

IMPROVEMENT OF MUSCULAR PERFORMANCE IN PATIENTS WITH CHRONIC HEART FAILURE AFTER SOME WEEKS OF LOW-FREQUENCY ELECTRICAL STIMULATION

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Abstract

The aim of this study was to investigate whether the long-termed low-frequency electrical stimulation (LFES) improves skeletal muscle performance and the rating of perceived exertion. Ten patients with chronic heart failure (NYHA III-IV) were examined before and after 3 and 5 weeks of stimulation of quadriceps muscles. All the patients were on the waiting list for heart transplantation, were symptomatically stable and with optimized pharmacologic treatment (ACEI, betablockers, diuretics). The isometric dynamometry testing of quadriceps muscles was performed. The rating of perceived exertion (RPE) was expressed using the Borg scale. The results of this study demonstrated a significant positive impact of the LFES after 3 and 5 weeks of stimulation on the muscle performance of quadriceps muscles in patients with CHF. Analysis of RPE showed improvement. LFES was subjectively well tolerated and did not exhibit any harmful effect on hemodynamic parameters.

Key words

Chronic heart failure, Low-frequency electrical stimulation, Dynamometry, Rating of perceived exertion

INTRODUCTION

The syndrome of chronic heart failure (CHF) is typically characterized by decreased exercise capacity with reduced peak oxygen consumption. The exercise abnormalities are closely related to impaired skeletal muscle behaviour. The skeletal muscle oxidative metabolism is depressed, intracellular pH levels decrease, phosphocreatine depletion during exercise increases and phosphocreatine resynthesis decreases (*1*). The increased sympathetic tone and stimulation of the renin-angiotensin-aldosterone system influence the redistribution of regional blood flow and

create endothelial dysfunction of all vessels. This leads to an impaired peripheral vascular dilatation in response to vasodilator stimuli and reduction of blood flow and O₂ supply in skeletal muscles (2). Chronic hypoxia damages strongly the structural and metabolic integrity of muscle fibers. The resulting general atrophy decreases the power and fatigue resistance of muscles. Chronic low-frequency electrical stimulation (LFES) has been shown to decrease fatigue and to improve the performance of skeletal muscles.

The aim of this study was to investigate whether the long-termed LFES improves skeletal muscle performance and the rating of perceived exertion.

MATERIALS AND METHODS

PATIENTS

A group of 10 patients (age 54 ± 7 years, ejection fraction $18 \pm 2\%$) diagnosed with CHF, classified as NYHA grades III to IV, were included in the study. They all had undergone coronarography, were symptomatically stable and on optimal pharmacological treatment (ACEI, betablockers, diuretics) that remained unchanged throughout the study.

PROTOCOL OF LFES APPLICATION

The muscles to be stimulated were quadriceps muscles. Special rectangular electrodes 80x100mm (St.Cloud International, Chantonnay, France) were positioned on the thighs cca 3cm under inguinal fold and 2cm over the upper patella border. Electrical stimulation was performed 1 hour/day, 7 days a week for 3 (5) weeks, using dual-channel stimulator Elpha 2000 (Danmeter, Odense, Denmark). The stimulator delivered a biphasic current of 10 Hz frequency. The pulse duration was 200 msec with an "on-off" mode of stimulus (20 s stimulation, 20 s pause). The maximal stimulation amplitude was 60 mA.

MEASUREMENTS

To determine the maximal muscle strength (F_{max}), an isometric dynamometry of quadriceps muscles was performed every week, using a PC-2 SDT dynamometer (Czech Republic).

To evaluate the influence of LFES on cardiovascular reactivity, two basic hemodynamic parameters were measured: blood pressure (systolic and diastolic - SBP and DBP) and heart rate (HR) before and after LFES application.

The rating of perceived exertion (RPE) was expressed using the Borg scale.

STATISTICAL ANALYSIS

The Wilcoxon paired test was used for statistical analysis. The results were expressed as mean \pm SD values. A P value < 0.05 was considered as significant.

RESULTS

A significant improvement of the quadriceps muscle strength (*Table 1, Fig. 1*) and of the RPE (*Table 2*) was observed after 3 and 5 weeks of stimulation (see the table below). SDB, DBP and HR values changes were not significant during all the period of stimulation.

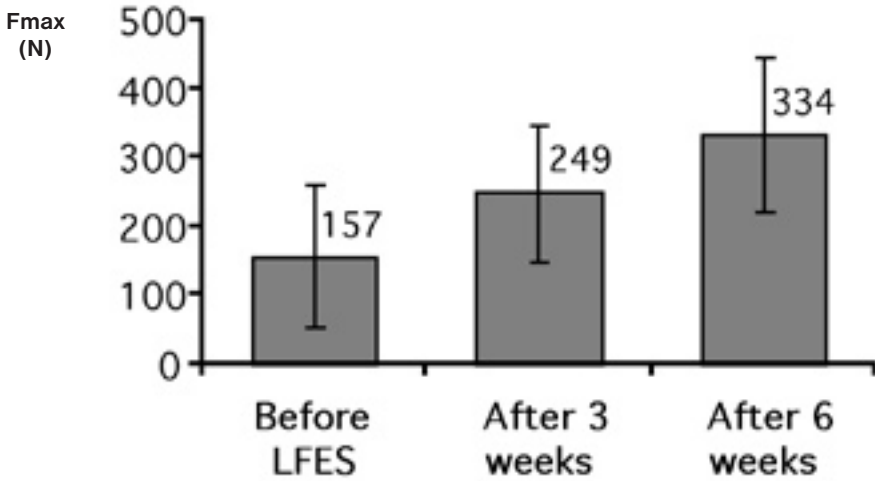


Fig. 1

Results of muscle strength measurements before and after 3 and 5 weeks of low-frequency electrical stimulation in patients with chronic heart failure

Table 1

Results of muscle strength measurements before and after 3 and 5 weeks of low-frequency electrical stimulation in patients with chronic heart failure

Muscle strength	Before LFES ($\bar{X} \pm SD$)	After 3 weeks ($\bar{X} \pm SD$)	After 5 weeks ($\bar{X} \pm SD$)
F _{max} (N)	157.1 ± 103.9	249.1 ± 100.6 *	334.1 ± 111.9 **

F_{max}, maximal muscle strength; N, Newtons; LFES, low-frequency electrical stimulation; \bar{X} , mean; SD, standard deviation; *, P < 0.05; ** P < 0.01.

Table 2

The changes of the rating of perceived exertion before and after 3 and 5 weeks of low-frequency electrical stimulation in patients with chronic heart failure

RPE (Borg scale)	Before LFES ($\bar{X} \pm SD$)	After 3 weeks ($\bar{X} \pm SD$)	After 5 weeks ($\bar{X} \pm SD$)
Exertion	69 ± 25	64 ± 26	51 ± 19
Dyspnea	21 ± 16	17 ± 17 *	12 ± 8 *

RPE, rating of perceived exertion; \bar{X} , mean; SD, standard deviation; *, P < 0.05.

DISCUSSION

The results of this study demonstrated a significant positive impact of the LFES after 3 and 5 weeks of stimulation on the muscle performance of quadriceps muscles in patients with CHF. Analysis of RPE, SBP, DBP and HR showed that LFES was subjectively well tolerated and did not exhibit any harmful effect on hemodynamic parameters.

In 2002 we have published our first results together with French authors with low-frequency electrical stimulation of skeletal muscles in patients with chronic heart failure (3). The low-frequency stimulation was well tolerated by all subjects and after one week improved the quadriceps muscle strength by 28 %. The results of magnetic resonance imaging analysis of the gastrocnemius muscle showed a significant increase in muscle volume after stimulation.

In previous our study we have found that three weeks of LFES significantly increased both muscle strength and blood flow velocity. It was concluded that LFES may improve the structural and functional patterns of skeletal muscles and may be useful in the treatment of patients with severe chronic heart failure (4). The beneficial effects of chronic low-frequency stimulation of thigh muscles in patients with advanced chronic heart failure were described also by *Nuhr et al* (5) and *Quittan et al* (6).

Experiments with LFES confirmed the crucial stimulation-induced changes in skeletal muscles, leading to the transformation of fast fatigable muscles, toward slower, fatigue-resistant ones (7,8). Previous studies showed that LFMES increases capillary density and enhances perfusion in rat and rabbit strength muscles (9,10). The published results showed also a significant improvement of exercise capacity parameters ($\dot{V}O_{2peak}$, $\dot{V}O_{2AT}$) in patients with CHF after 5 weeks of LFMES (11).

The method of LFES can be used also in heart transplantation candidates with cardiac pacemakers (12).

A c k n o w l e d g e m e n t

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ZLEPŠENÍ SVALOVÉ VÝKONNOSTI U PACIENTU S CHRONICKÝM SRDEČNÍM SELHÁNÍM PO NĚKOLIKA TÝDNECH NÍZKOFREKVENČNÍ ELEKTRICKÉ STIMULACE

Souhrn

Cílem práce bylo zkoumat, zda dlouhodobá nízkofrekvenční elektrická stimulace (NFES) zlepšuje svalovou výkonnost a subjektivní vnímání námahy. Deset pacientů s chronickým srdečním selháním (NYHA III-IV) bylo vyšetřeno před a po třech a pěti týdnech stimulace m. quadriceps femoris. Všichni pacienti byli na tzv. "waiting listu" pro transplantaci srdce, byli symptomaticky stabilní s optimální

farmakologickou léčbou (ACE-inhibitory, betablokátory, diuretika). Izometrická dynamometrie m. quadriceps femoris byla vyšetřena stejně jako subjektivní vnímání námahy (RPE) vyjádřené Borgovou škálou. Výsledky studie ukázaly signifikantní zlepšení svalové výkonnosti po 3 a 5 týdnech u pacientů s chronickým srdečním selháním. Analýza RPE ukázala zlepšení. NFES byla subjektivně velmi dobře tolerována a neovlivnila hemodynamické parametry.

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