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Short communication

Effects of soybean oligosaccharides on antioxidant enzyme activities and insulin resistance in pregnant women with gestational diabetes mellitus

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ABSTRACT

The effects of soybean oligosaccharides (SBOS) on antioxidant enzyme activities and insulin resistance in pregnant women with gestational diabetes mellitus (GDM) were investigated. Ninety-seven pregnant women with GDM were randomly divided into two groups, the control group (51 cases) and the SBOS group (46 cases). Before the group separation, the blood sugar level in patients was maintained stable by regular diet and insulin treatment. The control group was continued with the insulin treatment, while the SBOS group was treated with the combination of insulin and SBOS. Results showed that SBOS were able to reduce oxidative stress and alleviate insulin resistance in pregnant women with GDM, which indicates that SBOS may play an important role in the control of GDM complications.

1. Introduction

Gestational diabetes mellitus (GDM) is a special type of diabetes often associated with pregnancy (Bellamy, Casas, Hingorani, & Williams, 2009; Matuszek, Lenart-Lipińska, Burska, Paszkowski, & Smoleń ANowakowski, 2011). GDM imposes high risks on pregnancy and induces a series of symptoms including macrosmia, fetal abnormalities, high blood pressure, and polyhydramnios (Matuszek et al., 2011). In infants born by GDM mother, neonatal respiratory disease syndrome, hypocalcemia and hypoglycemia may occur after birth, and the perinatal mortality rate is high among these infants. Meanwhile, women with GDM, as well as their children, are more prone to other health problems such as type 2 diabetes (Löbner et al., 2006; Nelson, Matthews, & Poston, 2010). However, it is controversial to use current oral hypoglycemic drugs in pregnant women because of the safety and effectiveness concerns. Many diabetes-related organizations, including American Diabetes Association, are cautious about using these drugs in pregnant women. As a result, the clinical application of these drugs in pregnant women is limited (American Diabetes Association, 2013). Therefore, it is of great interest to develop other effective treatments, especially those that can be safely used in pregnant women (Bellamy et al., 2009; Löbner et al., 2006).

Soybean oligosaccharides (SBOS), which are isolated from the soybean seeds, are "potential prebiotic material" and approved by the Food and Drug Administration as GRAS (Generally Recognized As Safe) ingredient in USA. (Chen, Jun, Jun, Bo, & Rui, 2010a; Kim, Kim, & Hwang, 2003; Zhou, Kong, Yang, & Yin, 2012). Soybean oligosaccharides (SBOS) is a general claim of soluble oligosaccharides contained in soy or other legume. SBOS consist most of raffinose, stachyose and sucrose. Sucrose is formed by combination of a-D-glucose and b-D-fructose through a-1,2 glycosidic bond. Raffinose is a trisaccharide containing galactose linked a-(1–6) to the glucose unit of sucrose. Stachyose is a tetrasaccharide containing a galactose linked a-(1–6) to the terminal galactose unit of raffinose. Other reported major sugar of soybeans is sucrose with lower amounts of the monosaccharides, fructose, rhamnose and arabinose; significant levels of glucose occurred only in immature seeds. (Chen, Jun, Jun, Bo, & Rui, 2010a; Chen, Jun, Jun, Bo, & Rui, 2010b; Kim et al., 2003). SBOS have been shown to be a promising candidate for the prevention of many

Abbreviations: SBOS, soybean oligosaccharides; GDM, gestational diabetes mellitus; SOD, superoxide dismutase; CAT, catalase; GPx, glutathione peroxidase; TBARS, thiobarbituric acid reactive substance; MDA, Malondialdehyde; FPG, fasting plasma glucose; FINS, fasting insulin; APN, adiponectin; HOMA-IR, insulin resistance index; HBCI, islet βcells function index.

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chronic diseases such as cancer, osteoporosis, atherosclerosis and menopausal disorders (Chen et al., 2010b; Espinosa-Martosy & Rupérez, 2006; Mateos-Aparicio, Redondo-Cuenca, Villanueva-Suárez, & Zapata-Revilla, 2008). It has been reported that SBOS treatment reduces oxidative stress and abnormal blood lipid levels induced by high fat diets (Chen et al., 2010b). However, the effect of SBOS on antioxidant enzyme activities and insulin resistance in pregnant women with GDM remains not clear.

In this report, we studied 97 patients that were diagnosed as GDM according to the National Diabetes Data group (NDDG) standard. The effects of SBOS on antioxidant enzyme activities and insulin resistance in pregnant women with GDM were investigated.

2. Materials and methods

2.1. Materials

SBOS (SBOS consist most of raffinose, stachyose and sucrose, and the proportion of raffinose and stachyose is above 60%) were purchased from One Hundred Love Technology Co., Ltd. (Harbin, China). NovoRapid (Insulin Aspart Injection) and Novolin N (isophane protamine biosynthetic human insulin) were purchased from Novo Nordisk Company (Copenhagen, Denmark). Fasting plasma glucose (FPG) kit was provided by DiaSys Diagnostic Systems (Holzheim, Germany). Fasting insulin (FINS) kit was from Beijing Furui Biological Engineering Company (Beijing, China). Adiponectin (APN) ELISA kit was obtained from AssayPro (St. Charles, USA). Superoxide dismutase (SOD) detection kit, Glutathione peroxidase (GPx) detection kit, Catalase (CAT) detection kit and Malondialdehyde (MDA) detection kit were obtained from Nanjing Jiancheng Bioengineering Institute (Nanjing, China).

2.2. Patients and study design

Between June 2007 and March 2009, 97 pregnant women diagnosed as GDM according to the National Diabetes Data group (NDDG) standard were recruited in this study at Suzhou Municipal Hospital (Suzhou, China). The inclusion criterion was that pregnant women are older than 20 and carry singleton fetus, excluding those with diabetes, kidney disease, liver disease, hypertensive disease and intrahepatic cholestasis during pregnancy. Signed forms of consent were obtained from all participants, and the study was approved by Suzhou Municipal Hospital Research Ethics Board.

These 97 pregnant women whose blood sugar level was maintained stable by regular diet and insulin treatment were randomly divided into two groups. The control group (51 cases) and the SBOS group (46 cases). The differences in age, weight before pregnancy, body mass index (BMI), height and family history of diabetes in first-degree relatives between the two groups were not statistically significant. The control group was continued with the treatment by insulin alone through subcutaneous injection of a short-term effect insulin NovoRapid before every meal (three times a day), and an intermediate-term effect insulin Novolin N before sleep. The SBOS group was treated with the combination of the insulin (as in the control group) and SBOS (10 g/day in 200–300 ml warm water, took in orally before sleep).

In the first 7d of treatment, during which insulin dose adjustment was needed, the blood glucose level was monitored seven times a day (one time each before lunch and dinner, one time each 2 h after the three meals, one time in the morning when the stomach is empty, one time at 0:00 in the morning). The blood glucose level was checked and recorded three to four times a day after it maintained stable, and the dose of insulin was adjusted according to the blood glucose level. The control standard levels of blood glucose are: 4.4–6.7 mmol/L at 0:00 in the morning, 3.3–5.6 mmol/L in the morning when the stomach is empty, 3.3–5.8 mmol/L before lunch and dinner, 4.4–6.7 mmol/L 2 h after the three meals.

2.3. Biochemical analysis methods

2.3.1. Plasma glucose, insulin and APN analysis

Before treatment and after treatment for 8 weeks, fasting venous blood (10 ml) was withdrawn. The venous blood was divided into two aliquots: one aliquot (5 ml) was used to measure the FPG and FINS, and the other (5 ml) was centrifuged at 3000 rpm for 15 min to collect serum. The serum was stored at −80 °C for later use. Serum FPG, FINS and APN levels were measured according to the manufacturer's instructions.

2.3.2. Antioxidant enzyme activity analysis

The serum SOD activity was assayed by the inhibition of xanthine/xanthine oxidase-mediated reduction of cytochrome c as previously described (Sheng, Gu, & Xie, 2013). One unit of SOD activity was defined as the amount of enzyme required to produce 50% inhibition in the calibration curve obtained with standard SOD, and was expressed as U/mg protein.

The GPx activity was determined using the method previously reported (Sheng, Gu, Xie, Zhou, & Guo, 2007). One unit of enzyme activity was defined as the amount of NADPH (in nmol) consumed per min per mg protein. CAT activity was assayed by the method described by Wu et al. (2008). The enzyme-catalyzed conversion of H_2O_2 was measured. In brief, an aliquot of 0.5 ml cold sample, or a blank consisting of 0.5 ml distilled water was added in test tubes. The enzymatic reaction was initiated by adding 5 ml of cold 6 mM H_2O_2. After 3 min the reaction was stopped by adding 1 ml of 3 M H_2SO_4. Then 7 ml of 0.01 M $KMnO_4$ was added, and the absorbance was measured at 480 nm within 30–60 s. The concentration of TBARS was measured by a method reported by Sheng et al. (2013) with modifications. The TBARS concentration was expressed as MDA equivalents.

2.3.3. Insulin resistance analysis

The insulin resistance index (HOMA-IR) and islet βcells function index (HBCI) were calculated with a homeostasis model assessment method (HOMA) using the following formula (Chen et al., 2005):

$$\text{HOMA-IR} = \text{FINS} \times \text{FPG}/22.5$$

$$\text{HBCI} = \text{FINS} \times 20/(\text{FBG-3.5})$$

2.4. Statistical analysis

Statistical analysis was performed using SPSS software version 11.5 (SPSS Institute, Chicago, IL, USA). All data were expressed as means ± SEM. Student t test was used to assess the statistical significance. $P < 0.05$ was considered statistically significant.

3. Results

3.1. Effects of SBOS on serum SOD, CAT, GPx activities and TBARS level

As shown in Table 1, the serum SOD, CAT and GPx activities in the SBOS group were significantly higher than those in the control group ($P < 0.01$), while the TBARS level in the SBOS group was significantly lower than that in the control group ($P < 0.01$).