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List of Abbreviations

ACE		Angiotensin Converting Enzyme
ACEIs		Angiotensin Converting Enzyme Inhibitors
ADH	.....	Anti-Diuretic Hormone
AF	.....	Atrial fibrillation
ARBs	.....	Angiotensin Receptor Blockers
ARNI	.....	Angiotensin Receptor Neprilysin Inhibitor
AT	.....	Aerobic training
BB	.....	Beta blockers
BCL2	.....	B-cell lymphoma 2
BMI	.....	Body mass index
BNP	.....	B-type Natriuretic Peptide
CAD	.....	Coronary Artery Disease
CHF	.....	Chronic Heart Failure
CK	.....	creatinine kinase
CPET	.....	Cardiopulmonary exercise testing
CPX	.....	Cardiopulmonary Exercise Test
CR	.....	Cardiac Rehabilitation
CRT	.....	Cardiac Resynchronization Therapy
DM	.....	Diabetes Mellitus
ECG	.....	Electrocardiogram
EF	.....	Ejection Fraction
ES	.....	Electric Stimulation
ESR	.....	Erythrocyte sedimentation rate
EVR	.....	Exercise Ventilatory Response
GFR	.....	Glomerular Filtration Rate
HBP	.....	High Blood Pressure

List of Abbreviations

HF	Heart Failure
HFmrEF	Heart Failure with Midrange Ejection Fraction
HFpEF	Heart Failure with Preserved Ejection Fraction
HFrEF	Heart Failure with Reduced Ejection Fraction
HRR	Heart Rate Recovery
ICD	Implantable cardiac defibrillators
IGF-1	Insulin Growth Factor 1
iNOS	Inducible Nitric Oxide Synthetase
LDH	Lactate Dehydrogenase
LV	Left Ventricle
LVAD	Left Ventricular Assist Device
LVH	Left Ventricular Hypertrophy
METs	Metabolic equivalent of tasks
MHC	Myosin Heavy Chain
MLHFQ	Minnesota Living with Heart Failure Questionnaire
MuRF	Muscle Ring Finger Protein
NMES	Neuromuscular Electric Stimulation
NPs	Neuropeptides
NYHA	New York Heart Association Functional Classification
PET	Positron Emission Tomography
QOL	Quality of Life
RAS	Renin-Angiotensin Aldosterone System
RPE	Ratings of Perceived Exertion scale
TOE	Transoesophageal Echocardiography

List of Abbreviations

TTE	.....	Transthoracic Echocardiography
VCO₂	.....	Respiratory Carbon Dioxide Production
VE		Minute Ventilation
VO₂		Respiratory Oxygen Uptake
VT		Ventilatory Threshold
WL		Workload

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Abstract

Heart failure is a common and costly condition. Reduced endurance is the main limiting factor of exercise capacity in HF patients. CPX is considered the most objective method to assess exercise capacity in HF patients. Aim: To study the degree of improvement among chronic stable left ventricular heart failure patients with low and average functional capacity after functional capacity based rehabilitation program. Methods: Forty patients with CHF were randomized to either a control (received their medical treatment with no specific rehabilitation program) or a rehabilitation group. Symptom-limited cardiopulmonary exercise testing (CPX) was performed at baseline and at discharge from the program. Rehabilitation group was further divided according to their functional capacity measures obtained from CPX into group 1 and group 2. Minnesota Living with Heart Failure Questionnaire (MLHFQ) was obtained from all subjects. Group 1 received electric muscle stimulation of both lower limbs 5d/w for 5 weeks. Group2 received a conventional aerobic rehabilitation program 2 or 3 times/w for about 40 sessions. VO_{2p}, VO₂-VT, VE/VCO₂, peak load, HRR and MLHFQ values were compared before and after the treatment period. Results: EMS produced significant improvement of functional capacity measures in addition to quality of life. It was comparable to the aerobic rehabilitation in group 2. Both rehabilitation protocols caused significant improvement when compared to the control group. Conclusion: Functional capacity and quality of life were improved after either EMS or aerobic rehabilitation protocol when applied to selected CHF patients when compared to control patients who didn't receive any rehabilitation program.

Keyword: CHF, electromyostimulation, aerobic training, VE/VCO₂

INTRODUCTION

Heart failure is the pathophysiologic state in which the heart fails to pump blood at a rate commensurate with the requirements of the metabolizing tissues (*Hunt et al., 2001a*). The prevalence of heart failure increases dramatically with age, occurring in 1 to 2 percent of persons aged 45 to 54 years and up to 10 percent of individuals older than 75 years. The syndrome of chronic heart failure has become one of the most common cardiovascular disorders throughout the world, thus placing a heavy financial and social burden on public health funding (*Hambrecht et al., 2000*), (*Pina et al., 2003*) and (*Colucci and Braunwald, 2005*).

The clinical manifestations of heart failure depend on the rate at which the syndrome develops. If the abnormality develops gradually, number of adaptive mechanisms, including cardiovascular remodeling and neurohormonal activation occurs which allows the patient to tolerate and adjust to the abnormality (*Colucci and Braunwald, 2005*).

Chronic heart failure arose as a consequence of inadequate cardiac output and/or damming up of blood behind one or both ventricles (*Moraes et al., 2000*). Precipitating causes of heart failure may include arrhythmias, myocardial ischemia, systemic infections, pulmonary embolism, cardiac infection and inflammation, cardiac toxins and high output states (*Givertz et al., 2005*).