Effect of very short-term inpatient cardiac rehabilitation programs in acute myocardial infarction patients treated with primary percutaneous coronary intervention

Dejan Spiroski¹, Mojsije Andjić¹, Ivana Burazor¹, Slavica Stevović¹, Zoran Ćosić¹, Olivera Ilić Stojanović¹, Milica Lazović^{1, 2}, Ana Djordjević Dikić^{2, 3}, Marija Zdravković⁴, Dragan Lović⁵, Branko Beleslin^{2, 3}

¹ Institute for rehabilitation, Belgrade, Serbia, ² Belgrade University School of Medicine, Belgrade, Serbia, ³ Clinic for Cardiology Clinical Centre of Serbia, Belgrade, Serbia, ⁴ Hospital Medical Center Bežanijska kosa, Belgrade, Serbia, ⁵ Clinic for Internal Disease Inter Medica, Niš, Serbia

Abstract

Background: Exercise-based rehabilitation is an important part of treatment patients following acute myocardial infarction (MI). However, data are scarce on the effects of very short-term exercise programs in patients with acute MI treated with primary percutaneous coronary intervention (pPCI). The aim of the study was to evaluate the effects of very short-term exercise training on cardiopulmonary exercise testing (CPET) parameters in patients suffering acute MI treated with pPCI.

Methods: We studied 40 consecutive patients with MI treated with pPCI referred for rehabilitation to our institution. The study population consisted of 39 men and 1 women (age 50,60±8,40 years, left ventricular ejection fraction 53,05±6,74 %), who participated in 3-week clinical cardiac rehabilitation program. The program consisted of cycling for 7 times/week, and daily walking for 45 min at intensity of 70-80% of the individual maximal heart rate. All patients performed symptom-limited CPET on a bicycle ergometer with a ramp protocol of 10w/min. The CPET also performed after cardiac rehabilitation programs.

Results: After 3 weeks of exercise-based cardiac rehabilitation program improved exercise tolerance as compared to baseline (peak workload 111,50±15,07 vs 129,00±12,77 watts, respectively, p<0,001), as well as peak respiratory exchange ratio (1,02±0,10 vs 1,08±0,13, respectively, p<0,05). Peak systolic blood pressure, heart rate, peak and after 1 minute of rest were also improved. Most importantly, peak VO₂ (18,17±3,30 vs 20,64±3,27 ml/kg/min, respectively, p<0,001), peak VCO₂ (1,65±0,28 vs 1,96±0,25 ml/kg/min, respectively, p<0,001), peak ventilation (48,61±10,70 vs 57,27±9,85 L/min, respectively, p<0,001) and peak oxygen pulse (14,16±2,62 vs 60,18±14,19 ml/beat, respectively, p<0,05) were also improved. No major adverse cardiac events were noted during the rehabilitation program.

Conclusion: Very short-term exercise training in patients with acute MI treated with pPCI is safe and improves functional capacity, as well as test duration, work load and heart rate response.

Key Words cardiac pulmonary exercise testing, exercise training, cardiac rehabilitation, myocardial infarction

Background

Cardiovascular prevention and rehabilitation critically depend on physical activity and exercise training.^{1,2} Exercise-based rehabilitation leads to reduction in all-cause mortality and the risk of reinfarction. Also, it modulates other risk factors and improves exercise-based capacity and quality of life after myocardial infarction (MI).^{3,4} Aerobic exercise consists of three major components, that include intensity, duration and frequency of exercise sessions.^{3,5} The intensity of

exercise training prescription is a key issue in cardiac rehabilitation program. It has not been universally shown that exercise-based rehabilitation leads to improvement in exercise capacity and reduction in the incidence of cardiac events in patients following acute MI.^{1,6}

Cardiopulmonary exercise testing (CPET) using ramp incremental protocol is the gold standard for exercise intensity assessment and prescription in patients with cardiovascular disease. It has been advocated that this test should be performed, where available, in patients before and after cardiac rehabilitation (CR) program,^{7,8}

⁹ in order to quantify exercise capacity, chronotropic and inotropic responses to exercise, as well as to detect presence and severity of arrhythmias and inducible myocardial ischemia.¹⁰

Aerobic exercise training in cardiac patients is usually performed using the constant work-rate (CWR) exercise.⁵ The exercise intensity influences the metabolic and gas exchange responses to CWR. A number of studies have documented improvements in functional capacity after cardiac rehabilitation programs in patients with stable coronary artery disease and myocardial infarction who underwent percutaneous coronary intervention (PCI). Most studies have reported increase in peak VO_2 , in the range of 14 to 31% after exercise training.¹¹ Almost all previous studies have investigated effects of exercise-based rehabilitation that lasted for at least six weeks. As to our knowledge, there are no studies that investigated effects of very short-term exercise programs in patients suffering acute MI treated with primary PCI (pPCI).

Therefore, the aim of our study was to evaluate effect of very short-term (3 weeks) exercise training on CPET parameters in patients suffering acute MI treated with pPCI.

Methods

Study population. We studied 40 consecutive patients admitted to the Institute for rehabilitation Belgrade for exercise-based rehabilitation program who met all of the following criteria: 1) previous acute MI treated with pPCI, 2) ability to perform a symptom-limited CPET, and 3) signed informed consent. Patients were excluded if they had previous MI or revascularization (other than for index event), unstable angina, significant provokable ischemia, complex ventricular arrhythmias, primary valvular disease, severe peripheral vascular disease, severe chronic obstructive pulmonary disease, neuromuscular disease or orthopedic limitation. Study design was approved by the Belgrade University School of Medicine Ethics Committee, and written information and consent were obtained from all patients prior to any study procedure.

Cardiac rehabilitation program. Patients took part in a comprehensive CR program seven times a week for a period of three weeks. The program included exercise training, information sessions, dietary counseling, psychosocial support and smoking cessation. There were two training sessions daily, each of 45 minutes duration. First training session was performed in the morning, which included warm up and cool-down period and a 30-min training phase (aerobic interval training consisting of 3 minutes exercise and 3 minutes rest on a cycle ergometer). The second session was performed in the afternoon, in which aerobic training included walking on the flat surface (continuous training) and walking up stairs (interval training). The training intensity was aimed to be between 60-80% of peak VO_2 as assessed by CPET.

Cardiopulmonary exercise testing. Symptom-limited CPET was performed on a bicycle ergometer (Ergometer

DX1 and Ergometer AX1, Kettler, Ense-Parsit, Germany) with a ramp protocol of 10w/m (workload was increased by 10w/m). The aim was to achieve a maximal effort with a respiratory exchange ratio > 1.05 . Blood pressure was measured manually at rest and every one-minute during the entire testing. The electrocardiogram and heart rate (HR) were monitored at rest and throughout exercise all the time. Breathe-by-breath respiratory gas exchange parameters were measured by a computerized metabolic cart (Cardiovit AT 104 PC, Shiller, Baar, Switzerland). CPET was performed prior to the start of program and immediately after the end of three week exercise-based rehabilitation program. The following CPET parameters were measured: 1) peak VO_2 expressed in ml/kg/min and predicted percentage, 2) slope of minute ventilation vs. carbon dioxide production (VE/VCO_2), 3) peak respiratory exchange ratio (RER), defined as the peak $\text{VCO}_2/\text{peak VO}_2$ ratio, 4) peak VCO_2 , 5) peak oxygen pulse, defined as peak VO_2 divided by peak HR and expressed in ml/beat (O_2 pulse), 6) ventilatory anaerobic threshold detection (VAT), using the V-slope method, 7) maximum ventilation (VE max), 8) peak end-tidal CO_2 partial pressure, (PET CO_2), 9) peak HR, 10) HR recovery, 11) test duration, 12) peak work load, 13) peak systolic arterial blood pressure (SBP), and 14) peak diastolic blood pressure (DBP).

Echocardiography. Complete echocardiographic evaluations were performed using dedicated echocardiographic equipment (Vivid 3, General Electric, Little Chalfont, UK). Left ventricular ejection fraction (EF) was calculated using Simpson biplane method. Measurements were made just before the start and 3 weeks after the rehabilitation program.

Laboratory. Blood for biochemical analysis was drawn after 12 hours fasting period. The following serum parameters were measured: total cholesterol, high-density lipoprotein (HDL), low-density lipoprotein (LDL), triglycerides, fasting glucose, urea, creatinine, sodium, potassium, red blood cells, a high-sensitivity C-reactive protein (hsCRP).

Measurements were made just before start and after termination of inpatient rehabilitation program using biochemical analyzer (Roche 902, Basel, Switzerland).

Statistical analysis. The data were entered into an electronic database (Access, Microsoft) and analyzed using the SPSS 16.0 software (SPSS Inc., Chicago, USA). Continuous variables were expressed as mean and standard deviations. Categorical variables were expressed as percentages. The variables tested prior to the start of program and immediately after the end of three-week exercise-based rehabilitation program were analyzed and compared using analysis of variance (ANOVA). Dichotomous variables were analyzed using the χ^2 test and Fisher's exact test, and continuous variables were analyzed using the *t*-test. The level of statistical significance was set at two tailed probability value of < 0.05 .

Results

Demographic data and comorbidities. Basic demographic data for the patients included in the study are

Table 1. Baseline demographic data and comorbidities

Sex, male (%)	39/40 (97,5 %)
Age, years	50,60 ± 8,40
Diabetes, n (%)	8/40 (20 %)
Hypertension, n (%)	24/40 (60 %)
Hyperlipoproteinemia, n (%)	37/40 (92,5 %)
Obesity, n (%)	17/40 (42,5 %)
Smoking, n (%)	34/40 (85 %)
Family burden, n (%)	30/40 (75 %)

shown in Table 1. Briefly, the study population consisted of 39 men and 1 women, mean age of 50,60±8,40 years. More than two-thirds of patients suffered acute MI of the inferior wall. All patients had acute MI with ST segment elevation and received pPCI within 12 hours of typical chest pain. There were 34/40 (85%) of patients who actively smoke. Comorbidities are detailed in the Table 1. Patients received contemporary concomitant medical treatment, that is 40/40 (100%) patients were on dual antiplatelet therapy, 38/40 (95%) received beta-blockers, 31/40 (77,5%) were on angiotensin converting enzyme inhibitor or angiotensin receptor blocker, and 39/40 (97,5%) was on statin. Exercise-based rehabilitation program was started 34,2±10,9 days after acute MI.

CPET parameters. All CPET parameters were examined before and after completed CR programs (Table 2). After 3 weeks of exercise-based cardiac rehabilitation program improved exercise tolerance as compared to baseline (peak workload 111,50±15,07 vs 129,00±12,77 watts, respectively, $p<0,001$), as well as peak respiratory exchange ratio (1,02±0,10 vs 1,08 ± 0,13, respectively, $p<0,05$). Peak systolic blood pressure, heart rate, peak and after 1 minute of rest were also improved. Most importantly, peak VO₂ (18,17±3,30 vs 20,64±3,27 ml/

kg/min, respectively, $p<0,001$), peak VCO₂ (1,65±0,28 vs 1,96±0,25 ml/kg/min, respectively, $p<0,001$), peak ventilation (48,61±10,70 vs 57,27±9,85 L/min, respectively, $p<0,001$) and peak oxygen pulse (14,16±2,62 vs 60.18±14.19 ml/beat, respectively, $p<0,05$) were also improved.

Interestingly, exercise electrocardiography indicated the presence of ischemia in five patients (12,5%) before and one patients (2,5%) after CR program. There were no major adverse cardiac events during rehabilitation program.

Laboratory and clinical data. We noticed a statistically significant difference only at hsCRP values (7,27±5,73 vs 4,96 ± 5,50, respectively, $p<0,01$) comparing a start and three-week measurement.

There was significant differences in body mass index (28,82±4,41 vs 28,50±4,13, respectively, $p<0,001$). Left ventricular ejection fraction recorded no significant difference (53,05±6,74 vs 53,83±6,59, NS) before and after CR program (Table 3).

Discussion

Main finding of our study is that very short-term (three weeks daily, 21 training sessions) exercise training in patients with acute MI treated with pPCI is safe and improves functional capacity. Very short-term daily exercise training in these patients improves also peak work load and chronotropic parameters evaluated during CPET. This suggests that the effects of physical training depend on the total number of sessions regardless of the length of interval training.

Previous studies indicated that values of peak VO₂ on entry in cardiac rehabilitation program are relatively low, particularly in women. It has been shown that peak VO₂ measured in 2896 patients prior to cardiac rehabilitation program, was higher in men than women:

Table 2. Cardiopulmonary exercise test parameters (at start and 3 weeks after exercise rehabilitation)

	start	3 weeks	p value start/3 weeks
Peak work load (W)	111,50 ± 15,07	129,00 ± 12,77	< 0,001
Test duration (min)	11,15 ± 1,87	12,9 ± 2,36	< 0,001
Peak SBP (mmHg)	167,50 ± 19,01	177,75 ± 16,09	< 0,001
Peak DBP (mmHg)	93,75 ± 11,13	97,25 ± 9,99	> 0,05
HR at rest (bpm)	74,40 ± 11,80	74,73 ± 10,20	> 0,05
Peak HR (bpm)	116,28 ± 15,82	124,90 ± 17,75	< 0,001
HR recovery 1 min (bpm)	18,73 ± 9,29	22,18 ± 9,11	< 0,05
Peak RER	1,02 ± 0,10	1,08 ± 0,13	< 0,05
VO ₂ at rest (ml/kg/min)	4,44 ± 0,95	4,72 ± 1,32	< 0,05
VO ₂ at VAT (ml/kg/min)	12,67 ± 2,27	13,65 ± 2,78	> 0,05
Peak VO ₂ (ml/kg/min)	18,17 ± 3,30	20,64 ± 3,27	< 0,001
Peak VCO ₂ (ml/kg/min)	1,65 ± 0,28	1,96 ± 0,25	< 0,001
Peak PET CO ₂ (mmHg)	38,07 ± 4,12	38,08 ± 3,64	> 0,05
VE/VCO ₂ slope	27,56 ± 3,60	26,66 ± 2,54	> 0,05
Peak oxygen pulse (ml/beat)	14,16 ± 2,62	14,90 ± 2,56	< 0,05
Peak VE (L/min)	48,61 ± 10,70	57,27 ± 9,85	< 0,001

Abbreviations: DBP, diastolic blood pressure; HR, heart rate; PET, peak end-tidal; RER, respiratory exchange ratio; SBP, systolic blood pressure; VE, ventilation; VAT, ventilatory anaerobic threshold.

Table 3. Laboratory and clinical data (at start and 3 weeks after exercise rehabilitation)

Laboratory	start	3 weeks	p value start/3 week
Glucose (mmol/L)	5,37 ± 0,66	4,89 ± 0,41	> 0,05
Total cholesterol (mmol/L)	3,93 ± 0,86	3,79 ± 0,68	> 0,05
LDL cholesterol (mmol/L)	2,32 ± 0,76	2,76 ± 0,81	> 0,05
HDL cholesterol (mmol/L)	0,84 ± 0,21	0,82 ± 0,20	> 0,05
Triglycerides (mmol/L)	1,74 ± 0,76	1,76 ± 0,71	> 0,05
Creatinine (μmol/L)	83,72 ± 13,23	83,75 ± 13,58	> 0,05
Urea (μmol/L)	6,32 ± 1,22	5,96 ± 1,60	> 0,05
RBCs (10 ¹² /L)	4,59 ± 0,40	4,53 ± 0,38	> 0,05
Na (mmol/L)	142,08 ± 1,74	142,07 ± 1,69	> 0,05
K (mmol/L)	4,57 ± 0,29	4,65 ± 0,22	> 0,05
hsCRP (mg/L)	7,27 ± 5,73	4,96 ± 5,50	< 0,01
Clinical data			
BMI (kg/m ²)	28,82 ± 4,41	28,50 ± 4,13	< 0,001
LVEF (%)	53,05 ± 6,74	53,83 ± 6,59	> 0,05

(9,3±6,1 ml/kg/min vs 14,5±3.9 ml/kg/min; $p<0,0001$).¹² Previous studies have reported that in patients following acute MI, peak VO_2 and VO_2 at anaerobic threshold increase between 7% and 54% after a period of few weeks of exercise training.³ Lack of improvement in exercise capacity after an exercise training program is a predictor of poor prognosis. The study authored by Savage et al, which included 385 patients in CR program, showed that 81 (21%) patients failed to improve peak VO_2 after termination of the program.¹³ Similarly, patients with peak VO_2 below 10ml/kg/min had a poor prognosis, and those above 18ml/kg/min had a good prognosis.¹⁴ Therefore, the increase in peak VO_2 , after exercise training might contribute to better survival in patients following MI. Our data demonstrate an increase of 13,5% in peak VO_2 and 7,7% of VO_2 at anaerobic threshold. It is worth emphasizing that VO_2 at anaerobic threshold is independent of patient's motivation, and it is a good parameter to evaluate the training effect.³

In accordance with our findings is the results of one meta-analysis¹⁵ which have reported an average increase in peak VO_2 of 2 to 22% following exercise training program. Study by Gremeaux et al. also used three week exercise-training program, but with less frequent training sessions (3 days a week, total 15 sessions). This study showed marked improvement in peak VO_2 (+14,25%) and peak workload (+30,8%), after completion of the program as compared to baseline.¹⁶ Similarly, Bjarnason et al. have showed in a study which included 262 patients with coronary artery disease¹⁷ that the maximum exercise workload had improved significantly (105,3±32,3 vs. 123,9±37,3 watts, $p<0,001$) after a four week, three times per week, ambulatory CR program.

Six electronic databases were searched to identify studies investigating resistance training, coronary heart disease and physical function. Improvements in peak oxygen uptake (WMD: 0.61, 95% CI: 0.20-1.10), peak work capacity (SMD: 0.38, 95% CI: 0.11-0.64) and muscular strength (SMD: 0.65, 95% CI: 0.43-0.87) significantly favoured resistance training in combination with aerobic training over aerobic training only with moderate quality evidence. There was no evidence of a difference

in effect when comparing resistance training and aerobic training. Resistance training in combination with aerobic training is more beneficial than aerobic training alone for improving physical function.¹⁸

Longer, but less intensive, exercise rehabilitation programs may also improve functional capacity following acute MI. In the study that included 94 patients following acute MI treated with pPCI, exercise sessions were prescribed for 3 months, 3 day a week (total of 36 sessions), and significant improvement in peak VO_2 was noted at the end of rehabilitation program as compared to baseline (20±4 vs. 14±4 ml/kg/min, $p<0,001$), as well as in peak workload ($p<0,001$).¹⁹ Lavie and Milani²⁰ have reported that exercise training program can be also improve heart rate recovery (- 10 to 12%), peak anaerobic threshold (+10 to 15%), as well as metabolic parameters including total cholesterol (-5%), triglycerides (-15%), HDL-cholesterol (+5 to 10%), and LDL-cholesterol (-3%).²⁰ Our study showed modest improvements in metabolic parameters that failed to reach statistical significance.

Overall, 359 patients who have suffered acute MI, and were referred for CR after PCI from 2010 to 2015 and underwent an exercise tolerance test before and after phase II CR were included in this study. The patients were divided into two groups: obese group with body mass index (BMI) ≥ 25 kg/m² (n=170; age, 54,32±9,98 years; BMI, 27,52±2,92 kg/m²) and non-obese group with BMI < 25 kg/m² (n=189; age, 59,12±11,50 years; BMI 22,86±2,01 kg/m²). There were significant changes in resting heart rate (HR_{rest}) before and after CR between the obese and non-obese groups (before CR, $p=0,028$; after CR, $p=0,046$), but other cardiopulmonary exercise capacity before and after CR was not different between the groups. HR_{rest} ($p<0,001$), maximal metabolic equivalents (METs, $p<0,001$), total exercise duration (TED, $p<0,001$), and maximal oxygen consumption ($\text{VO}_{2\text{max}}$, $p<0,001$) improved significantly in the obese and non-obese groups after CR. No difference in the change in the cardiopulmonary exercise capacity rate was detected between the groups. CR may improve functional capacity in patients who suffered AMI regardless of their obesity.²¹

A number of other CPET parameters may be improved following comprehensive exercise-based training program in patients with coronary artery disease. Heart rate recovery after 1 minute (HRR1) reflects parasympathetic activity after exercise training. HRR1 improves after 36 sessions (12 weeks, 3 times per week) exercise training, as reported by Dimopoulos et al. in a small study that included only 29 patients with heart failure who took part in a CR program.²² Our study extends this data on patients following acute MI treated with pPCI as we also showed improvement in HRR1 following exercise-program, which indicates good training response and higher contribution to the autonomic nervous system. VE/VCO_2 slope is also an important parameter for prognosis, expected to decrease after exercise training.²³ Patients with a VE/VCO_2 slope exceeding 55 had a 2 year mortality of 65% reported as reported by the study by Francis and co-authors.¹⁴ For the reasons that are not clear, our data failed to show improvement in VE/VCO_2 slope after training.

Study limitations. The major limitation of the present is relatively small number of patients.

Conclusions

Very short-term exercise training in patients with acute MI treated with pPCI is safe and improves functional capacity, as well as test duration, work load and heart rate response.

References

- Piepoli MF, Corrà U, Benzer W, et al. Secondary prevention through cardiac rehabilitation: physical activity counseling and exercise training. Key components of the position paper from the Cardiac Rehabilitation Section of the European Association of Cardiovascular Prevention and Rehabilitation. *Eur Heart J*. 2010; 31(16):1967-74.
- Balady GJ, Williams M, Ades PA et al. Core Components of Cardiac Rehabilitation/ Secondary Prevention Programs: 2007 Update. A Scientific Statement From the American Heart Association Exercise, Cardiac Rehabilitation, and Prevention Committee, the Council on Clinical Cardiology; the Councils on Cardiovascular Nursing, Epidemiology and Prevention, and Nutrition, Physical Activity, and Metabolism; and the American Association of Cardiovascular and Pulmonary Rehabilitation. *Circulation*. 2007; 115 (20):2675-82.
- Bjarnason-Wehrens B, Halle M. Exercise Training in Cardiac Rehabilitation. In: Niebauer J, ed. *Cardiac Rehabilitation Manual*. London: Springer – Verlag; 2011. p. 89-119.
- Wenger NK. Current status of cardiac rehabilitation. *J Am Coll Cardiol*. 2008; 51 (17): 1619-31.
- Hansen D, Dendale P, Berger J, Meeusen R. Rehabilitation in cardiac patients. What do we know about training modalities? *Sports Med*. 2005; 35(12):1063-84.
- American Association for Cardiovascular and Pulmonary Rehabilitation. Guidelines for Cardiac Rehabilitation and Secondary Prevention Programs. 4th Edition. Champaign, IL: Human Kinetics; 2004(2):5-18
- Mezzani A, Hamm LF, Jones AM, McBride PE, et al. Aerobic exercise intensity assessment and prescription in cardiac rehabilitation: a joint position statement of the European Association for Cardiovascular Prevention and Rehabilitation, the American Association of Cardiovascular and Pulmonary Rehabilitation and the Canadian Association of Cardiac Rehabilitation. *Eur J Prev Cardiol* 2012. 20(3) 442-467
- Balady G, Arena R, Sietsema K, et al. Clinician's Guide to Cardiopulmonary Exercise Testing in Adults. A Scientific Statement From the American Heart Association. *Circulation*. 2010; 122(2):191-225.
- Wasserman K, Hansen JE, Sue DY, et al. Principles of Exercise Testing and Interpretation. 4th ed. Philadelphia: Lippincott Williams & Wilkins; 2005, pp.111-132
- Guazzi M, Adams V, Conraads V, et al. Clinical recommendations for cardiopulmonary exercise testing data assessment in specific patient populations. *Circulation*. 2012; 126 (18): 2261-74.
- Schmid JP, Zurek M, Saner H. Chronotropic incompetence predicts impaired response to exercise training in heart failure patients with sinus rhythm. *Eur J Prev Cardiol*. 2013; 20(4):585-92.
- Ades PA, Savage PD, Brawner CA, et al. Aerobic Capacity in Patients Entering Cardiac Rehabilitation. *Circulation*. 2006; 113:2706-12.
- Savage PD, Antkowiak M, Ades PA. Failure to Improve Cardiopulmonary Fitness in Cardiac Rehabilitation. *J Cardiopulm Rehabil Prev*. 2009; 29(5):284-91.
- Francis DP, Shamim W, Davies LC, et al. Cardiopulmonary exercise testing for prognosis in chronic heart failure. Continuous and independent prognostic value from VE/VCO_2 slope and peak VO_2 . *Eur Heart J*. 2000; 21(2):154-61.
- Piepoli MF, Davos C, Francis DP, et al. Exercise training meta-analysis of trials in patients with chronic heart failure (ExTraMATCH). *BMJ*. 2004;328:189.
- Gremeaux V, Duclay J, Deley G, et al. Does eccentric endurance training improve walking capacity in patients with coronary artery disease? A randomized controlled pilot study. *Clin Rehabil*. 2010; 24(7):590-9.
- Bjarnason-Wehrens B, Predel HG, Graf C, et al. Improvement of physical performance and aerobic capacity mediated by a novel 4-week ambulatory cardiac rehabilitation program. *Z Kardiologie*. 1999; 88(2):113-22.
- Xanthos PD, Gordon BA, Kingsley MI. Implementing resistance training in the rehabilitation of coronary heart disease: A systematic review and meta-analysis. *Int J Cardiol*. 2017;230: 493-508.
- Che L, Wang LM, Jiang JF, et al. Effects of early submaximal cardiopulmonary exercise test and cardiac rehabilitation for patients with acute myocardial infarction after percutaneous coronary intervention: a comparative study. *Zhonghua Yi Xue Za Zhi*. 2008; 88(26):1820-3.
- CJ, Milani RV. Cardiac Rehabilitation Update 2008—Biological, Psychological and Clinical Benefits. *US Cardiology*. 2008; 5(1):72-76.
- Lim SK, Han JY, Choe YR. Comparison of the Effects of Cardiac Rehabilitation Between Obese and Non-obese Patients After Acute Myocardial Infarction. *Ann Rehabil Med*. 2016;40(5):924-932.
- Dimopoulos S, Anastasiou-Nana M, Sakellariou D, et al. Effects of exercise rehabilitation program on heart rate recovery in patients with chronic heart failure. *Eur J Cardiovasc Prev Rehabil*. 2006;13 (1):67-73.
- Arena R, Myers J, Abella J, et al. Development of a ventilatory classification system in patients with heart failure. *Circulation*. 2007; 115(18): 2410-17.

Sažetak

Uticaj kratkih programa bolničke kardiološke rehabilitacije kod pacijenata sa akutnim infarktom miokarda lečenih primarnom perkutanom koronarnom intervencijom

Dejan Spiroski¹, Mojsije Andjić¹, Ivana Burazor¹, Slavica Stevović¹, Zoran Ćosić¹, Olivera Ilić Stojanović¹, Milica Lazović^{1,2}, Ana Djordjević Dikić^{2,3}, Marija Zdravković⁴, Dragan Lović⁵, Branko Beleslin^{2,3}

¹ Institut za rehabilitaciju, Beograd, Srbija, ² Medicinski fakultet Univerziteta u Beogradu, Beograd, Srbija, ³ Klinika za kardiologiju Klinički centar Srbije, Beograd, Srbija, ⁴ Kliničko bolnički centar Bežanijska kosa, Beograd, Srbija, ⁵ Klinika za interne bolesti Inter Medica, Niš, Srbija

Uvod: Rehabilitacija zasnovana na vežbanju je važan deo lečenja pacijenata nakon akutnog infarkta miokarda (IM). Međutim, veoma su oskudni podaci o efektima kratkoročnih programa fizičke aktivnosti kod pacijenata sa akutnim IM koji su lečeni primarnom perkutanom koronarnom intervencijom (pPCI). Cilj ovog rada je bio da se evaluiraju efekte kratkotrajnih programa fizičke aktivnosti na parametre kardiopulmonalnog testa opterećenja (KPTO) kod pacijenata nakon akutnog IM lečenih (pPCI).

Metode: Ispitali smo 40 pacijenata sa IM lečenih pPCI-om koji su upućeni u našu ustanovu radi sprovođenja rehabilitacije. Studijska populacija se sastojala od 39 muškaraca i 1 žene (starosne dobi $50,60 \pm 8,40$ godina, ejection one frakcije leve komore, $53,05 \pm 6,74\%$), koji su učestvovali u 3 nedeljnom programu kardiološke rehabilitacije. Program se sastojao od vožnje bicikle 7 puta nedeljno i svakodnevnog hodanja u trajanju od 45 minuta na intenzitetu od 70-80% individualne maksimalne srčane frekvence. Svi pacijentima je urađen simptomima ograničen KPTO na biciklergometru po ramp protokolu od 10 W/min. KPTO je takođe rađen nakon sprovedenog programa kardiološke rehabilitacije.

Rezultati: Nakon 3 nedeljnog programa kardiološke rehabilitacije zasnovanog na vežbanju poboljšana je tolerancija na napor u poređenju sa polaznim nivoom (maksimalno radno opterećenje $111,50 \pm 15,07$ vs $129,00 \pm 12,77$ wati, $p < 0,001$), kao i maksimalni odnos disajne razmene ($1,02 \pm 0,10$ vs $1,08 \pm 0,13$, $p < 0,05$). Maksimalna vrednost sistolnog krvnog pritiska, srčana frekvencija, maksimalna i 1 minut nakon odmora, takođe su poboljšani. Najznačajnije poboljšanje je zabeleženo kod maksimalne VO_2 ($18,17 \pm 3,30$ vs $20,64 \pm 3,27$ ml/kg/min, $p < 0,001$), maksimalne VCO_2 ($1,65 \pm 0,28$ vs $1,96 \pm 0,25$ p < 0,001), maksimalne ventilacije ($48,61 \pm 10,70$ vs $57,27 \pm 9,85$ L/min, $p < 0,001$) i maksimalnog kiseoničnog pulsa ($14,16 \pm 2,62$ vs $60,18 \pm 14,19$ ml/otkucaj, $p < 0,05$). Tokom sprovođenja programa rehabilitacije nisu zabeleženi značajni neželjeni kardiološki događaji.

Zaključak: Kratkoročni fizički trening kod pacijenata sa akutnim IM koji su lečeni pPCI je pre svega bezbedan, poboljšava funkcionalni kapacitet, kao i trajanje testa, stepen opterećenja i reakciju srčane frekvence.

Ključne reči: kardiopulmonalni test opterećenja, fizički trening, kardiološka rehabilitacija, infarkt miokarda.