# Impact of Resistance Training in Patients with Chronic Heart Failure

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***Abstract*— This study aims to determine the positive effects of Resistance Training in Chronic Heart Failure patients with inspiratory muscle weakness. 16 patients were enrolled, and underwent a 3 months training program. They were randomized into one of two groups consisting of Resistance Training or control group. Resistance Training was performed at 60% of 1 repetition maximum and each workout was composed of 3 sets of 10 repetitions, with at least 30 seconds of rest between sets. However, the control group did not participate in any exercise program. Pulmonary Function, Respiratory and Skeletal Muscles Function tests were performed as well as Quality of Life and Functional Capacity before and after training periods. Results have shown the beneficial effects of Resistance Training on the skeletal and respiratory muscle function, the functional capacity reflected by the six-minute walk test, the cardiac function, exercise performance, as well as on dyspnea and Quality of Life.**

***Keywords- Heart Failure; Resistance Training; Skeletal Muscle Function; Ejection Fraction.***

## I. INTRODUCTION

Exercise intolerance, dyspnea and fatigue are the main obstacles that Chronic Heart Failure (CHF) patients face during their daily life activities. These phenomena might contribute to physical impairment and result in a poor Quality of Life (QoL) [1]. Such restrictions happen as a consequence of reduction in skeletal muscle mass and strength, which might be explained by both qualitative and quantitative abnormalities [2]. In fact, there are histological and biochemical derangements expressed respectively by altered fibers distribution and reduced oxidative enzyme activity in addition to muscle metabolism impairment, mitochondrial changes, inflammation and muscle atrophy [3]. After a period of intense evaluation of the safety and effectiveness of exercise rehabilitation in CHF patients, exercise training was shown to be the cornerstone of cardiac rehabilitation programs.

Because muscle dysfunction represents a hallmark of heart failure, the emphasis was on Resistance Training (RT), in order to restore the normal muscle structure and function [4]. For many years, bed rest and limited physical activity were recommended for all stages and forms of heart failure; while exercise was not suggested [5]. Nowadays, however, the concept of cardiac rehabilitation, including exercise training, and specifically RT, is well spotlighted and highly recommended recently, mainly because of studies that show its benefits in various outcomes [6] [7]. In fact, application of such programs induces significant histological, metabolic and functional adaptations in skeletal muscles, thereby, improving patient's QoL. McKelvie was the first to demonstrate in 1995 that there are no significant differences between cycling and RT regarding left ventricle response in heart failure patients [8]. This study found similar results with those obtained from Meyer et al. where central hemodynamics was stable and well tolerated during resistance exercise [9]. In addition, from the research conducted by Grosse et al. who performed RT at 65% of 1 Repetition Maximum (RM), an increase of 80–102% of muscular endurance and 14.5% of VO2peak was reported [10]. Pu et al. who performed RT at 80% of 1RM, also showed a 43% and 13% increase of muscular strength and Six-Minute Walk Test (6MWT), respectively [11].

These findings are consistent with those of Levinger et al. who discovered 18% increase of muscular strength and 19% amelioration of VO2 peak after training patients at 40–80% of 1RM [12]. As shown above, the significant improvements in muscle strength and endurance, the adaptation of muscle mass and the increase in the QoL and functional capacity had been proved by many researchers after RT [11] [13] [14]. Each study performs RT according to specific characteristics such as intensity, duration, frequency, number of repetitions and sets of exercise. Overall, these features should be taken into consideration to

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avoid any cardiovascular stress, and thereby any harmful consequence. The aim of our study is to determine the effects of RT on skeletal and respiratory muscle function, functional capacity, cardiac function, dyspnea and QoL in patients with CHF. The paper proceeds as follows: Section II describes the experimental design, data are analyzed in Section III, Section IV presents the discussion and, finally, Section V draws the conclusions.

## II. METHODS

16 patients with stable CHF and inspiratory muscle weakness were randomly assigned to a training program for 12 weeks (3 times / week). The patients were divided, thereafter, into two different groups: controls (n=8) and resistance (n=8). Patients in the control group did not exercise at all and were instructed to continue their normal life activities during the three months of trial. However, RT consisted of strength exercises that targeted the muscles of the quadriceps, the hamstrings and gluteus muscles of the lower extremities; Biceps, Triceps, Deltoid, and Pectoralis of the upper extremities. The patients started training at 60% of 1RM that was assessed and recalculated every two weeks.

During the test, verbal encouragement was used. Maximum Voluntary Isometric Force (MVIF) for right and left muscles was measured; three sets of three repetitions, separated by 20 seconds of rest were given to the patient to develop maximum force.

Concerning the isometric endurance time or Maintenance Time (MT), it was assessed by maintaining 50% of the MVIF as long as possible, until exhaustion. This procedure was repeated three times separated by 5 minutes of rest.

At baseline and after the training period, patients underwent pulmonary function test by spirometry, respiratory muscle function assessment by electronic pressure transducer in order to measure Respiratory Muscle Strength (MIP), echocardiography, to asses Left Ventricle Ejection Fraction (LVEF), stress test, skeletal muscle function test using hand-held dynamometer, and 6MWT. Dyspnea, according to Borg scale, and QoL, according to Minesotta living with heart failure questionnaire (MLWHFQ), were also assessed.

## III. RESULTS

Compared to control, the training group had 18% ($p<0.05$) and 11% ($p<0.05$) improvement in the right and left MVIF respectively, and a 24% improvement in the right quadriceps muscle endurance capacity (MT) ($p<0.05$).

Moreover, RT has shown a 27% improvement in exercise time ($p<0.01$), 24% in METS ($p<0.01$), and a 15% improvement in dyspnea sensation ($p<0.001$). A significant increase in 6MWT distance (13%, $p<0.01$), a decrease in NYHA functional class (33%, $p<0.05$), and a decrease in MLWHFQ score (30%, $p<0.05$) were also noticed. In addition, a little increase in (LVEF) was observed in RT (5%, $p<0.05$) versus no changes in the control group. Concerning respiratory muscle function, RT was able to improve MIP by 14% ($p<0.01$).

## IV. DISCUSSION

In this study, RT was able to bring out significant improvements in the skeletal muscle function, the cardiac function, NYHA functional class, and dyspnea as well as on functional capacity and QoL. Surprisingly, RT has also shown significant impact on respiratory muscle strength. Since the control group had no significant improvements in any of these parameters, we can confirm the effectiveness of the RT.

The benefits gained in skeletal muscle function affect positively the overall exercise performance and are closely related to beneficial adaptations in the muscle structure and function such as an increase in type 1 fiber, decrease in circulatory pro-inflammatory markers and a better muscle oxidative capacity [4]. In addition, such an intensive RT might induce an increase in the motor unit recruitment and so will impact on root mean square (RMS) value towards an upward trend.

In addition, we observed that the right quadriceps muscle is stronger than the left quadriceps muscle. These variations can be explained by the fact that maybe most of patients are right leg dominants.

Besides, as known, skeletal and respiratory muscle changes in heart failure are associated with biochemical and metabolic disorders. Thus, the fact of improvement in respiratory muscle function in our study may be attributed to the beneficial effects of RT in increasing mitochondrial enzymes and decreasing pro-inflammatory cytokines [3].
The skeletal muscle hypothesis confirms that impairments in the skeletal muscle not only alter the skeletal muscle by itself, but also contribute to further deteriorations and worsens the symptomes [15]. In the same manner as this hypothesis, RT also works not only by improving the skeletal muscle function, but also by enhancing the overall exercise performance and QoL, thus reducing hospitalizations as well as mortality rates. Therefore, regular RT programs are very efficient in counteracting these negative skeletal muscle abnormalities seen in CHF.

## V. CONCLUSION

This study had shown the crucial effect of RT, for it has improved the respiratory muscle strength. RT was safe and effective in improving skeletal muscle function, exercise performance, dyspnea and QoL in CHF patients, as well as in improving cardiac LVEF.

We recommend that future studies investigate the usefulness of the electrical activity of the muscles known as Electromyography (EMG) in clinical diagnosis, in heart failure patients, in order to monitor the progression of skeletal muscle activity and function.

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