Electrical Stimulation As A new Approach of Cardiac Rehabilitation for Patients with Dilated Cardiomyopathy

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ABSTRACT

Back ground: *Dilated cardiomyopathy (DCM) is the most common form of non-ischemic cardiomyopathy. It occurs more frequently in men than in women, and is most common between the ages of 20 and 60 years. Electrical stimulation of skeletal muscles in humans has been shown to be valuable therapeutic intervention in neurology in post surgery treatment and in the cases of long-term immobilization.* ***Aim of the work:*** *To evaluate the effect of iso planner electrical stimulation of quadriceps and calf muscles on skeletal muscle strength in patient with DCM.* ***Methodology:*** *Forty patients with DCM were involved in this study, there ages ranged from 40 -60 years with mean age 47.4±5.6 years. Patients were divided into two groups, 20 patient for each study and control group, patients in the study received both iso planner electrical stimulation with frequency four sessions per week for four successive weeks in addition to medical treatment but patients in control group received only medical treatment.* ***Results:*** *The results of these study revealed statistically significant improvement in skeletal muscle strength of quadriceps and calf muscles of both lower limbs in the study group patients in comparison to which of the control group.* ***Conclusion:*** *The most important conclusion arising from these reports is that electrical stimulation should be considered as an alternative to classical exercise training,one that can easily performed at home.The safety and easy application of electrical stimulation could be of great benefit in the rehabilitation of patients with cardiomyopathy,and congestive heart failure,especially those with a severe grade of disease.*

INTRODUCTION

Dilated cardiomyopathy (DCM) is a heart muscle disease characterized by ventricular dilatation and impaired systolic function. Initially patients present with signs and symptoms of heart failure, due either to volume overload or to low cardiac output. Usually, by the time of the diagnosis, probands (here referring to the first individual diagnosed within a family) have severe impairment of the left ventricular ejection function and are in New York Heart Association (NYHA) functional class III-IV[10].

Dilated cardiomyopathy is the most common form of non-ischemic cardiomyopathy. It occurs more frequently in men than in women, and is most common between the ages of 20 and 60 years[9]. About one in three cases of congestive heart failure (CHF) is due to dilated cardiomyopathy[3].

In some patients symptoms of left- and right-sided congestive heart failure develop gradually. Left ventricular dilatation may be present for months or even years before the patient becomes symptomatic. The electrocardiogram often shows sinus tachycardia or a trial fibrillation, ventricular arrhythmias, left atrial abnormality, and sometimes intraventricular conduction defects and low voltage. Echocardiogram shows left ventricular dilatation with normal or thinned walls and reduced ejection fraction[5].

In severe cardiomyopathy, the effects of decreased cardiac output and poor perfusion become more apparent, and patients will manifest with cold and clammy extremities, cyanosis, claudication, generalized weakness, dizziness, and syncope[1].

The progression of heart failure is associated with left ventricular remodeling, which manifests as gradual increases in left ventricular end-diastolic and end-systolic volumes, wall thinning, and a change in chamber geometry to a more spherical, less elongated shape. This process is usually associated with a continuous decline in ejection fraction. The concept of cardiac remodeling was initially developed to describe changes which occur in the days and months following myocardial infarction. It has been extended to cardiomyopathies of non-ischemic origin, such as idiopathic dilated cardiomyopathy or chronic myocarditis, suggesting common mechanisms for the progression of cardiac dysfunction[7].

Backward failure of the right ventricle leads to congestion of systemic capillaries. This helps to generate excess fluid accumulation in the body. This causes swelling under the skin (termed peripheral edema) and usually affects the dependent parts of the body first (causing foot and ankle swelling in people who are standing up[12].

The increased peripheral resistance and greater blood volume place further strain on the heart and accelerates the process of damage to the myocardium. Vasoconstriction and fluid retention produce an increased hydrostatic pressure in the capillaries. This shift of balance of forces in favour of interstitial fluid formation as the increased pressure forces additional fluid out of the blood, into the tissue. This results in edema (fluid build-up) in the tissues[1].

The effects of electrical muscle stimulation are classically different according to the stimulation characteristics and, more particularly, to the stimulation frequency. Indeed, high frequencies (>40-50 HZ) inducing titanic contractions are mainly dedicated to the improvement of the muscular strength, similar to resistance training, whereas low frequencies (10 Hz) improve mainly the metabolic and histochemical characteristics of skeletal, similar to endurance training[8].

Electrical stimulation of skeletal muscles in humans has been shown to be valuable therapeutic intervention in neurology in post surgery treatment and in the cases of long-term immobilization However, the number of studies concerning the effects of ES in cardiovascular rehabilitation was limited[4].

Muscle strength increased significantly both in the isometric and isokinetic modes of measurement. This is in line with the principal findings that ES is effective in preventing disuse atrophy of skeletal muscles and in inhibiting muscle protein break down[2].

METHODOLOGY AND SUBJECTS

Patients

- We evaluated 40 patients with dilated cardiomyopathy, classified as New York Heart Association (NYHA) classes' III to IV, Their age was ranged 40-60 years,with mean age of (47.5±5.7 years). Their mean ejection fraction (EF) was (21.5±3.1%).
- Patients were divided into two groups; study group and control group, 20 patients for each group.
- Patients have to be symptomatically stable, NYHA classes III-IV (was medically diagnosed by echocardiography & coronarography and functional assessment), and optimized pharma-cological treatment that had remained unchanged for two months before and throughout the study.
- Patients of the study group were received both electrical stimulation with frequency 4 sessions per week for four successive

weeks, and medical treatment and patients of the control group were received only medical treatment.

Evaluation

All patients of both groups were subjected to:

- Muscle strength measurement; to determine the maximal muscle strength the Lafayette manual muscle of quadriceps and calf test system (USER MANUAL) (MMT) Model 01163, White Plains, New York (10602) muscles were performed.
- Manual Muscle Test System (MMT) of the quadriceps and calf muscles was performed before and after the end of the three weeks period of the study.
- All measurements were performed while the patient is sitting ، the back well supported, the pelvis and knees flexed at an angle of 90 degrees.
- The patients then were carried out 3 consecutive maximal voluntary extensions (contraction time 3sec-resting time 7sec) the highest value was considered as the maximal strength.

Treatment

- Patients of the study group were received electrical stimulation in form of iso planer vector current stimulation, with frequency: 50 Hz, spectrum: 50 Hz and sweep time of 1 sec.
- The stimulated muscles included quadriceps and calf muscles on both lower extremities. Special vacum rounded electrodes were be used.
- Electrical stimulation was performed for 40 min./day for four days a week for four consecutive weeks. The maximal stimulation amplitude was 60 mA. The maximal stimulation amplitude was 60 mA.
- For the quadriceps muscles vacuum electrodes were positioned on the thighs approximately 5cm below the inguinal fold and 3 cm above the upper patella border. For the calf muscles the electrodes were positioned approximately 2cm under the knee joint and just over the proximal end of the Achilles tendon.

Data Analysis

The mean, standard deviation and the range will be calculated for all subjects. Paired "T" test will be used to determine the mean value of muscles strength for each subject before and after treatment program and to compare the changes with each group.

RESULTS

This study was included forty patients with dilated cardiomyopathy. Their age was ranged 40-60 years,with mean age of (47.5±5.7years). Their mean ejection fraction (EF) was (21.5±3.1%) Patients were divided into two groups; study group and control group, 20 patients for each group. Patients of the study group were received both electrical stimulation with frequency 4 sessions per week for four successive weeks, and medical treatment, and patients of the control group were received only medical treatment.

Table (1) and Fig. (1) show the difference of mean and standard deviation (SD) values of muscle strength of the right quadriceps before and after the treatment program between control and treatment groups before ands after the exercise program.

Table (1): Statistical analysis for muscle strength of the right quadriceps before and after the treatment program.

Group / Parameter	Treatment Group	Control Group	t-value	P-value
Before program	10.37±2.9	10.17 ± 2.4	0.2	P>0.05**
After program	16.6 ± 3.6	10.1± 2.5	6.6	P<0.05*
P-value	P<0.05 *	P>0.05**		

Level of significance at P<0.05 * = significant ** = nonsignificant

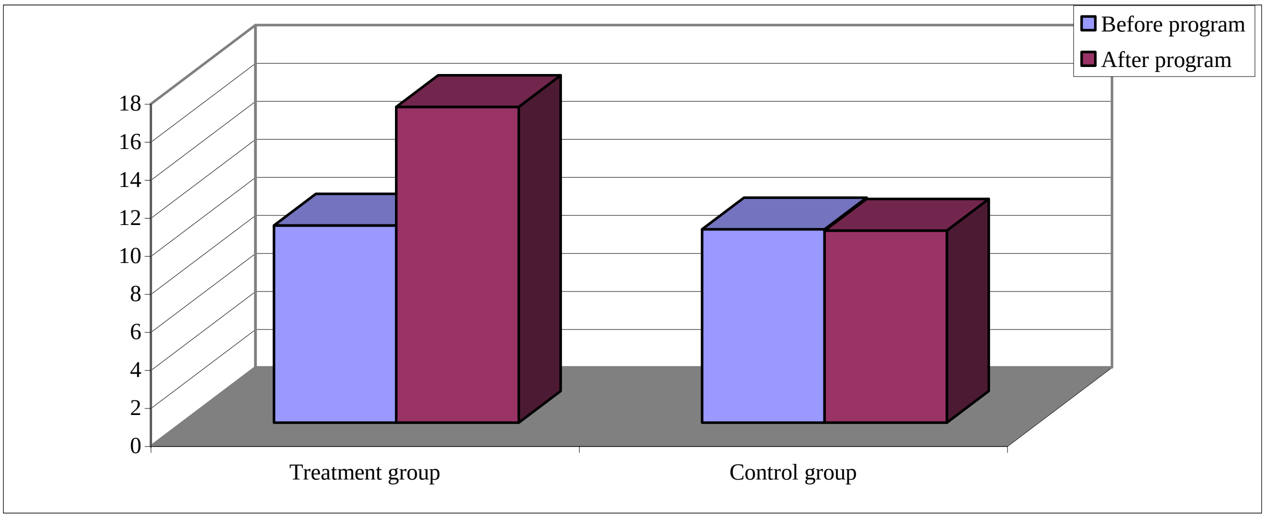

Fig. (1): Statistical analysis for muscle strength of the right quadriceps before and after the treatment program.

Table (2) and Fig. (2) show the difference of mean and standard deviation (SD) values of muscle strength of the Left quadriceps before and after the treatment program between control and treatment groups before ands after the exercise program.

Table (2): Statistical analysis for muscle strength of the Left quadriceps before and after the treatment program.

Group / Parameter	Treatment Group	Control Group	t-value	P-value
Before program	10.2±2.9	10.05 ± 2.5	0.2	P>0.05**
After program	16.3 ± 3.5	10.15± 2.45	6.3	P<0.05*
P-value	P<0.05 *	P>0.05**		

Level of significance at P<0.05 * = significant ** = nonsignificant

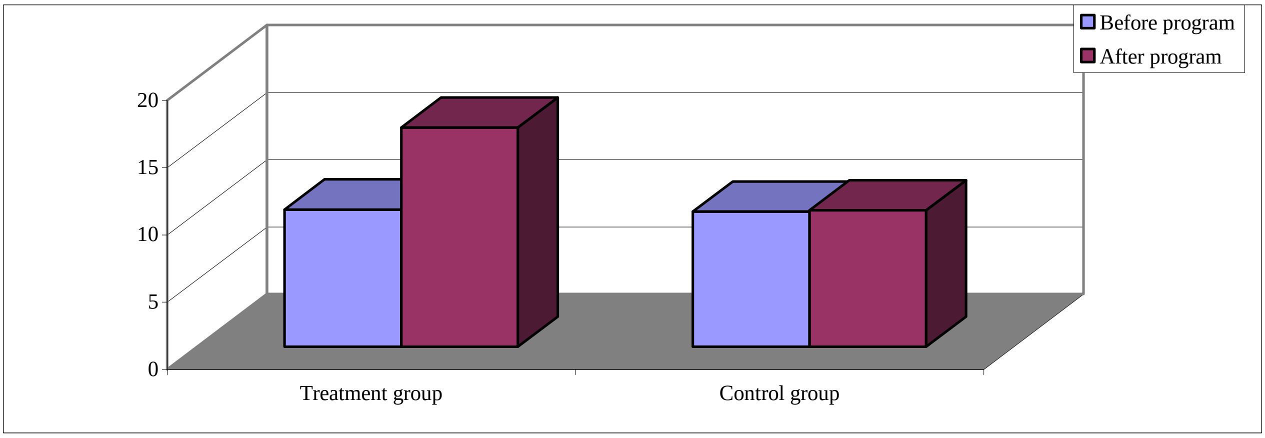

Fig. (2): Statistical analysis for muscle strength of the Left quadriceps before and after the treatment program.

Table (3) and Fig. (3) show the difference of mean and standard deviation (SD) values of muscle strength of the right Calf muscle before and after the treatment program between control and treatment groups before ands after the exercise program.

Table (3): Statistical analysis for muscle strength of the right Calf muscle before and after the treatment program.

Group / Parameter	**Treatment** Group	**Control** Group	t-value	P-value
Before program	5.47±1.2	5.37 ± 0.9	0.2	P>0.05**
After program	10.25± 2.02	5.3± 1.2	9.05	P<0.05*
P-value	P<0.05 *	P>0.05**		

Level of significance at P<0.05 * = significant ** = nonsignificant.

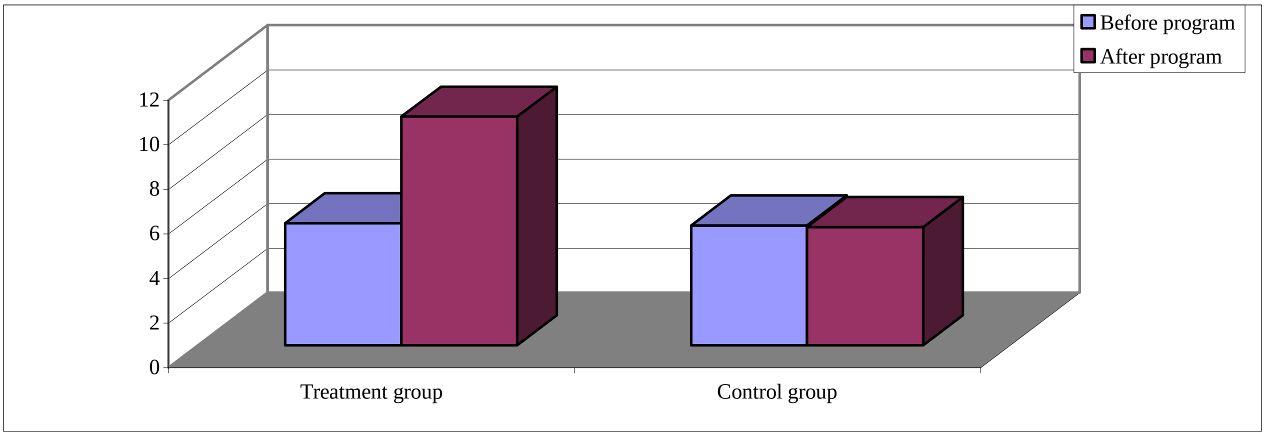

Fig. (3): Statistical analysis for muscle strength of the right Calf muscle before and after the treatment program.

Table (4) and Fig. (4) show the difference of mean and standard deviation (SD) values of muscle strength of the Left Calf muscle before and after the treatment program between control and treatment groups before ands after the exercise program.

Table (4): Statistical analysis for muscle strength of the Left Calf muscle before and after the treatment program.

Group / Parameter	Treatment Group	Control Group	t-value	P-value
Before program	5.4±1.3	5.3 ± 1.29	0.17	P>0.05**
After program	10.3 ± 1.9	5.37± 0. 9	10.05	P<0.05*
P-value	P<0.05 *	P>0.05**		

Level of significance at P<0.05 * = significant ** = nonsignificant

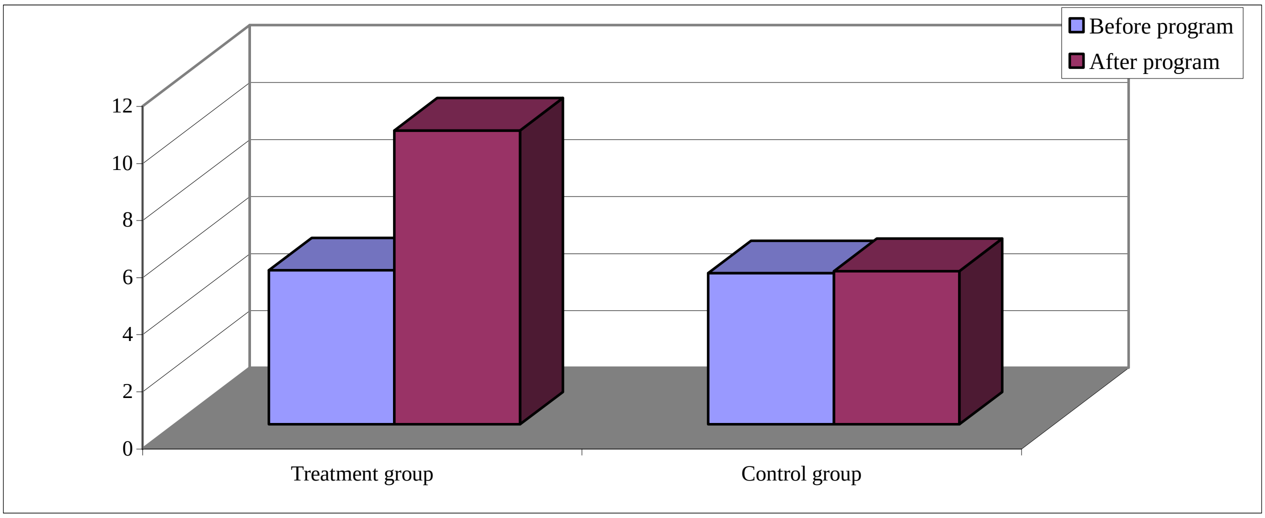

Fig. (4): Statistical analysis for muscle strength of the Left Calf muscle before and after the treatment program.

DISCUSSION

Functional electrical stimulation (FES) is a method of exercising, which requires less baseline functional capacity to perform. It has been studied in patients who cannot undertake conventional forms of exercise, e.g. patients with scoliosis,and muscular dystrophy. It is recognized to improve muscle fatigue resistance and muscle strength[8].

Our present investigation was designed to investigate whether isoplaner vector electrical stimulation of quadriceps and calf muscles has a beneficial effect on muscles strength in patients with dilated cardio myopathy or not.

Forty patients diagnosed with dilated cardiomyopathy randomly assigned into two groups, study group twenty patients and, control group twenty patients. Each patient of the study group received electrical stimulation for 40 min./day, four days a week, for four consecutive weeks in addition to medical treatment, on the other hand each patient of the control group received medical treatment only. Pre and post program muscles strength assessment was done for each patient of both groups.

The results in the present investigation revealed statistically significant increase and improvement in quadriceps and calf muscles strength of patients of the study group compared with those of control group.

Similarly, Vaquero and Chicharro, 1998[11] found a significant increase in functional capacity in CHF patients after eight weeks of electrical stimulation of the lower limbs. The beneficial influence of FES on muscle strength was reported[11].

Electrical muscle stimulation targets a smaller number of muscle groups. So FES is well tolerated, safe, although only a crude assessment of central response to local muscle stimulation, it is in keeping with other investigators who have identified no change in cardiac output and only small changes in heart rate during periods of FES. Whilst this supports the safety of this form of muscle training in patients with cardio myopathy[8]. Also Wiesinger et al., 2001[12] did not observe any life threatening side effects of FES on blood pressure or heart rate.

In other words, electrical stimulation can attain a more intensive work level than any type of exercise. Chronic FES-induced changes in neural regulation and neural motor unit recruitment increases the number of fatigue resistant slow (oxidative) fibers, and the concomitant enhancement of neoangiogenesis and capillary density undoubtedly contributes to the increased exercise capacity and nutritive flow to the skeletal muscle mass[6].

The most important conclusion arising from these reports is that electrical stimulation should be considered as an alternative to classical exercise training, one that can easily performed at home. The safety and easy application of electrical stimulation could be of great benefit in the rehabilitation of patients with cardiomyopathy, and congestive heart failure, especially those with a severe grade of disease.

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الملخص العربي

تقييم استجابة قوة العضلات الهيكلية للتنبيه الكهربائي لدي مرضي تضخم عضلة القلب المتوسع

هدف هذه الدراسة هو تقييم استجابة قوة العضلات الهيكلية للتنبيه الكهربائي لدي مرضي تضخم عضلة القلب المتوسع . أجريت هذه الدراسة على أربعين مريض من مرضى تضخم عضلة القلب المتوسع تتراوح أعمارهم ما بين أربعين إلى ستين عاما و تم تقسيمهم إلى مجموعتين، المجموعة الأولى (مجموعة الدراسة) التي تلقت للتنبيه الكهربائي للعضلات الهيكلية (العضلة الرباعية وعضله الساق) مع العلاج الدوائي والمجموعة الثانية (المجموعة الضابطة) والتي تلقت العلاج الدوائي فقط . وكانت مدة الدراسة أربعة أسابيع بمعدل أربعة جلسات في الأسبوع ، تم قياس قوة العضلات الهيكلية قبل بدأ برنامج العلاج وبعد الانتهاء منه . وقد أظهرت النتائج وجود تحسن ملحوظ مع وجود تغيرات ذات دلالة إحصائية في معدل قوة العضلات الهيكلية لدى المجموعة الأولى التي تلقت للتنبيه الكهربائي مع العلاج الدوائي . وعدم وجود تحسن مع تغيرات ذات دلالة إحصائية في معدل قوة العضلات الهيكلية لدى المجموعة الثانية التي تلقت العلاج الدوائي فقط ،لذلك يوصى بإضافة للتنبيه الكهربائي للعضلات الهيكلية (العضلة الرباعية وعضله الساق) لعلاج مرضى تضخم عضلة القلب المتوسع .