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The effect of a vegetarian versus conventional hypocaloric diet on serum concentrations of persistent organic pollutants in patients with type 2 diabetes

H. Kahleova [a,*], S. Tonstad [b], J. Rosmus [c], P. Fisar [c], A. Mari [d], M. Hill [e], T. Pelikanova [a]

[a] Institute for Clinical and Experimental Medicine, Videnska 1958/9, 140 21 Prague, Czech Republic
[b] Department of Endocrinology, Morbid Obesity and Preventive Medicine, Oslo University Hospital, Oslo, Norway
[c] State Veterinary Institute Prague, Sidlistni 24, 165 03 Prague, Czech Republic
[d] C.N.R. (National Research Council) Institute of Systems Science and Biomedical Engineering, Padua, Italy
[e] Institute of Endocrinology, Narodni 8, 11394 Prague, Czech Republic

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Abstract *Background and aims:* The aim of this study was to explore the effect of a vegetarian versus conventional diet on the serum levels of persistent organic pollutants (POPs) in patients with T2D after 12 weeks of dietary intervention and to assess their relationships with metabolic parameters.

Methods and results: Men and women with T2D were randomly assigned to follow either a vegetarian diet without fish or meat ($n = 37$) or an isocaloric conventional antidiabetic diet ($n = 37$). Both diets were energy restricted (minus 500 kcal/day). All foods were provided to the participants. At randomization (week 0) and 12 weeks, the meal test was performed to assess the β-cell function and serum levels of 24 POPs. Dioxins and dioxin-like POPs were analyzed by isotope dilution high-resolution gas chromatography (HRGC) and mass spectrometry after cleanup of the silica and carbon columns. Non-dioxin-like POPs were analyzed by gas chromatography with an electron capture detector (GC–ECD). Statistical analyses used were repeated-measures analysis of variance (ANOVA), a multivariate regression model, and Pearson's correlations.

We observed a statistically nonsignificant trend toward increases in the serum levels of most POPs in response to both hypocaloric diets with no differences between groups. In the groups combined, the change in serum concentrations of total POPs was correlated to changes in HbA1c ($r = +0.34$; $p < 0.01$), fasting plasma glucose ($r = +0.41$; $p < 0.01$) levels, and β-cell function measured as insulin secretion at a reference glucose level ($r = -0.37$; $p < 0.01$), independent of the changes in body weight and volume of visceral fat.

Conclusion: Short-term hypocaloric vegetarian and conventional diets did not reduce the POP levels, possibly due to mobilization of fat stores. Our findings support the relationship between POPs and diabetes, especially β-cell function.

Trial registration: ClinicalTrials.gov number, NCT00883038, completed.

Abbreviations: CG, control group; MCR, metabolic clearance rate of glucose; POPs, persistent organic pollutants; T2D, type 2 diabetes; VG, vegetarian group.

* Corresponding author. Institute for Clinical and Experimental Medicine, Videnska 1958/9, 14021 Prague 4, Czech Republic. Tel.: +420 261 362 150; fax: +420 261 362 820.
E-mail address: hana.kahleova@gmail.com (H. Kahleova).

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Introduction

The prevalence of obesity and type 2 diabetes (T2D) is increasing globally at an alarming rate, in association with population growth, aging, and urbanization [1]. This epidemic is commonly explained by reduced physical activity and dietary changes, but plausible evidence supports the role of certain environmental factors [2]. There is emerging evidence that man-made chemicals, described as persistent organic pollutants (POPs), are involved in the development of obesity, metabolic syndrome, and T2D [3–5]. Cross-sectional studies showing the association between serum concentrations of POPs and prevalence of diabetes [6] have been supported by prospective and experimental data [7,8].

POPs constitute a group of various substances including polychlorinated biphenyls (PCBs) and organochlorine pesticides (OCPs) that are ubiquitously present in the environment. Commercial production of POPs has been limited internationally; however, the POPs continue to accumulate in the environment and food supply as they are lipophilic and resistant to degradation [9–11]. The major sources of POPs are contaminated foods, mainly fish and seafood, meats, and dairy products [12,13]. This suggests that a vegetarian diet excluding these main sources of POPs might lead to a reduction to exposure and body levels.

A vegan diet has been shown to promote weight loss and improve glycemic control compared to a conventional antidiabetic diet in patients with T2D [14]. We have further shown that a vegetarian diet leads more effectively to an increase in insulin sensitivity, reduction in visceral fat, and improvement in oxidative stress markers than a conventional diabetic diet in subjects with T2D [15]. In the present study, we conducted a secondary analysis of this study [15] to explore the effect of a vegetarian versus conventional diet on the serum levels of POPs in patients with T2D after 12 weeks of dietary intervention.

Methods

The characteristics of the sample and the methods are described in detail elsewhere [15]. Briefly, we recruited 74 subjects with T2D treated with oral hypoglycemic agents, both men (47%) and women (53%), aged 30–70 years, with HbA1c between 6 and 11% (42–97 mmol/mol) and body mass index (BMI) between 25 and 53 kg m^{-2}, for the study. The study design was a randomized, non-blinded, parallel group controlled clinical trial. The subjects were randomly assigned to either the vegetarian dietary group (VG, $n = 37$), who were instructed to follow a vegetarian diet, or the control group (CG, $n = 37$) who were instructed to follow a conventional antidiabetic diet for 12 weeks. The diets were both designed to be isocaloric and energy restricted (500 kcal/day subtracted from the estimated needs) with caloric intakes based on the measurement of the resting energy expenditure of each subject by indirect calorimetry (metabolic monitor VMAX; Sensor Medics, Anaheim, CA, USA [16]) performed at baseline. The study protocol was approved by the Ethics Committee of the Institute for Clinical and Experimental Medicine and Faculty Thomayer Hospital in Prague, Czech Republic.

Diets

All meals during the study were provided. The patients came almost every day to eat lunch or dinner at a vegetarian restaurant or the Institute for Clinical and Experimental Medicine and picked up the meals for the next 1–2 days. The vegetarian diet (~60% of total energy from carbohydrates, 15% protein, and 25% fat) consisted of vegetables, grains, legumes, fruits, and nuts. Animal products were not provided and the patients were instructed to avoid them entirely or limit their intake to one portion of plain low-fat yogurt a day. The conventional diabetic diet was administered according to the dietary guidelines of the Diabetes and Nutrition Study Group (DNSG) of the European Association for the Study of Diabetes (EASD) [17]. This diet contained 50% of the total energy from carbohydrates, 20% protein, <30% fat (≤7% saturated fat), and <200 mg/day of cholesterol/day. Records of all visits to pick up meals were kept. At weeks 0 and 12, a 3-day dietary record was completed by each participant (2 weekdays and 1 weekend day). A registered dietician analyzed all the 3-day dietary records using the country-specific food nutrient database NutriDan 1.2. At weeks 3 and 8, a registered dietician made unannounced telephone calls to obtain a 24-h dietary recall. This information was not analyzed, but allowed the investigators to check the adherence and to provide additional counseling.

Dietary adherence

Adherence to the prescribed diet was defined as the average daily energy intake being no more than 200 kcal in excess of the intake prescribed. Additional criteria for adherence to vegetarian diet were the average daily cholesterol intake < 100 mg, while in the control group, the average daily cholesterol limit was <300 mg. The patients had to meet both criteria (energy and cholesterol) to be considered adherent to the prescribed diet.

Advice on physical activity

Participants were asked not to alter their exercise habits during the 12 weeks of dietary intervention. The physical activity was assessed by pedometer Omron HJ-113 (Omron, Kyoto, Japan) worn by each subject for 2 weekdays and 1 weekend day at baseline and after 12 weeks. In addition, the subjects responded to two questionnaires regarding their activity levels, the International Physical Activity Questionnaire (IPAQ) [18] and the Baecke questionnaire [19] at weeks 0 and 12.

Glucose monitoring and medication

All participants were given an Accu-Chek Go glucometer (Roche, Basel, Switzerland) and were instructed on how to