.05)	**S**	**S**			

SD: standard deviation; P-value: probability; S: significant and NS: non-significant

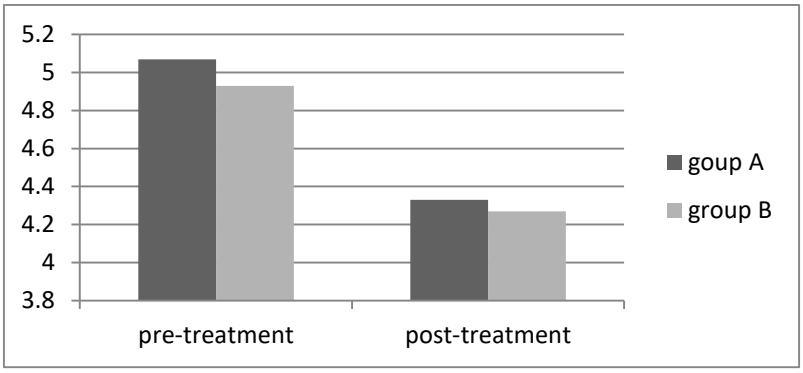


Figures (2): represent the mean values of pre- and post-LVEDD between high intensity and moderate intensity groups

Table (3): Comparison between pre- and post-LVESD within high and moderate groups.

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

SD: standard deviation; P-value: probability; S: significant and NS: non-significant

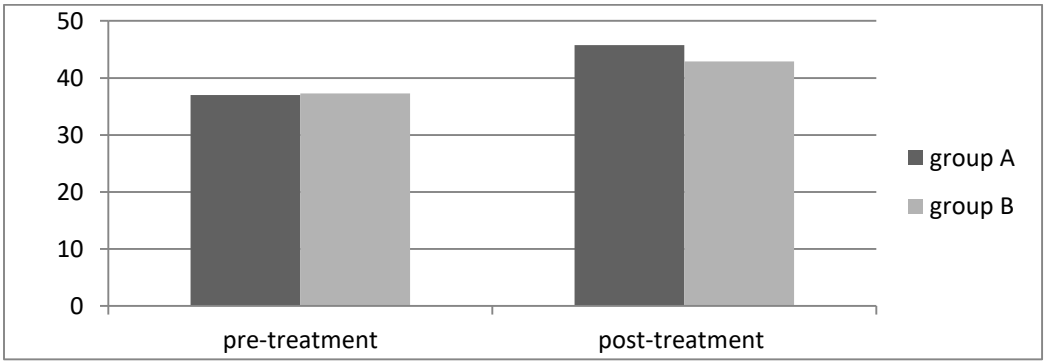


Figures (3): Represent the mean values of pre- and post-LVESD between high intensity and moderate intensity groups.

Table (4): Comparison between pre- and post-EF% within high moderate groups.

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

SD: standard deviation; P-value: probability; S: significant and NS: non-significant

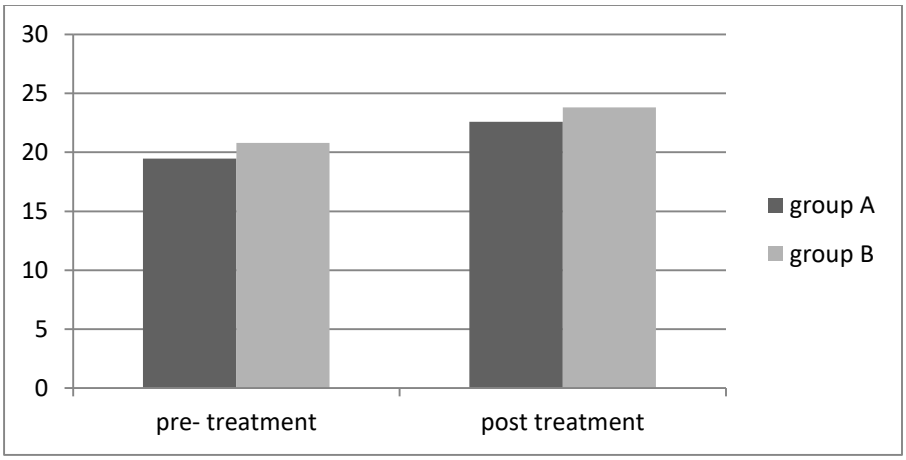


Figures (4): Represent the mean values of pre- and post-EF% between high intensity and moderate intensity groups.

Table (5): Comparison between pre- and post-FS within high moderate groups.

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

SD: standard deviation; P-value: probability; S: significant and NS: non-significant



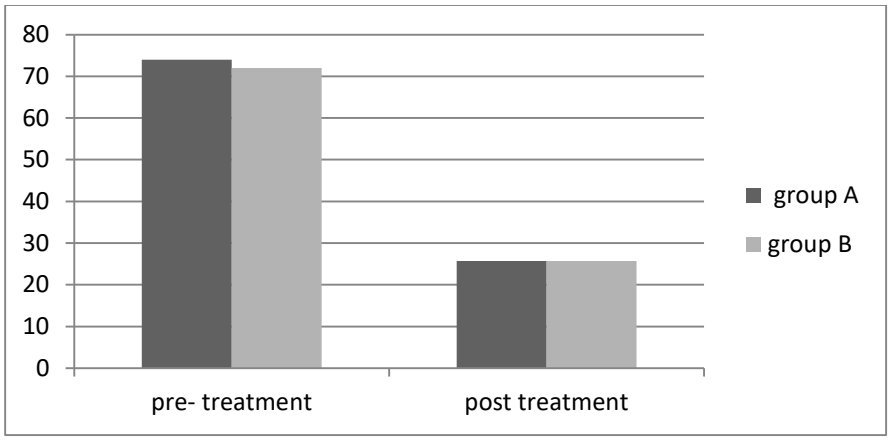
Figures (5): Represent the mean values of pre- and post-FS between high intensity and moderate intensity groups.

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

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

SD: standard deviation; P-value: probability; S: significant and NS: non-significant

Table (6) and Figure (6) represented the comparative mean values of pre- and post-MLWHF between high intensity and moderate intensity groups. The mean values of MLWHF pre-treatment were 74.00 ±4.30in high intensity group and 72.00±4.55in moderate intensity group. Whereas, the mean values of post-treatment MLWHF were 25.67±3.20 in high intensity group and 25.67±3.71 in moderate intensity group. The statistical analysis by independent t-test revealed that there were no significant difference in pre-MLWHF (P=0.061; P>0.05) while, a significant difference in post-MLWHF (P=0.0001; P<0.05) between high intensity group and moderate intensity group.



Figures (6): Represent the mean values of pre- and post-MLWHF between high intensity and moderate intensity groups.

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 and moderate intensity group as (23.60 and 15.03%, respectively) and revealed that there were no significant difference in pre-EF% (P=0.952; P>0.05) while, a significant difference in post-EF% (P=0.001; P<0.05) between high intensity group and moderate intensity group. For measurement of QOL through Minnesota questionnaire there were improvement between pre- and post-MLWHF within high group and, moderate group with percentage of improvement (65.31 and 64.35 %, respectively).also revealed that there were no significant difference in pre-MLWHF (P=0.061; P>0.05) while, a significant difference in post-MLWHF (P=0.0001; P<0.05) between high intensity group and moderate intensity group. 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 HI aerobic exercises attain better cardiorespiratory fitness and QOL than those who do MI 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). 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 $\dot{V}O_2max$ 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 $\dot{V}O_2max$, 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, Helgerud et al., (2007) studied effect of high intensity (90-95% HR_{max}) and moderate intensity (70-85% HR_{max}) exercises on VO_{2max} 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 VO_{2max} 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 cardio respiratory 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% HR_{max}, 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 vasoconstrictiveneuro hormones 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 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 declared that present study was performed in absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

All authors contributed equally in all parts of this study.

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