Bratisl Lek Listy 2010; 111 (4)
205 – 211

CLINICAL STUDY

Complementary therapy in diabetic patients with chronic complications: a pilot study

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Abstract: *Background:* Oxidative stress and dysregulation of antioxidant function play a pivotal role in the diabetic complications.
Methods: Fifty-nine patients with diabetes were randomly assigned into three groups. 1) PL group (n=19): Polarized light (PL) was applied to neuropathic ulcers of diabetic foot twice daily for ten minutes in pulse regimen during three months. 2) QALA group (n=20): Antioxidants (60 mg hydrosoluble CoQ10, 100 mg alpha-lipoic acid (ALA) and 200 mg vitamin E) were used in two daily doses for three months. 3) QALAPL group (n=20): Patients used antioxidants along with PL applications. To test for differences in means, paired Student's t-test (before and after three months) was used.
Results: Three months application of PL significantly increased plasma concentrations of coenzyme Q10, α-tocopherol, τ-tocopherol and β-carotene, and decreased lactate dehydrogenase (LDH) activity. Supplementation with antioxidants decreased plasma lipid peroxides, increased concentration of CoQ10 and improved echocardiographic parameters. Simultaneous application of PL and antioxidants significantly stimulated plasma CoQ10 and α-tocopherol concentrations, decreased LDH activity and contributed to improvement in heart left ventricular function in diabetics.
Conclusion: Thus the data show that supportive therapy with PL along with the antioxidants hydrosoluble CoQ10, alpha-lipoic acid and vitamin E is an effective way of controlling the complications of type 2 diabetes *(Tab. 7, Fig. 2, Ref. 44)*. Full Text (Free, PDF) *www.bmj.sk.*
Key words: polarised light, coenzyme Q10, alpha-lipoic acid, alpha-tocopherol, neuropathic diabetic ulcers, heart function.

Diabetes mellitus (DM) is a chronic disease caused by impaired insulin secretion in pancreatic β-cells and/or by variable degrees of insulin resistance, both resulting in hyperglycaemia. Glycation is intimately associated with enhanced free radical formation, which is detrimental to biomolecules and tissues. Oxidative stress contributes to degenerative changes in pancreatic mitochondrial β-cells (24) and participates in the development of chronic diabetic complications, including neuropathy, angiopathy and cardiomyopathy (8, 9, 31). On the basis of our previous findings on the beneficial effect of antioxidant nutrients and polarized light in treating diabetic complications we carried out an additional study on the effect of the antioxidants coenzyme Q10, alpha-lipoic acid and vitamin E along with polarized light in patients with diabetic complications.

*Coenzyme Q*10 (CoQ10) or *vitamin Q* is essential for ATP synthesis and participates in many metabolic pathways. Three chemical forms of CoQ10 are in the organism – oxidised, reduced and semiquinone radical (25). CoQ10 has a fundamental role as an electron carrier in mitochondrial bioenergetics. It is also an antioxidant. CoQ10 attenuates endothelial dysfunction in patients with diabetes mellitus type 2 (43). CoQ10 has been considered to improve glycaemic control through various mechanisms, including a decrease in oxidative stress (3).

α-lipoic acid, also known as *thioctic acid* (ALA), is a cofactor and an antioxidant that scavenges hydroxyl radicals, hypochlorous acid and singlet oxygen. With its reduced form – dihydrolipoic acid (DHLA) – it functions as an antioxidant, recycles other antioxidants, and increases intracellular levels of glutathione (30). ALA was shown to increase nitric oxide-mediated vasodilation in patients with diabetes, via a mechanism possibly linked to reduced oxidative stress (16). Its clinical effect in diabetics was demonstrated in several studies (44, 45).

Vitamin E (as alpha-tocopherol) is an antioxidant responsible for protecting polyunsaturated fatty acids and lipoproteins in

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Trial registration: The Slovak Cardiology Society Grant (2007–2009), Agency for Science of the Ministry of Education – VEGA (1/0142/09), VEGA (1/0755/09), KEGA3 (1/2050/04).

Acknowledgements to Dr. Hemmi Bhagavan (USA) for review this manuscript, the Slovak Cardiology Society Grant (2007–2009), Agency for Science of the Ministry of Education – VEGA (1/0142/09), VEGA (1/0755/09), KEGA3 (1/2050/04), the support of Tishcon Corp. (USA) with TERA (hydrosoluble CoQ10-Q-GEL with -lipoic acid and vitamin E), and Biotherapy (Czech Republic) for lending Biostimuls devices are gratefully acknowledged. Technical support: Stetkova A[1], Schwarzova M[5].

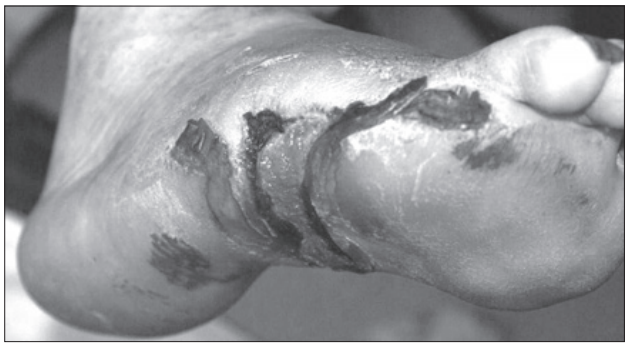

Fig. 1. Diabetic foot wound before polarized light effect.

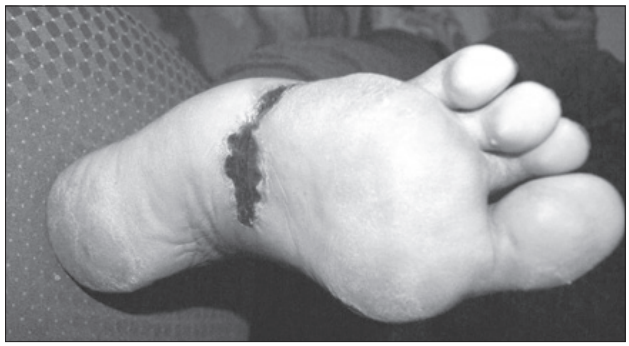

Fig. 2. Three months effect of polarized light on diabetic foot wound.

membranes against peroxidation by scavenging peroxyl radicals on breaking chain propagation steps (4). Acting as a scavenger of free oxygen and lipid peroxyl radicals, α-tocopherol is oxidised to tocopheryl radical. Active α-tocopherol can be regenerated by ascorbic acid or ubiquinol (18, 39). The differing results obtained from a variety of clinical studies involving vitamin E attest to the complexity of studying the potential protective role of vitamin E against chronic disease processes (7).

Polarised light (PL) as visible red light (610–760 nm) has been shown to increase mitochondrial energy metabolism. It was found that two-week application of red PL on rats led to a significant stimulation of NAD-linked and inhibition of FAD-linked respiratory chain functions (14). Simultaneous supplementation with CoQ10 and PL application improved also FAD-linked mitochondrial respiratory chain function (15). Diabetic foot ulcer before and after 3-months polarized light application on ulcer healing is shown in Figures 1 and 2.

The objective of this study was to determine whether application of red polarised light and/or supplementation with antioxidants (hydrosoluble coenzyme Q10, α-lipoic acid, α-tocopherol) could improve selected inflammatory, metabolic and left ventricular heart functions in type 2 diabetics with chronic complications.

Materials and methods

This randomised prospective study included 59 patients (32 men) aged 60.1±10.3 years (mean ± SD) – with diabetes type 2 and neuropathic diabetic foot ulcers of grade 0 (23 pts, 39.0 %), grade 1 (16 pts, 27.1 %) and grade 2 (20 pts, 33.9 %) according to the Wagner classification (Wagner, 1979) treated with insulin (39 pts, 66.1 %) and/or perorally with antidiabetics (27 pts, 45.8 %), betablockers (22 pts, 37.3 %), ACE inhibitors (22 pts, 37.3 %), AT1-receptor antagonists (11 pts, 18.6 %), calcium channel blockers (18 pts, 30.5 %), diuretics (13 pts, 22.0 %), nitrates (5 pts, 8.5 %), trimetazidine (9 pts, 15.3 %), central antihypertensives (6 pts, 10.2 %), antiaggregants (26 pts, 44.1 %), anticoagulants (3 pts, 5.1 %), fibrates (4 pts, 6.8 %), statins (12 pts, 20.3 %).

Inclusion criteria of diabetics: Diagnosis of type 2 diabetes mellitus (DM) with neuropathic diabetic foot ulcer without angiopathy, duration of DM >5 years, patients with negative ulcer cultivation, conventional treatment of hypertension, not treated with CoQ10 and/or alpha-lipoic acid and/or alpha-tocopherol for six months before the study.

Exclusion criteria of diabetics: Bacterial infectious complications during the study, patients with antibiotic treatment, with changed hypertension therapy during the study.

Patient baseline characteristics (Tab. 1) were as follows: body mass index (BMI) 29.8±7.5 kg/m^2; systolic blood pressure (sBP) 134.7±13.6 mmHg; diastolic blood pressure (dBP) 82.3± ±9.6 mmHg; pulse rate (PR) 76.8±11.5 per minute; cardio-thoracic index (CTI) 0.45±0.06; blood glucose 9.8±3.4 mmol/l and glycated haemoglobin (HbA1c) 8.5±2.1 %.

Diabetic patients from various territories of Slovakia were randomly divided into three groups:

1. *PL group* (n=19), in which the diabetics themselves applied red PL (626 nanometers) to neuropathic foot ulcers in pulse regimen twice daily for 10 minutes during three months.

2. *QALA group* (n=20), the patients used antioxidants (60 mg hydrosoluble CoQ10, 100 mg ALA and 200 mg α-tocopherol) in two daily doses for three months.

3. *QALAPL group* (n=20) – the diabetics applied red PL to neuropathic foot ulcers and used antioxidants in the same doses as in the QALA group.

After three months of treatment the following parameters were compared with their respective baseline values: C-reactive protein (CRP), lactate dehydrogenase (LDH) plasma activity,

Tab. 1. Baseline characteristics of patients.

Number of patients (%)	59 (100)
Men (%)	32 (54.2)
Age (years)	60.1±10.3
BMI (kg/m2)	29.8±7.5
sBP (mm Hg)	134.7±13.6
dBP (mm Hg)	82.3±9.6
PR (per minute)	76.8±11.5
CTI	0.45±0.06
Blood glucose (mmol/l)	9.8±3.4
HbA1c (%)	8.5±2.1

Abbreviations: BMI – body mass index; sBP – systolic blood pressure; dBP – diastolic blood pressure; PR – pulse rate; CTI – cardio-thoracic index; HbA1c – glycated haemoglobin

Tab. 2. Effect of 3-month polarised light application (PL group) on selected metabolic parameters in diabetics.

Parameters PL Group	Reference values	Before the study (mean ± SD)	After 3 months (mean ± SD)	Statistics (P)
CRP (mg/l)	0–5.0	4.90 ± 2.81	3.80 ± 2.15	NS
LDH (mkat/l)	1.67–4.0	6.04 ± 1.93	5.61 ± 2.05	<0.04
MDA (mmol/l)	<4.5	5.08 ± 0.77	5.47 ± 1.24	NS
CoQ10 (mmol/l)	0.4–1.0	0.35 ± 0.17	0.74 ± 0.17	<0.0001
α-tocopherol (mmol/l)	15–40	14.39 ± 5.51	22.56 ± 7.11	<0.0006
τ-tocopherol (mmol/l)	2–7	1.13 ± 0.51	2.01 ± 1.18	<0.006
β-carotene (mmol/l)	0.3–3.0	0.22 ± 0.13	0.30 ± 0.18	<0.005
CoQ10/TAG		0.33 ± 0.28	0.52 ± 0.23	<0.005
CoQ10/total cholesterol		0.16 ± 0.37	0.14 ± 0.04	NS
CoQ10/HDL cholesterol		0.27 ± 0.12	0.53 ± 0.18	<0.0001
CoQ10/LDL cholesterol		0.12 ± 0.07	0.26 ± 0.09	<0.0001

Abbreviations: CRP – C reactive protein; LDH – lactate dehydrogenase; CoQ10 – coenzyme Q10; MDA – malondialdehyde; TAG – triacylglycerols; HDL – high density lipoproteins; LDL – low density lipoproteins; SD – standard deviation; NS – not significant

Tab. 3. Effect of 3-month antioxidant supplementation (QALA group) on selected metabolic parameters in diabetics.

Parameter QALA Group	Reference values	Before the study (mean ± SD)	After 3 months (mean ± SD)	Statistics (P)
CRP (mg/l)	0–5.0	4.90 ± 3.00	5.50 ± 2.43	NS
LDH (mkat/l)	1.67–4.0	5.79 ± 1.89	6.10 ± 1.82	NS
MDA (mmol/l)	<4.5	5.31 ± 0.80	4.58 ± 0.65	<0.001
CoQ10 (mmol/l)	0.4–1.0	0.77 ± 0.32	1.11 ± 0.47	<0.01
α-tocopherol (mmol/l)	15–40	24.62 ± 8.66	28.39 ± 9.20	NS
τ-tocopherol (mmol/l)	2–7	2.08 ± 1.22	0.89 ± 0.35	<0.0001
β-carotene (mmol/l)	0.3–3.0	0.19 ± 0.11	0.21 ± 0.20	NS
CoQ10/TAG		0.40 ± 0.20	0.66 ± 0.44	<0.003
CoQ10/total cholesterol		0.14 ± 0.05	0.21 ± 0.08	<0.0006
CoQ10/HDL cholesterol		0.62 ± 0.32	0.89 ± 0.38	<0.09
CoQ10/LDL cholesterol		0.25 ± 0.09	0.40 ± 0.21	<0.003

Abbreviations: CRP – C reactive protein; LDH – lactate dehydrogenase; CoQ10 – coenzyme Q10; MDA – malondialdehyde; TAG – triacylglycerols; HDL – high density lipoproteins; LDL – low density lipoproteins; SD – standard deviation; NS – not significant

plasma concentrations of CoQ10, alpha-tocopherol, gamma-tocopherol, beta-carotene and the ratios CoQ10/TAG (triacylglycerols), CoQ10/total cholesterol, CoQ0/HDL-cholesterol, and CoQ10/LDL-cholesterol. CRP was determined by particle enhanced turbidimetric immunoassay, LDH by the bichromatic rate technique (340, 383 nm), total cholesterol by the polychromatique endpoint technique (452, 540, 700 nm), TAG by the bichromatic endpoint technique (510, 700 nm) and HDL-cholesterol by the homogeneous method for directly measuring HDL-cholesterol levels without the need for off-line pretreatment or centrifugation steps. LDL cholesterol was calculated as the difference between total cholesterol, VLDL-cholesterol, and HDL-cholesterol values. Plasma malondialdehyde (MDA) concentrations were determined by the reaction with thiobarbituric acid (TBA) spectrophotometrically at 532 nm (28). Plasma concentrations of endogenous antioxidants (coenzyme Q10, α-tocopherol, τ-tocopherol, β-carotene) were determined by a modified HPLC method (20, 21, 40).

Selected echocardiographic parameters of left ventricular (LV) systolic and diastolic functions were measured by Doppler echocardiography: EF LV, LVESD and LVEDD – endsystolic and enddiastolic LV diameters, IVS – interventricular septum thickness, PW – LV posterior wall thickness, DT – deceleration time and E/A – ratio of early velocity and velocity during atrial systole.

Written consent was obtained from all the subjects after informing them of the nature of the study. This study was a non-intervention study, conforming to the principles outlined in the Declaration of Helsinki.

Statistical analysis

The normally distributed data (according to Shapiro-Wilk's test) are presented as means SD. Categorical variables are reported as percentage of the total number of subjects. Paired Student's t-test was used for intragroup comparisons of mean differences. All *P* values cited are two-sided alternatives; differences with *P* values less than 0.05 were judged as statistically significant. With the number of patients available for analysis, our study had a power of >80 % to discern treatment outcome differences as a function of baseline-parameter values in the patients.

Tab. 4. Effect of 3-month simultaneous polarised light application and antioxidant supplementation (QALAPL group) on selected metabolic parameters in diabetics.

Parameter QALAPL Group	Reference values	Before the study (mean ± SD)	After 3 months (mean ± SD)	Statistics (P)
CRP (mg/l)	0–5.0	8.10 ± 3.67	5.90 ± 3.12	NS
LDH (mkat/l)	1.67–4.0	3.58 ± 0.65	3.27 ± 0.53	<0.0001
MDA (mmol/l)	<4.5	4.43 ± 1.10	4.55 ± 1.03	NS
CoQ10 (mmol/l)	0.4–1.0	0.59 ± 0.19	1.11 ± 0.40	<0.0001
α-tocopherol (mmol/l)	15–40	16.24 ± 3.44	23.44 ± 6.46	<0.0001
τ-tocopherol (mmol/l)	2–7	1.08 ± 0.44	1.24 ± 1.33	NS
β-carotene (mmol/l)	0.3–3.0	0.47 ± 0.48	0.48 ± 0.35	NS
CoQ10/TAG		0.60 ± 0.32	1.00 ± 0.58	<0.002
CoQ10/total cholesterol		0.12 ± 0.04	0.23 ± 0.08	<0.0001
CoQ10/HDL cholesterol		0.51 ± 0.19	1.02 ± 0.51	<0.0002
CoQ10/LDL cholesterol		0.21 ± 0.07	0.38 ± 0.15	<0.0001

Abbreviations: CRP – C reactive protein; LDH – lactate dehydrogenase; CoQ10 – coenzyme Q10; MDA – malondialdehyde; TAG – triacylglycerols; HDL – high density lipoproteins; LDL – low density lipoproteins; SD – standard deviation; NS – not significant

Tab. 5. Effect of 3-month polarised light application (PL group) on selected echocardiographic parameters in diabetics.

Parameter PL group	Before the study (mean ± SD)	After 3 months (mean ± SD)	Statistics (P)
EF LV (%)	55.80 ± 9.61	55.70 ± 10.06	NS
LVEDD (mm)	55.30 ± 3.45	56.10 ± 3.14	NS
LVESD (mm)	38.80 ± 4.10	38.70 ± 4.40	NS
IVS (mm)	12.60 ± 1.40	12.50 ± 1.32	NS
PW (mm)	11.97 ± 1.30	11.90 ± 1.20	NS
E/A	0.69 ± 0.12	0.69 ± 0.12	NS
DT (ms)	273.70 ± 27.17	274.00 ± 25.36	NS

Abbreviations: EF LV – left ventricular ejection fraction; LVESD – endsystolic left ventricular diameter; LVEDD – enddiastolic left ventricular diameter; IVS – interventricular septum thickness; PW – left ventricular posterior wall thickness; E/A – ratio of early velocity (E) and velocity during atrial systole (A); DT – deceleration time; SD – standard deviation; NS – not significant

Tab. 6. Effect of 3-month antioxidant supplementation (QALA group) on selected echocardiographic parameters in diabetics.

Parameter QALA group	Before the study (mean ± SD)	After 3 months (mean ± SD)	Statistics (P)
EF LV (%)	55.90 ± 8.68	58.50 ± 7.72	<0.0002
LVEDD (mm)	56.30 ± 5.31	54.90 ± 4.64	<0.0001
LVESD (mm)	39.70 ± 5.58	38.40 ± 5.19	<0.0001
IVS (mm)	12.50 ± 1.50	11.90 ± 1.10	<0.0001
PW (mm)	11.60 ± 1.80	11.10 ± 1.31	<0.0001
E/A	0.66 ± 0.28	0.68 ± 0.26	<0.0004
DT (ms)	292.30 ± 36.51	284.00 ± 29.00	<0.0001

Abbreviations – EF LV – left ventricular ejection fraction; LVESD – endsystolic left ventricular diameter; LVEDD – enddiastolic left ventricular diameter; IVS – interventricular septum thickness; PW – left ventricular posterior wall thickness; E/A – ratio of early velocity (E) and velocity during atrial systole (A); DT – deceleration time; SD – standard deviation

Results

Polarised light (PL) group

Three-month PL application on neuropathic diabetic foot ulcers led to a slight decrease in plasma CRP and LDH plasma activity. The following plasma levels of endogenous antioxidants were stimulated significantly: a-tocopherol, t-tocopherol, b-carotene and CoQ10, while lipid peroxidation (MDA levels) was not significantly changed. The ratios of CoQ10/TAG, CoQ10/HDL cholesterol and CoQ10/LDL cholesterol in plasma were increased significantly (Tab. 2). The selected echocardiographic parameters studied were not affected by three-month PL application (Tab. 5).

QALA group – antioxidant supplementation

Three-month antioxidant supplementation (CoQ10, ALA, α-tocopherol) caused a significant decrease in plasma τ-tocopherol, an increase in plasma CoQ10 and in the ratios of CoQ10/TAG, CoQ10/total cholesterol, CoQ10/HDL cholesterol and CoQ10/LDL cholesterol. MDA levels were decreased significantly (Tab. 3). The selected echocardiographic parameters showed significant improvement changes (Tab. 6).

QALAPL group – simultaneous polarised light application and antioxidant supplementation

Simultaneous PL application and antioxidant supplementation (hydrosoluble CoQ10, α-lipoic acid and α-tocopherol) decreased CRP plasma level in 27.2 % without statistically significant and significantly decreased LDH plasma activity. Three-month treatment led to a significant increase in CoQ10 and α-tocopherol plasma levels. The ratios of CoQ10/TAG, CoQ10/total cholesterol, CoQ10/HDL cholesterol and CoQ10/LDL cholesterol in plasma were increased significantly. Other parameters (Tab. 4) were not significantly changed. An extremely significant improvement was shown in echocardiographic parameters (Tab. 7).

Discussion

C-reactive protein plasma level

C-reactive protein (CRP) is the acute-phase reactant of inflammation produced by the liver. Data from the Women's Health Study identified enhanced levels of CRP as a predictor of diabetes development in women (34). Raised CRP is considered a predictor of the development of diabetes also in middle-aged men,

Tab. 7. Effect of 3-month simultaneous polarised light application and antioxidant supplementation (QALAPL group) on selected echocardiographic parameters in diabetics.

Parameter QALAPL group	Before the study (mean ± SD)	After 3 months (mean ± SD)	Statistics (P)
EF LV (%)	59.60 ± 9.24	63.60 ± 8.38	<0.0001
LVEDD (mm)	52.00 ± 3.69	49.50 ± 3.36	<0.0001
LVESD (mm)	35.20 ± 4.19	32.90 ± 4.48	<0.0001
IVS (mm)	11.20 ± 1.30	10.30 ± 1.16	<0.0001
PW (mm)	10.50 ± 1.24	9.50 ± 1.23	<0.0001
E/A	1.00 ± 0.06	1.03 ± 0.07	<0.0001
DT (ms)	242.40 ± 25.50	227.80 ± 22.39	<0.0001

Abbreviations: EF LV – left ventricular ejection fraction; LVESD – endsystolic left ventricular diameter; LVEDD – enddiastolic left ventricular diameter; IVS – interventricular septum thickness; PW – left ventricular posterior wall thickness; E/A – ratio of early velocity (E) and velocity during atrial systole (A); DT – deceleration time; SD – standard deviation .

independent of established risk factors (10). An increase of CRP concentration (even within the clinically normal range) is an independent predictive factor of future cardiovascular events (29, 36). The main inducers of CRP are the pro-inflammatory cytokine interleukin 6 (IL-6), the tumor necrosis factor α (TNF-α) and IL-1 (11), which are released from macrophages after stimulation by advanced glycation end products (AGEs) (41). A randomised, placebo-controlled, double-blind trial showed that exposure of a small area of the human body to light led to a fast decrease in the elevated pro-inflammatory cytokine plasma content (TNF-α, IL-6, and IFN-τ), which may be an important mechanism of the anti-inflammatory effect of phototherapy. These changes resulted from transcutaneous photomodification of a small volume of blood and a fast transfer of the light-induced changes to the entire pool of circulating blood (46) may result in a decrease in plasma CRP. In our study, PL application led to a 22.5 % decrease of CRP in the PL group, not statistically significant (Tab. 2).

In the QALAPL group, plasma CRP decreased by 27.16 % although not statistically significant (Tab. 4). Schmeltzer et al provided evidence for involvement of CoQ10 as an antioxidant in inflammation via NF-B pathway (39).

Lactate dehydrogenase activity

There was a significant increase in the lactate dehydrogenase (LDH) activity in diabetics. Table 2 shows plasma LDH activity of the PL group at baseline (higher than reference values) and its significant decrease after three months of treatment. A similar result was found in the QALAPL group (Tab. 4). It thus seems that the decrease of plasma LDH activity in diabetics was due to the effect of PL. In the past, several investigators demonstrated increased ATP synthesis by irradiation absorption of monochromatic visible light and near infrared radiation causing changes in redox properties of respiratory chain components and acceleration of electron transfer (15). In the inner mitochondrial segment two types of photoreceptors were described: rod inner segment (RIS) and cone inner segment (CIS) (32). The effect of red PL on plasma LDH activity may be mediated through these receptors, their activation resulting in stimulation of mitochondrial respiratory chain, increase in ATP production and improvement in cellular hypoxic and pseudohypoxic states. Under these conditions, pyruvate is degraded to acetyl coenzyme A (acetylCoA) and LDH plasma activity is decreased.

Plasma levels of selected endogenous antioxidants, malondialdehyde and ratios of CoQ10 and lipid fractions

Hyperglycaemia in diabetic patients leads to generation of oxygen free radicals through glucose autooxidation and non-enzymatic glycation (6). Increased levels of lipid peroxides have been implicated in the pathogenesis of diabetic complications (1).

Lipoproteins, especially LDLs, are easily oxidised, and LDL oxidation products are cytotoxic. As LDLs are rich in polyunsaturated fatty acids, their oxidation leads to the formation of conjugated dienes and malondialdehyde. The concentration of hydroperoxides of phospholipids and of cholesterol begins to increase once available reduced CoQ10 has been consumed (23). Thus the decline of the ratios of CoQ10 and individual lipid fractions can be unfavourable leading to the development of chronic diabetic complications.

Several antioxidant protective mechanisms reduce the deleterious effects of lipid peroxides (2). They constitute a primary defensive system that includes enzymatic defenses (glutathione peroxidase and superoxide dismutase) and naturally occurring antioxidant nutrients, such as CoQ10, β-carotene and vitamin E (tocopherols). Both α- and τ-to copherol are taken up by the intestine and secreted in chylomicron particles to be transported and transferred to peripheral tissues, such as muscle, adipose tissue and brain. The resulting chylomicron remnants are taken up by the liver, where α-tocopherol is reincorporated into nascent VLDLs by α-tocopherol transfer protein. However τ-tocopherol appears to be degraded by a cytochrome P450-dependent process and then excreted primarily in urine (17).

PL application led to a significant increase in plasma endogenous antioxidants (CoQ10, both tocopherols and ß-carotene) and an increase in the CoQ10/TAG, CoQ10/HDL cholesterol, and CoQ10/LDL cholesterol ratios. The baseline plasma concentrations of these antioxidants were below the reference values and PL treatment brought them up to normal range (Tab. 2).

Antioxidants supplementation caused a significant decrease in MDA plasma concentration, and an increase in plasma CoQ10 to the normal range. On the other hand, plasma τ-tocopherol level was significantly decreased (from the normal range to lower values). This result is in accord with a previous study (5) which showed that supplementation with α-tocopherol caused a decrease in plasma τ-tocopherol. The QALA group (Tab. 3) showed a significant increase in the CoQ10/TAG, CoQ10/total cholesterol, CoQ10/HDL cholesterol, and CoQ10/LDL cholesterol ratios.

In the QALAPL group, CoQ10 and α-tocopherol values were significantly increased. The ratio of CoQ10/lipid fractions was also increased significantly (Tab. 4).

These results indicate that red PL alone (or in combination with antioxidant nutrients) can decrease oxidative stress in dia-

betics with chronic complications. Enhancement of plasma CoQ10 and α-tocopherol levels by PL is consistent with the results of a previous study (14). PL increases in plasma τ-tocopherol and this effect is also seen in the QALAPL group.

People with low blood levels of vitamin E were found to be more likely to develop type 2 diabetes (37). Previous studies found significantly lower levels of plasma α-tocopherol in patients with diabetes (12, 33, 35). The antioxidant ability of vitamin E is known to be restored by other endogenous antioxidants such as vitamin C, ubiquinol and thiols. ALA is rapidly converted to DHLA in many tissues. Evidence for vitamin E recycling by DHLA has come from several studies. DHLA protects against microsomal lipid peroxidation, but only in the presence of vitamin E (30). Likewise, patients with type 2 diabetes were found to have significantly lower blood levels of CoQ10 compared to healthy people (13, 26). In diabetes, mitochondrial oxidative phosphorylation is significantly reduced, and CoQ10 levels and ATP production are decreased (19). The mutual interaction between CoQ10, ALA and vitamin E and polarised light under oxidative stress conditions is indicative of the benefit of simultaneous antioxidant nutrient therapy in diabetics with chronic complications.

Selected echocardiographic parameters

Left ventricular diastolic dysfunction precedes more advanced stages of congestive heart failure. Timely diagnosis and treatment of heart failure launched in the face of diastolic dysfunction is considered the optimal strategic approach. ATP plays an essential role in the bioenergetics of the heart muscle. Administration of CoQ10 to patients with isolated diastolic dysfunction (hypertensive heart disease, mitral valve prolapse, chronic fatigue syndrome) was reported to result in improvement in diastolic function, decrease in myocardial thickness, and improvement in functional classification (22). Oda (27) published results on patients with load-induced diastolic dysfunction and documented normalisation of diastolic function in all patients after CoQ10 supplementation.

In the present study, we found that three months complementary therapy with 60 mg CoQ10, 200 mg vitamin E and 100 mg ALA caused significant improvement in all selected echocardiographic parameters without any side effects. Simultaneously, LV thickness and both systolic and diastolic LV volumes were reduced. The ejection fraction of the LV was improved, and so were the E/A ratio and deceleration time (Tab. 6). Belardinelli et al documented that oral CoQ10 improved functional capacity, endothelial function of left ventricular contractility in chronic heart failure (2). Simultaneous PL treatment with antioxidant supplementation led to similar results (Tab. 7). The mechanism of the effect of PL may relate to increased ATP production in cell mitochondria, as shown in experimental models [14] through activation of mitochondrial photoreceptors, described by Perkins et al (32).

There was no significant improvement in sBP (134.7±13.6 vs 131.2±12.0 mmHg) and dBP (82.3±9.6 vs 80.5±5.4 mmHg) during the study. Blood glucose and HbA1c values before the study and after three-month treatment were not affected (9.8±3.4 vs 9.9±4.1 mmol/l, NS; 8.5±2.1 vs 8.2±1.8 %, NS). Conventional treatment of hypertension was not changed for six months before and during the study.

Conclusion

Results of this pilot study offer a novel modality in the treatment of neuropathic diabetic foot ulcers by polarised light. The data also show that antioxidant nutrients supplementation (with hydrosoluble coenzyme Q10, alpha-lipoic acid and vitamin E) can contribute to improvement in heart left ventricular function in diabetics. Simultaneous administration of antioxidant nutrient along with polarized light offers a new approach in the treatment of diabetic patients with chronic complications.

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Received August 10, 2009.
Accepted January 17, 2010.