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FUNCTIONAL CAPACITY IN MEN AFTER CORONARY ARTERY BYPASS SURGERY INFLUENCED BY PHYSICAL TRAINING

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A b s t r a c t

The purpose of the study was to examine the effect of a 12-week controlled outpatient rehabilitation program with combined load on muscle strength and selected indicators of physical fitness and performance and to verify the safety of the program in men after coronary artery bypass grafting (CABG). Nine men after CABG aged 64 ± 7 years, with mean ejection fraction of left ventricle 50 ± 12 % were included. Before the rehabilitation program and after it symptom-limited spiroergometry was carried out up to the symptom-limited maximum. The training intensity was determined at the level of the anaerobic threshold. An isometric test ("handgrip") was made before the beginning of resistance training. If the response was normal, 1-RM test (one repetition maximum test) was made. A statistically significant increase of the capacity of the transport system (1441 ± 307.7 vs. 1768 ± 482.2 ml.min^{-1}), physical performance (90 ± 17.3 vs. 120 ± 37.4 W) and muscular strength (bench press 30 ± 9.8 vs. 36 ± 9.1 kg, pulldown 30 ± 9.4 vs. 37 ± 6.6 kg, leg extension 30 ± 8.6 vs. 36 ± 7.8 kg) was recorded.

K e y w o r d s

Cardiac exercise therapy, Aerobic training, Resistance training, Coronary artery bypass surgery

INTRODUCTION

Cardiovascular rehabilitation is a universally accepted part of the complex care of patients with cardiovascular disease (*1*). It increases physical fitness, improves the quality of life (*2–4*), and decreases cardiovascular mortality (*5, 6*). Dynamic endurance aerobic activities (walking, cycling, jogging, swimming, etc.) are the basis of cardiovascular rehabilitation programs (*7–9*). As a certain level of muscular strength that can be diminished in patients with ischaemic heart disease (*9, 10*) is necessary for a number of working and recreational activities, usefulness of resistance training as an adjuvant component of rehabilitation programs for cardiac patients has been considered (*9*). In spite of a concern regarding the cardiovascular safety of resistance training, resistance exercises proved to be a safe part of cardiovascular rehabilitation (*1, 9–16*).

PURPOSE

The purpose of the study was to examine the effect of a 12-week controlled outpatient rehabilitation program on muscle strength and selected indicators of physical fitness and performance and to verify the safety and the effectiveness of a combination of aerobic and resistance training in patients after coronary artery bypass surgery (ACB).

METHODS

Ten men after ACB aged 64 ± 7 years, with a mean ejection fraction of left ventricle 49 ± 11 %, who were at least 6 weeks (40 ± 28 weeks) after the surgery, were included into the study.

All subjects gave their informed consent.

Methods of examination

Before the beginning of the exercise training (RHB) program and after its completion we carried out symptom-limited spiroergometry up to the symptom-limited maximum (Pulmonary Function System 1070, MedGraphics, USA). The examination was started by monitoring resting ECG in lying and sitting positions (Schiller CS 100), followed by 3-minute adaptation in sitting position on an ergometer. The load was increased every 2 minutes by 20 W up to the symptom-limited maximum. The anaerobic threshold was determined from the course of changes of ventilation-respiration parameters. The values of load, heart rate, and RPE for the training were determined at the anaerobic threshold level.

Before the beginning of resistance training (i.e., in the 3rd week of the RHB program) we did an isometric test ("handgrip", DHG-SY3, Recens) to verify blood pressure response to isometric load. In the case of a normal response the entrance 1-RM test (one-repetition maximum test) was done in three exercises of resistance training. The test was repeated in the 6th week and in the 12th week of the RHB program.

Rehabilitation program

The outpatient controlled RHB program lasted 12 weeks altogether with a frequency of three times a week. The training unit lasted 60 minutes and consisted of several phases (*Table 1*).

Table 1
Composition of the training unit

1st – 2nd week, only aerobic training	3rd – 12th week, combined training
10 min warm-up phase	10 min warm-up phase
40 min aerobic phase	25 min aerobic phase
10 min relaxation phase	15 min resistance training
	10 min relaxation phase

The warm-up phase was aimed at preparing the cardiovascular and motor system for further load, prevention of musculoskeletal lesion. It consisted of dynamic endurance exercises (simple floor gymnastic exercises, exercises with gymnastic apparatus), and stretching of muscle groups with a tendency to shortening.

The aerobic phase was effected on a bicycle ergometer (Ergoline REHA E900) controlled by the ErgoSoft+ for Windows program. The aerobic training intensity was determined at the anaerobic threshold level.

The resistance training was realised on multifunctional muscle conditioning machines TK-HC COMPACT. Four exercises were done (bench press, pulldown, leg extension on the machine, and sitting-lying positions). The resistance training intensity was determined by the 1-RM method and training loads were determined in per cents of maximum: 30–60 % 1-RM (each week increase by 10 %). The number of sequences was 3–5 with the number of repetitions 10x. Before starting the resistance training, the patients were thoroughly informed about proper breathing and the technique of doing exercises.

Modified Schultz autogenic training was used for relaxation.

In the course of the whole training monitoring of heart rate, blood pressure, and degree of RPE during the aerobic phase and, in 1-RM test, also ECG was carried out.

RESULTS

The effect of a 12-week controlled outpatient rehabilitation program showed, in patients after coronary artery bypass surgery, a statistically significant increase of symptom-limited oxygen intake, and oxygen intake converted to kg of body mass (evaluated also at anaerobic threshold level, *Table 2*) was recorded.

Table 2
Parameters of aerobic capacity in patients after coronary artery bypass surgery before and after 12-week controlled outpatient rehabilitation program

	Before RHB	**After RHB**	**p**
VO_2SL ($ml.min^{-1}$)	1452 ± 292.2	1789 ± 459.6	>0.05
VO_2SL/kg ($ml.min^{-1}.kg^{-1}$)	16.5 ± 3.32	20.3 ± 5.94	>0.05
VO_2ANP ($ml.min^{-1}$)	1003 ± 191.5	1151 ± 220.1	>0.01

VO_2SL = symptom-limited oxygen intake, VO_2ANP = oxygen intake at anaerobic threshold level

Symptom-limited performance and performance converted to kg of body mass (evaluated also at anaerobic threshold level, *Table 3*) were also increased.

Table 3
Performance parameters in patients after coronary artery bypass surgery before and after 12-week controlled outpatient rehabilitation program

	Before RHB	**After RHB**	**p**
WSL (W)	89 ± 16.6	123 ± 36.2	>0.05
WSL/kg ($W.kg^{-1}$)	1.0 ± 0.25	1.4 ± 0.49	>0.05
WANP (W)	46 ± 13.5	66 ± 18.6	>0.05

WSL = symptom-limited performance, WANP = performance at anaerobic threshold level

Muscle strength of the groups trained was also considerably increased (*Table 4*).

Table 4
Performance in 1-RM test in patients after coronary artery bypass surgery before and after 12-week controlled outpatient rehabilitation program

	Before RHB	**After RHB**	**p**
Bench press (kg)	31 ± 9.4	38 ± 6.9	>0.01
Pulldown (kg)	29 ± 8.7	35 ± 7.5	>0.01
Leg extension (kg)	30 ± 9.3	36 ± 8.7	>0.01

Statistical processing was made in the Microsoft Excel and Statistica, version 7 programs. Distribution was tested by Lillefors modification of the Kolmogorov-Smirnov test of normality. Some parameters had normal distribution. The Wilcoxon test was used for all parameters.

Our results in patients after coronary artery bypass surgery showed a statistically significant increase of the capacity of the transport system (1441 ± 307.7 vs.

1768 ± 482.2 ml.min-1), physical performance (90 ± 17.3 vs. 120 ± 37.4 W), and muscular strength (bench press 30 ± 9.8 vs. 36 ± 9.1 kg, pulldown 30 ± 9.4 vs. 37 ± 6.6 kg, leg extension 30 ± 8.6 vs. 36 ± 7.8 kg) was recorded.

DISCUSSION

After thoracotomy the capacity for physical performance of the patients is limited. Healing of the lesion takes 4–6 weeks on average. The first 3 months after the surgery physical strain causing tangential acting of forces and pressure on the sternum region should be contraindicated. Before starting the resistance training the attending physician must confirm that the sternum is stable (*4, 17–19*). If there are no postoperative complications and the patient is compensated from the cardiological point of view, effortless muscle conditioning exercises directed at lower extremities can be started even sooner (*20*).

From the study of Maiorany et al. it follows that the mere resistance training does not lead to the increase of symptom-limited oxygen intake. The authors monitored in their study, apart from other things, the influence of a 10-week resistance training on muscle strength in 26 men after ACB. The training unit included a warm-up phase and stretching (5 min), a resistance training (36 min), and a relaxation phase (5 min). The patients did 12 exercises altogether (7 for upper extremities, 4 for lower extremities, and 1 exercise for strengthening of abdominal muscles). At the beginning of the training the patients completed 1 cycle (the so-called "round") of exercises with an intensity of 40 % of maximal voluntary contraction (MVC) with the ratio of effort and rest 1:1 (30 s effort and 30 s rest). The number of repetitions was 10–15. The intensity in the first 2 weeks was increasing in such a way that the number of cycles increased to 2–3, according to the capabilities of the patient. From the 2nd week on, all patients were already doing exercises with 40 % of MVC in 3 cycles, by the 4th week the intensity was increased to 50 % of MVC, from the 6th week on the ratio of effort and rest was changed to 2:1 (40 s effort and 20 s rest), from the 8th week the intensity was increased to 60 % of MVC. This study confirmed that a resistance training of low to medium intensity in suitably chosen patients is safe and represents an effective stimulus for the increase of muscle strength of big muscular groups in men after ACB (*21*).

After the group of men went through the 12-week training with combined load, we also observed a considerable increase of muscle strength of the muscular groups trained. Due to a combination of resistance and aerobic training the aerobic capacity and load tolerance were also substantially increased.

A combination of aerobic and resistance training with an intensity at the anaerobic threshold level seemed in practice to be safe and adequately physiologically effective on condition of a correct choice of patients and their careful continuous checking.

Provided that the safe limits are complied with, combined training associates positive effects of aerobic and resistance exercise and seems to be optimal for the

group of patients that we have been monitoring. A favourable effect of the training continues only if the patient pursues regular exercise. If no regular physical exercise follows after the rehabilitation program, the values of aerobic capacity and physical performance return to the level before the training approximately within a time as long as that of the duration of the regular training.

CONCLUSION

A 12-week combined training in men after coronary artery bypass surgery resulted in increasing the oxygen capacity transport by 23 %, physical performance by 38 %, and muscle strength by 20 %.

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

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