

BAROREFLEX SENSITIVITY IN PATIENTS WITH TYPE 2 DIABETES MELLITUS: EFFECT OF EXERCISE TRAINING

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Abstract

The aim of this study was to determine the baroreflex sensitivity of heart rate (BRS, ms/mmHg) in patients with type 2 diabetes mellitus before and after a 12-week exercise training. We examined two groups of patients with type 2 diabetes mellitus: diabetes mellitus normotensives (DMN; n = 6) and diabetes mellitus hypertensives (DMH; n = 7) in whom hypertension was treated with enalapril and calcium antagonists. Baroreflex sensitivity (BRS) was evaluated by means of calculations of spectral analysis on the basis of spontaneous fluctuation of systolic blood pressure and pulse interval. The blood pressure and cardiac interval were recorded (Finapres, 5-minute recording, metronome-controlled breathing, 0.3 Hz). Our results showed that the exercise treatment of patients with type 2 diabetes mellitus increased the baroreflex sensitivity of heart rate in both the normotensives and the hypertensives.

Key words

Diabetes mellitus type 2, Baroreflex sensitivity, Exercise therapy, Hypertension

INTRODUCTION

Diabetes mellitus and arterial hypertension, together with other pathological conditions (insulin resistance, hyperinsulinemia, obesity, dyslipidemia, protrombotic activity of haemocoagulation), are the basic risk factors for atherosclerosis. A complex of these pathological conditions, designated as the metabolic syndrome of insulin resistance (IR), is accompanied by an increase in activity of the sympathetic nervous system; it has also been proved to contribute to the risk of cardiovascular complications (1, 2, 3). Several methods for the determination of sympathetic nervous system activity have been described that are both invasive, such as microneurography, and non-invasive, e.g., determination of heart rate variability (HRV), baroreflex heart rate sensitivity (BRS) and heart rate assessment at rest. Depressed values of HRV and a depressed value of BRS indicate an increased sympathetic nervous activity. The ATRAMI (Autonomic Tone and Reflexes After Myocardial Infarction) study has demonstrated that depressed BRS and HRV are strong risk factors for sudden

cardiac death in patients after myocardial infarction. This and other studies showed a significant decrease in the number of surviving patients with a low BRS in comparison with a group of patients with BRS higher than 3 ms/mm Hg (4). In patients with diabetes, decreased BRS and HRV can be considered to be an early sign of cardiovascular autonomic neuropathy (CAN) accounting for an approximately five-fold increase in mortality. This serious complication of diabetes remains without clinical signs for a long time and that is why detection of its presence is important in its initial stage (5, 6).

Our study was focused on the evaluation of a potential favourable effect of walking exercise on the baroreflex sensitivity of heart rate in patients with type 2 diabetes.

MATERIAL AND METHODS

Two groups of patients with type 2 diabetes mellitus were included. The DMN group consisted of six normotensive patients and the DMH group comprised seven hypertensives treated with enalapril and calcium antagonists. They were examined before and after the exercise training that lasted for 12 week. Their basic characteristics are given in *Table 1*.

Diabetes was treated in all patients by diet and/or oral antidiabetic drugs. None of the patients manifested any specific diabetic complications of a serious degree. They had no other diseases contraindicating the exercise therapy. No patient had any clinical manifestation of diabetic cardiovascular neuropathy and none had any long-term metabolic decompensation or any form of ischaemic heart disease. After the standard internal examination (medical history, physical examination, ECG at rest, basic laboratory examination) all patients were subjected to the initial bicycle spiroergometry (Cardiovit CS-10 Schiller, gas analyser Medgraphics) for the determination of a safe intensity of exercise activity. We chose the protocol with a workload increasing up to the symptom-limited maximum, i.e., basic load at 40 W and each further workload step at 20 W for 2 min. We determined the level of anaerobic threshold (AT) and expressed it in the values of oxygen uptake (VO_{2AT} , VO_{2AT}/kg), heart rate (HR_{AT}) and multiple metabolic equivalents (MET_{AT}). The HR_{AT} value was the basis for determining safe intensity for each patient when exercise training was prescribed.

The baroreflex sensitivity of heart rate (BRS) was determined by a 5-minute continuous beat-to-beat recording of blood pressure (Peñáz method, Finapres Ohmeda) at both spontaneous breathing and a controlled breathing frequency of 0.33 Hz (by metronome). The BRS value was determined by a spectral analysis of spontaneous fluctuation of systolic blood pressure (SBP) and pulse interval (PI). The value of cross-spectral power density of PI and SBP fluctuation was divided by the value of power spectral density of systolic blood pressure fluctuation at 0.1Hz. The value obtained, i. e., modulus, was considered to be the measure of BRS. The value of this function at a frequency of 0.1 Hz corresponds to BRS (ms/mm Hg). Then all patients were involved in the walking programme for 12 weeks. To check the intensity and speed of walking, we instructed the patients to maintain the heart rate value at the AT level and the value of Borg's scale corresponding to the AT level. The training was performed at least three times a week for 30 to 60 min. Spiroergometry was repeated and BRS values were determined after 12 weeks of the training programme by the same method as used at the beginning.

The experimental protocol completed with the Declaration of Helsinki was approved by the local Ethics Committee. A written informed consent was obtained from each subject prior to their participation.

The data obtained were processed by Microsoft Excel 97. Statistical analysis was carried out by the Wilcoxon test for paired values at the significance level of 0.05.

Table 1
Characteristics of the patients

Patient group	N	Age in years (mean \pm SD)	BMI (mean \pm SD)	DM duration in years (mean \pm SD)
DMN	6	56 \pm 4	30 \pm 2	5.3 \pm 5
DMH	7	60 \pm 8	31 \pm 1	12 \pm 9

DM, diabetes mellitus; DMN, normotensive diabetic patients; DMH, diabetic patients with treated hypertension; BMI, body mass index; N, number of patients

Table 2
Results of baroreflex sensitivity examination before and after walking exercise

Patient group	BRS (ms/mm Hg) (mean \pm SD)	SBP (mm Hg) (mean \pm SD)	DBP (mm Hg) (mean \pm SD)	PI (ms) (mean \pm SD)
DMN(1)	3.5 \pm 1.1	119 \pm 17	71 \pm 10	775 \pm 114
DMN(2)	4.7 \pm 1.2*	122 \pm 13	71 \pm 13	788 \pm 69
DMH(1)	5.1 \pm 1.8	140 \pm 26	70 \pm 14	946 \pm 146
DMH(2)	7.2 \pm 2.3*	135 \pm 18	68 \pm 11	944 \pm 170

DMN(1), normotensive diabetic patients before training; DMN(2), normotensive diabetic patients after training; DMH(1), diabetic patients with treated hypertension before training; DMH(2), diabetic patients with treated hypertension after training; BRS, baroreflex sensitivity; SBP, systolic blood pressure; DBP, diastolic blood pressure; PI, pulse interval; *, statistically significant change at $P < 0.05$

RESULTS

The results of BRS before and after the training programme are given in *Table 2*.

The value of BRS increased significantly after 12 weeks of walking exercise in both groups of diabetic patients. We did not find any changes in values of SBP, DBP or PI in either group after the exercise therapy.

DISCUSSION

Diabetes mellitus type 2 is accompanied, in the majority of patients, by the development of insulin resistance (IR) at the time of disease manifestation. IR appears to be a key factor in the development of other pathological conditions involved in the metabolic syndrome. The main therapeutic objective in patients with type 2 diabetes is to decrease both IR and sympathetic tone. Physical activity is also one of the non-pharmacological, therapeutic means.

The favourable influence of endurance training on autonomous cardiovascular functions has been reported both in experiments with dogs with myocardial ischaemia (9) and in our patients with ICHS (10). After 12 weeks of endurance training, *Howorka et al.* found a significant increase in the total spectral power of HRV in diabetic patients who either had no signs of cardiovascular autonomic neuropathy or suffered only from a moderate form of it (11). In our study based on determination of BRS, walking therapy had a favourable effect on the increased sympathetic activity of autonomous cardiovascular functions in patients with type 2 diabetes mellitus. Because walking is easy, safe and psychologically acceptable physical activity, we consider this as a valuable finding.

From our study we can conclude that, in patients with type 2 diabetes mellitus, walking exercise lasting for several weeks significantly increases the baroreflex sensitivity of heart rate. Physical activity, as a non-pharmacological intervention, is very important in patients with the metabolic syndrome in whom the simultaneous occurrence of diabetes, arterial hypertension, obesity, dyslipidemia and insulin resistance is accompanied by an increased activity of the sympathetic nervous system. Our results give full support to this view because the 12-week walking programme significantly decreased sympathetic nervous activity in our DM patients.

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BAROREFLEXNÍ SENSITIVITA U PACIENTŮ S DIABETES MELLITUS TYPU 2: VLIV POHYBOVÉ LÉČBY

S o u h r n

Cílem této studie je stanovení baroreflexní sensitivity srdeční frekvence (BRS, ms/mmHg) u pacientů s diabetes mellitus typu 2 před 12-týdenní pohybovou léčbou a po ní. Vyšetřili jsme pacienty (n = 6) s diabetes mellitus typu 2 bez hypertenze (DMN) a pacienty (n = 7) s hypertenzí léčenou enalaprilem a kalciovými antagonisty (DMH). BRS byla hodnocena pomocí výpočtů spektrální analýzy na základě spontánního kolísání systolického krevního tlaku a pulsního intervalu. Krevní tlak a srdeční interval byly zaznamenávány (Finapres, pětiminutový záznam, metronomem řízené dýchání; 0,3 Hz). Na základě výsledků můžeme udělat závěr, že pohybová léčba pacientů s diabetes mellitus typu 2 zvýšila baroreflexní sensitivitu srdeční frekvence jak u pacientů bez hypertenze, tak u pacientů s hypertenzí.

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