Benefit of Combined Cardiac Rehabilitation on Exercise Capacity and Cardiovascular Parameters in Patients with Type 2 Diabetes

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Favorable effects of exercise training on cardiovascular prognosis have been reported repeatedly in patients with diabetes mellitus type 2 (DM2). However, little is known about the cardiovascular rehabilitation effects in diabetic patients with coronary artery disease (CAD). This study has evaluated the benefits of combined aerobic-resistance training in two groups of patients - diabetics and non-diabetics - after percutaneous coronary intervention (PCI). Changes in exercise capacity parameters, resting cardiovascular and anthropometrical parameters were evaluated in 77 patients who completed 12-weeks of combined aerobic-resistance training: 32 patients with DM2 (DM) and 45 patients without DM2 (NDM). Significant improvements in exercise capacity (total peak workload [Wpeak], peak workload per kg of body weight [Wpeak/kg], total peak oxygen uptake [VO2peak], peak oxygen uptake per kg of body weight [VO2peak/kg]) were found in both DM and NDM (p < 0.01 and p < 0.001, respectively). The decrease in resting heart rate (HRrest), resting systolic (SBPrest) resting diastolic (DBPrest) blood pressures, body weight (BW) and BMI in the DM group was not statistically significant. However, there was a statistically significant decrease in SBPrest, BW and BMI in the NDM group. In conclusion, this study demonstrated similar beneficial effects of combined cardiovascular training on exercise capacity in patients with or without type 2 diabetes mellitus. Our results suggest that the combined cardiac training is well tolerated and useful in secondary prevention in patients with DM2 and CAD.

type 2 diabetes mellitus; cardiac rehabilitation; aerobic-resistance training; exercise capacity.

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Coronary artery disease (CAD) in patients with type 2 diabetes mellitus (DM2) is the major cause of mortality and morbidity (Donahue and Orchard 1992; Haffner et al. 1998; Laakso 1999; Hu et al. 2005) in Western countries. These patients have 2 to 4 times higher risk of cardiovascular diseases as compared with individuals without diabetes mellitus. Moreover, the progno-
sic of diabetics without history of CAD is as con-
squential as the prognosis of non-diabetics with a
history of acute coronary event (Haffner et al. 1998; Whiteley et al. 2005). The prognosis of
diabetic patients with acute coronary syndrome is
worsened by presence of other risk factors associ-
ated in metabolic syndrome, such as hypertension,
obesity and dyslipidaemia (Zuanetti et al. 1993;
Behar et al. 1997; Vaccaro et al. 2004; Otter et al.
2004; Howard et al. 2006). The benefits of cardia-
c rehabilitation programs in patients with CAD
both in programs with only aerobic exercise train-
ing (Oldridge et al. 1988; O’Connor et al. 1989;
Yoshida et al. 2001; Taylor et al. 2004, 2006) and
in those with resistance or combined aerobic-
resistance exercise (Stewart et al. 1998; Adams et
al. 1999; Jancik et al. 2003; Izawa et al. 2004;
Vincent and Vincent 2006) have been repeatedly
reported.
Cardiac rehabilitation programs in patients
with DM2 require a specific approach taking into
account low cardiorespiratory fitness and cardio-
vascular maladaptation, resulting from left ven-
tricular dysfunction, impaired coronary flow
reserve, endothelial dysfunction, cardiac auto-
nomic neuropathy and insulin resistance (Fang et
al. 2004). Generally, in patients with type 2 dia-
abetes mellitus exercise training enhances cardio-
vascular adaptation by improvement of the endo-
thelial dysfunction (Maiorana et al. 2001). Exer-
cise training improves endothelial vasodilator
function and left ventricular diastolic function; the
data on decreased arterial stiffness and reduction
of left ventricular mass are less robust. Furth-
more, the abdominal fat reduction within exercise
training is associated with a decrease in insulin
resistance and hyperinsulinemia and has further
favorable consequences concerning blood pres-
 sure and endothelial function in patients with
DM2 and obesity (Stewart 2002; Ozcelik et al.
2005).
Only a few studies have focused on the
effects of cardiac rehabilitation in patients with
DM2 or in patients with established metabolic
syndrome. Milani and Lavie (1996), Banzer et al.
(2004), Verges et al. (2004), Lavie and Milani
(2005), and Hindman et al. (2005) presented con-
tradictory results concerning functional capacity
in standard programs with aerobic training in the
diabetic patients after acute coronary events.
Therefore, whether they can obtain cardiac reha-
bilitation a similar benefit to non-diabetic individ-
uals has not been fully investigated.
Moreover, no data on the effects of com-
bined, aerobic – resistance training especially in
diabetic patients after acute coronary event are
available at present. The aim of this study was
therefore to examine the benefit of combined car-
diac rehabilitation program in patients with type 2
diabetes mellitus after acute coronary event.
Anthropometrical parameters (body weight [BW],
body mass index [BMI]), resting cardiovascular
parameters (heart rate at rest [HRrest], systolic
blood pressure at rest [SBPrest], diastolic blood
pressure at rest [DBPrest]) and parameters of exer-
cise capacity (total peak workload [Wpeak], peak
workload per kg of body weight [Wpeak/kg], total
peak oxygen uptake [VO2peak], peak oxygen
uptake per kg of body weight [VO2peak/kg], peak
rate pressure product [RPPpeak]) were studied.

PATIENTS AND METHODS
Patients involved in the study were those who were
hospitalized at the 1st Department of cardioangiology, St.
Anna’s Faculty Hospital in Brno with a diagnosis of
myocardial infarction or unstable angina and underwent
percutaneous coronary intervention (PCI). After dis-
charge from the clinic they were included in phase II car-
diac rehabilitation program at the Department of func-
tional diagnostics and rehabilitation, St. Anna’s Faculty
Hospital in Brno.
Criteria of inclusion in the study were: history of
acute coronary event with PCI for myocardial infarction
or unstable angina, start of the cardiac rehabilitation pro-
gram no longer than 4 weeks after discharge from hospi-
tal and the completion of 12-week rehabilitation pro-
gram. Before inclusion in the study all subjects provided
informed consent. The study was approved by the local
Ethics Committee of St. Anna’s Faculty Hospital in Brno
and it conformed with the principles outlined in the
Declaration of Helsinki and to the GCP guidelines of the
European Community.

The exercise program
The exercise program comprised of 12 weeks of
phase II cardiac out-patient rehabilitation starting on average 3 - 4 weeks after discharge from hospital. The training, medically supervised and continuously monitored, was performed three times a week. The first two weeks consisted of aerobic training only and resistance training was added in the third week. Each exercise session started with 10 min of warm up period, followed by 20 min of aerobic and 20 min of resistance exercise. Each session was ended by 10 min of cool down period. Aerobic exercise was performed on bicycle ergometers (Ergoline REHA E900, Bitz, Germany) using program ErgoSoft+ for Windows. At baseline, the exercise intensity was determined according to the heart rate at the individual level of anaerobic (ventilatory) threshold, assessed by spiroergometry. Resistance training was performed on multifunctional strength equipment (TK-HC COMPACT, Zdenek Hruby Co., Brno, Czech Republic). The training intensity was determined by one-repetition maximum test (1-RM). The initial intensity was 30% of 1-RM, and every week the intensity was raised by 10% 1-RM up to the level of 50% of 1-RM. Three exercise types were used: pull-down, bench-press and leg extension.

After six weeks of program, control spiroergometry was performed and new values of training intensity set according to measured ventilatory threshold.

Assessment of outcomes
Exercise performance before and after completion of rehabilitation program was assessed using spiroergometry, performed according to a standardized protocol by Wasserman et al. (1999). Resting cardiovascular parameters (HRrest, SBPrest, DBPrest) were measured in sitting position at least 15 min before the start of the spiroergometric testing. The test was done at starting workload of 30 watts and with progressively increasing working rate (20 W/2 min) to the maximal tolerance level on electrically braked bicycle ergometer (system Cardiovit Schiller CS-200, Baar, Switzerland). After the peak workload was reached, the recovery period followed. During exercise, oxygen uptake and carbon dioxide production were measured by analysis of blood gas samples taken breath by breath (CPX/D system, Medical Graphics Corporation, St. Paul, Minneapolis, MN, USA). Data were averaged every 30-s intervals. Peak oxygen uptake (VO2peak) was determined according to the method by Wasserman et al. (1999). Heart rate was monitored continuously using 12-lead electrocardiograph (Schiller Co.). Blood pressure and perceived exertion rate according to Borg scale were recorded every 2 min.

At baseline and at the end of rehabilitation program the basic anthropometrical parameters (body weight, body mass index) were assessed. Body weight was measured by standard method; BMI was calculated as weight (kg) divided by squared height (m²). Blood samples for biochemical analysis of fasting blood glucose, total cholesterol (TC), HDL cholesterol (HDL-C), LDL cholesterol (LDL-C) and triglycerides (TG) were taken after at least 8 hours of fasting, before antidiabetic treatment (oral or by insulin), and measured by photometric method (ADVIA 1650, Bayer, Germany). Left ventricle ejection fraction (LVEF) was determined by transthoracic echocardiography (Sonos 2000, Hewlett-Packard, Andover, MN, USA). Other outcomes assessed included treatment received for the management of diabetes.

Data analysis
Results are presented as mean ± s.d. or 95% confidence limit. For statistical analysis of differences between DM and NDM, Student’s unpaired t-test was used for continuous variables and \( \chi^2 \) test for categorical variables. Within each group, paired Student’s t-test was employed for comparison of the values before and after rehabilitation.

Within DM and NDM groups, each outcome of interest was compared before (baseline) and after the intervention as the percentage change in baseline (\( \Delta \% \)). The unpaired t-test was used to calculate differences in the percentage change in baseline (\( \Delta \% \)) between DM and NDM. We used an \( \alpha \) level of significance of 0.05. Statistical analysis was performed using program STATISTICA Cz 7 (StatSoft, Inc.).

RESULTS
Baseline clinical and biochemical characteristics of diabetic patients (DM, \( n = 32; 25 \) men, 7 women) and non diabetic group (NDM, \( n = 45; 30 \) men, 15 women) are summarized in Table 1. NDM patients were considered as a control group. All patients completed 12 weeks of phase II cardiac out - patient rehabilitation program. There was no significant difference in age, body weight, BMI, LVEF and diagnosis between the groups at baseline. Concerning biochemical parameters, the significant difference between DM and NDM was found only in fasting glycemia (6.8 ± 1.2 vs 5.1 ± 0.6, \( p < 0.01 \)); the values of lipid metabolism (TC, HDL-C, LDL-C and TG) did not differ significantly between both groups.
Clinical signs of cardiovascular diabetic neuropathy or other diabetic complications were not present in DM group. Twenty three diabetics (71%) and 27 non-diabetics (60%) were treated for hypertension and 28 diabetics (87.5%) and 33 non-diabetics (73.3%) for dyslipidaemia. The incidence of hypertension and dyslipidaemia did not differ significantly in DM and NDM. Established antidiabetic treatment consisted of diet (50%), oral antidiabetics (40.6%) and insulin therapy (9.4%). Average duration of DM2 in our group was 9.5 ± 3.4 years. No medication was changed during rehabilitation program in any of participants.

Table 2 summarizes the data in DM and NDM before and after rehabilitation. At baseline, the exercise capacity parameters \( W_{\text{peak}}/\text{kg} \) and \( V_{\text{O2peak}}/\text{kg} \) were significantly lower in DM patients in comparison with the NDM ones (1.08 ± 0.4 vs 1.3 ± 0.4, \( p < 0.05 \); 17.0 ± 4.6 vs 19.1 ± 4.9, \( p < 0.05 \)). However, there was no significant difference in the \( W_{\text{peak}} \) and \( V_{\text{O2peak}} \) as well as the cardiovascular parameters (resting HR, systolic and diastolic BP) between both groups. The peak RPP value was significantly higher in NDM compared to DM group (247.5 ± 64.2 vs 211.8 ± 56.0, \( p < 0.05 \)). After rehabilitation program in DM, the exercise capacity parameters increased significantly: \( W_{\text{peak}} \) (91.7 ± 31.9 vs 106.0 ± 38.6, \( p < 0.01 \)), \( V_{\text{O2peak}} \) (1,445.2 ± 400 vs 1,637 ± 454, \( p < 0.01 \)), \( W_{\text{peak}}/\text{kg} \) (1.08 ± 0.4 vs 1.3 ± 0.5, \( p < 0.01 \)) and peak \( V_{\text{O2peak}}/\text{kg} \) (17.0 ± 4.6 vs 19.3 ± 6.0, \( p < 0.01 \)). The RPP\text{peak} in DM increased significantly (211.8 ± 56.0 vs 240.7 ± 76.1, \( p < 0.05 \)) too, while the decrease of resting HR, SBP and DBP did not reach statistical significance. In body weight and BMI the significant changes in DM were not observed. In NDM, after intervention, the parameters of exercise capacity increased significantly: \( W_{\text{peak}} \) (102.1 ± 31.5 vs 113.6 ± 31.9, \( p < 0.01 \)), \( V_{\text{O2peak}} \) (1,555.3 ± 396.0 vs 1,682.8 ± 430.0; \( p < 0.01 \)), \( W_{\text{peak}}/\text{kg} \) (1.3 ± 0.4 vs 1.4 ± 0.4; \( p < 0.001 \)), \( V_{\text{O2peak}}/\text{kg} \) (19.1 ± 4.9 vs 21.1 ± 5.3; \( p < 0.001 \)). Resting HR and DBP did not change significantly. Decrease in resting SBP was significant (138.2 ± 20.0 mmHg vs 132.2 ± 19.2 mmHg; \( p < 0.05 \)) as well as decrease in body weight (81.3 ± 11.5 kg vs 79.7 ± 11.0 kg; \( p < 0.05 \)) and BMI (28.3 ± 3.4 vs 27.8 ± 3.4; \( p < 0.05 \)) in NDM.

The comparison of all parameters after reha-
bilitation program between DM and NDM did not show significant changes except of body weight, which was significantly lower in NDM than in DM (79.7 ± 11 vs 86 ± 12.5, \( p < 0.05 \)).

The comparison of percentage changes in exercise capacity and cardiovascular parameters between DM and NDM groups after 12 weeks of rehabilitation is summarized in Table 3. The improvement degree in exercise capacity (\( W_{\text{peak}} \), \( V_{O_{2}\text{peak}} \), \( V_{O_{2}\text{peak}}/\text{kg} \), \( V_{O_{2}\text{peak}}/\text{kg} \)) shows non significant differences between DM and NDM patients. The percentage decreases in resting HR, SBP and DBP in DM did not differ significantly from those in NDM. In \( \text{RPP}_{\text{peak}} \) the percentage increase in DM (15.7%) did not differ significantly from NDM (4.5%), but the trend to significance was observed (\( p = 0.07 \)).

### Table 2. Evaluation of exercise capacity and cardiovascular parameters in DM and NDM patients before and after cardiac rehabilitation.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>DM (n = 32)</th>
<th>NDM (n = 45)</th>
<th>( p )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( W_{\text{peak}} ) (watt)</td>
<td>91.7 ± 31.9</td>
<td>106.0 ± 38.6**</td>
<td></td>
</tr>
<tr>
<td>( W_{\text{peak}}/\text{kg} ) (watt/kg)</td>
<td>1.08 ± 0.4</td>
<td>1.3 ± 0.5**</td>
<td></td>
</tr>
<tr>
<td>( V_{O_{2\text{peak}}} ) (ml)</td>
<td>1,445.2 ± 400.0</td>
<td>1,637.0 ± 454.0**</td>
<td></td>
</tr>
<tr>
<td>( V_{O_{2\text{peak}}}/\text{kg} ) (ml/kg)</td>
<td>17.0 ± 4.6</td>
<td>19.3 ± 6.0**</td>
<td></td>
</tr>
<tr>
<td>Resting HR (b/min)</td>
<td>64.7 ± 9.5</td>
<td>62.7 ± 9.8</td>
<td></td>
</tr>
<tr>
<td>Resting SBP (mmHg)</td>
<td>136.6 ± 17.3</td>
<td>132.6 ± 14.7</td>
<td></td>
</tr>
<tr>
<td>Resting DBP (mmHg)</td>
<td>83.2 ± 11.3</td>
<td>81.6 ± 9.6</td>
<td></td>
</tr>
<tr>
<td>( \text{RPP}_{\text{peak}} ) (b/min.mmHg)</td>
<td>211.8 ± 56.0</td>
<td>240.7 ± 76.1*</td>
<td></td>
</tr>
<tr>
<td>Body weight (kg)</td>
<td>86.1 ± 13.4</td>
<td>86.0 ± 12.5</td>
<td></td>
</tr>
<tr>
<td>BMI (kg/m(^2))</td>
<td>29.2 ± 5.1</td>
<td>29.2 ± 4.8</td>
<td></td>
</tr>
</tbody>
</table>

Values are expressed as means ± s.d.  
\(*p < 0.05\), **\( p < 0.01\), ***\( p < 0.001\) significant difference between values before and after training program.

### Table 3. Changes in exercise capacity and cardiovascular parameters after completion of combined cardiac training.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>DM (n = 32)</th>
<th>NDM (n = 45)</th>
<th>( p ) value</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \Delta % )</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( W_{\text{peak}} ) (watt)</td>
<td>18.8 ± 34.3</td>
<td>15.4 ± 26.6</td>
<td>NS</td>
</tr>
<tr>
<td>( W_{\text{peak}}/\text{kg} ) (watt/kg)</td>
<td>18.6 ± 36.1</td>
<td>20.7 ± 38.4</td>
<td>NS</td>
</tr>
<tr>
<td>( V_{O_{2\text{peak}}} ) (ml)</td>
<td>15.0 ± 24.1</td>
<td>9.7 ± 17.7</td>
<td>NS</td>
</tr>
<tr>
<td>( V_{O_{2\text{peak}}}/\text{kg} ) (ml/kg)</td>
<td>14.6 ± 25.0</td>
<td>11.1 ± 19.0</td>
<td>NS</td>
</tr>
<tr>
<td>Resting HR (b/min)</td>
<td>−2.6 ± 11.4</td>
<td>−2.8 ± 15.7</td>
<td>NS</td>
</tr>
<tr>
<td>Resting SBP (mmHg)</td>
<td>−2.1 ± 11.1</td>
<td>−3.5 ± 12.8</td>
<td>NS</td>
</tr>
<tr>
<td>Resting DBP (mmHg)</td>
<td>−1.0 ± 13.1</td>
<td>−1.7 ± 12.2</td>
<td>NS</td>
</tr>
<tr>
<td>( \text{RPP}_{\text{peak}} ) (b/min.mmHg)</td>
<td>15.7 ± 31.5</td>
<td>4.5 ± 22.9</td>
<td>NS</td>
</tr>
</tbody>
</table>

Values are expressed as means ± s.d.  
95% CI, confidence limit; NS, non significant difference.
DISCUSSION

The present study demonstrated benefit of combined aerobic resistance training in diabetic and non-diabetic patients experienced PCI after acute coronary event. Before starting the training program, the values of exercise capacity $W_{\text{peak}}/\text{kg}$, $V_{\text{O}_2\text{peak}}/\text{kg}$ and the corresponding $\text{RPP}_{\text{peak}}$ were significantly lower in DM patients than in NDM group, although the values of $W_{\text{peak}}$ and $V_{\text{O}_2\text{peak}}$ did not differ significantly. These results correspond to previously published studies, demonstrating that the DM2 is associated with cardiovascular dysfunction including reduced exercise capacity and physical fitness, which are strong predictors of cardiovascular mortality (Milani and Lavie 1996; ACSM 2000; ADA 2001; Banzer et al. 2004; Fang et al. 2004, 2005). It has been repeatedly reported that hyperglycemia is associated with increased stiffness of large vessels including aorta. Its compliance plays an important role in the coronary artery blood flow modulation, the myocardial workload capacity, and therefore also in the global exercise capacity (Kingwell 2002; Cortigiani et al. 2007). As well, impaired exercise capacity in type 2 diabetes is associated not only with anthropometrical parameters, such as age, sex or BMI, but also with left ventricle dysfunction and impairment of cardiac autonomic regulation (Fang et al. 2005; Sargin et al. 2005; Kasahara et al. 2006). Lower $\text{RPP}_{\text{peak}}$ in DM group can be explained by the assumptive presence of various stages of diabetic cardiovascular autonomic neuropathy (CAN). Clinical symptoms of CAN in diabetic patients in our study were not manifested at rest. Although cardiovascular reflex tests or heart rate variability examination were not performed in all of our DM patients, we dare to presuppose that they suffer subclinical form of CAN. Our assumption is based on previously reported facts (Kempler et al. 1993; Ziegler 1994; Valensi et al. 2003).

There were no significant differences in the baseline values of resting systolic, diastolic blood pressure and heart rate between DM and NDM groups. The mean values of blood pressure (BP) in both groups can be considered as a result of effective pharmacological control of hypertension, even though the mean values of BP in DM group have not reached target values for patients with diabetes mellitus and CAD (Kawabe and Saito 2007; Rydén et al. 2007). The baseline values of anthropometrical parameters - body weight and BMI - were not significantly different between DM and NDM and reflected overweight in both groups.

The reported benefit consisted of significant improvement of exercise capacity parameters ($W_{\text{peak}}$, $W_{\text{peak}}/\text{kg}$, $V_{\text{O}_2\text{peak}}$ and $V_{\text{O}_2\text{peak}}/\text{kg}$) in both groups. Moreover, there was a significant increase of $\text{RPP}_{\text{peak}}$ in DM patients. It corresponds to the increased value of $W_{\text{peak}}$ and partially also to the fact that lower baseline $\text{RPP}_{\text{peak}}$ value predicts better training outcome. In NDM patients, the increase of $\text{RPP}_{\text{peak}}$ was not significant unlike the parameters of exercise capacity which were significantly increased (see above). Thus, we may conclude that in NDM patients myocardial oxygen supply – demand relationship improved.

Non-significant changes of resting HR and BP (except of significant SBP decrease in NDM group) were observed in both groups. Besides, the comparison of both groups after completion of the training program (Table 2) reflects similar benefits: no differences in the parameters of exercise capacity and $\text{RPP}_{\text{peak}}$, as well as in the resting cardiovascular parameters. We suppose that good control of diabetes and blood pressure in DM patients before they start any rehabilitation program contribute to a significant improvement in exercise capacity (Oizumi et al. 2007). We are well aware of the fact that the benefit of rehabilitation in our study was enhanced by relatively low BMI in DM subjects. Another non-significant change between the compared groups is in the degree of exercise capacity improvement: 14 – 19% increase of exercise capacity in diabetic subjects compared to the 10 – 20% increase present in NDM patients after 12 weeks of the rehabilitation program.

The effect of cardiac aerobic rehabilitation in DM patients was studied only in a few studies and with controversial results, depending on the duration of rehabilitation program and followed
parameters (Milani and Lavie 1996; Verges et al. 2004; Hindman et al. 2005; Banzer et al. 2007). Data similar to our results were reported by Milani and Lavie (1996): they observed significant improvement in exercise capacity after completion of 3 month of standard aerobic cardiac rehabilitation both in patients with type 2 DM (38% improvement degree) and those without type 2 DM (34%). The study of Banzer et al. (2004) confirmed previous results by Milani and Lavie (1996): the diabetic patients achieved nearly the same, significant improvement in exercise capacity (increase by 26%) as non-diabetic patients (27%); it is also in agreement with our results.

Hindman et al. (2005) assessed the effectiveness of cardiac rehabilitation program with aerobic exercise in diabetic and non-diabetic patients after myocardial infarction and/or revascularization therapy. After the completion of rehabilitation, the exercise capacity in DM patients improved by 26.3% without significant decrease in BMI. The improvement achieved in diabetes group was comparable with non-diabetes group (25.5%). Similar result was achieved in our study - improvement of exercise capacity does not depend on decrease of BMI value. However, significant improvements in anthropometrical parameters in cardiac rehabilitation programs cannot be achieved without special behavior-based body weight intervention being a part of these programs (Sparling et al. 1990; Savage et al. 2002; Lambert et al. 2007). Although no educational part was included in our program, we observed significant improvement in BW and BMI in non-DM patients.

In contrast to our results, Verges et al. (2004) reported significantly lower improvement of exercise capacity (VO\text{2peak}) after 2 month cardiac rehabilitation in patients with DM2 compared to non-diabetic patients (13% vs 30%, p < 0.01). Plausible explanation of this discrepancy might be longer duration (3 months) of training program and training type (aerobic + resistance) in our study. Also normal BMI value in non-diabetic patients (24.9) and unsatisfactory diabetes compensation (fasting glycemia 8.44 mmol/l, HBA\text{1C} 7.22% in Verges study vs 6.8 mmol/l, HBA\text{1C} 6.8 ± 2.9% in our study) might account for marked improvement of exercise capacity in non-diabetics in the study of Verges. Verges et al. (2004) proved indirect significant correlation between glycemia and VO\text{2peak} change in diabetic patients, but no effect of age and LVEF on VO\text{2peak} change was found in this group. As well, in the present study the better outcomes in exercise capacity in DM group were achieved despite higher mean age (64.3 ± 6.2 in our patients vs 57.4 ± 8.8 years in Verges group) and lower LVEF (46.5 ± 12.0 vs 53.0 ± 13.0%, respectively).

The important finding of this study is that DM2 patients after acute coronary event can start with combined aerobic-resistance exercise early after hospital discharge. It is recommended to start with rehabilitation program phase II after acute coronary event as soon as possible, usually within 3-4 weeks after discharge (Chaloupka et al. 2006). All patients are carefully evaluated concerning risk stratification according AHA (Fletcher et al. 2001) and Czech Society of Cardiology (Chaloupka et al. 2006) before starting cardiac rehabilitation. The low intensity resistance training may be added to aerobic standard cardiac rehabilitation after 2 weeks of previous aerobic training in low risk patients (Fletcher et al. 2001; Chaloupka et al. 2006; Vincent and Vincent 2006). The safety of this training modality is confirmed in patients with different types of CAD (Stewart et al. 1998; Adams et al. 1999; Vincent and Vincent 2006), in older patients (Chaloupka et al. 2000), and in patients with systolic left ventricular dysfunction (LVEF 35 ± 4%) (Jancik et al. 2003).

In conclusion, this study demonstrated similar beneficial effects of combined cardiovascular training on exercise capacity in patients with or without type 2 diabetes mellitus. Combined cardiovascular training makes significant improvements to SBP\text{rest}, BW and BMI in patients without diabetes mellitus. Although the patients with type 2 diabetes mellitus experiencing acute coronary event are under higher risk associated with exercise, our results suggest that the aerobic + resistance training in these patients with low risk
according AHA (Fletcher et al. 2001) is well tolerated and useful in secondary prevention. Further study is necessary to evaluate the safety of combined cardiac training in patients with DM2.

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References


