Can J Diabetes 40 (2016) 135–142

Contents lists available at ScienceDirect

Canadian Journal of Diabetes

journal homepage: www.canadianjournalofdiabetes.com

Original Research

Alterations in Plasma Glucose and Cardiac Antioxidant Enzymes Activity in Streptozotocin-Induced Diabetic Rats: Effects of *Trigonella foenum-graecum* Extract and Swimming Training

Karimeh Haghani PhD [a], Salar Bakhtiyari PhD [a,*], Jafar Doost Mohammadpour MSc [b]

[a] *Department of Clinical Biochemistry, Faculty of Medicine, Ilam University of Medical Sciences, Ilam, Iran*
[b] *Department of Physiology, Faculty of Medicine, Ilam University of Medical Sciences, Ilam, Iran*

ARTICLE INFO

Article history:
Received 16 December 2014
Received in revised form
3 July 2015
Accepted 19 August 2015

Keywords:
Endurance
Fenugreek
Heart antioxidants
Swimming training
Type 1 diabetes

ABSTRACT

Objectives: Diabetes mellitus is a group of metabolic diseases characterized by chronic hyperglycemia. *Trigonella foenum-graecum* (fenugreek) and swimming training have previously been reported to have hypoglycemic and antioxidant effects. We aimed to evaluate the effects of swimming training and fenugreek aqueous extract, alone and in combination, on plasma glucose and cardiac antioxidant enzymes activity of streptozotocin-induced diabetes in rats.
Methods: We divided 70 male Wistar rats equally into 7 groups: diabetic control (DC), healthy control (HC), swimming (S), fenugreek seed extract (1.74 g/kg) (F1), fenugreek seed extract (0.87 g/kg) (F2), swimming + fenugreek seed extract (1.74 g/kg) (SF1), and swimming + fenugreek seed extract (0.87 g/kg) (SF2). We used streptozotocin for the induction of diabetes. Statistical analyses were performed using the statistical program SPSS.
Results: We did not detect any significant differences in body weight in the F1, F2, S, SF1 and SF2 groups compared with the DC group ($p>0.05$). The results also revealed that the hypoglycemic effect of combined swimming and fenugreek was significantly stronger ($p<0.05$) than either of those alone. The F1, S, SF1 and SF2 groups showed improved superoxide dismutase activity with respect to the DC group ($p<0.05$). Catalase activity in the F1, S, SF1 and SF2 groups were significantly higher than those of the DC group ($p<0.05$). Glutathione peroxidase activity in the S, SF1 and SF2 groups were significantly increased compared with the DC group ($p<0.05$).
Conclusions: Our findings suggest that the combination of fenugreek seed extract and swimming could be useful for the treatment of hyperglycemia and cardiac oxidative stress induced by type 1 diabetes mellitus.

Mots clés :
Endurance
Fenugrec
Antioxydants cardiaques
Entraînement en natation
Diabète de type 1

RÉSUMÉ

Objectifs : Le diabète sucré représente un groupe de maladies métaboliques caractérisées par une hyperglycémie chronique. Nous savons déjà que *Trigonella foenum-graecum* (le fenugrec) et l'entraînement en natation ont des effets hypoglycémiques et antioxydants. Notre objectif était d'évaluer les effets de l'entraînement en natation et de l'extrait aqueux de fenugrec, seul ou en combinaison, sur la concentration plasmatique du glucose et l'activité des enzymes antioxydantes cardiaques au cours du diabète induit par la streptozotocine chez les rats.
Méthodes : Nous avons réparti 70 rats Wistar mâles de façon égale en 7 groupes : maîtrise du diabète (MD), maîtrise de la santé (MS), natation (N), extrait de graines de fenugrec (1.74 g/kg; F1), extrait de graines de fenugrec (0.87 g/kg; F2), natation+extrait de graines de fenugrec (1.74 g/kg; NF1) et natation+extrait de graines de fenugrec (0.87 g/kg; NF2). Nous avons utilisé la streptozotocine pour induire le diabète. Les analyses statistiques ont été réalisées à l'aide du programme statistique SPSS.
Résultats : Nous n'avons détecté aucune différence significative du poids corporel dans les groupes F1, F2, N, NF1 et NF2 par rapport au groupe MD ($p>0.05$). Les résultats ont également révélé que l'effet hypoglycémique de la combinaison de la natation et du fenugrec était significativement plus fort ($p<0.05$) que chacun de manière isolée. Les groupes F1, N, NF1 et NF2 ont montré une amélioration de l'activité

* Address for correspondence: Salar Bakhtiyari, PhD, Department of Clinical Biochemistry, Faculty of Medicine, Ilam University of Medical Sciences, Ilam, Iran.
E-mail address: bakhtiyaribio@gmail.com, bakhtiyari-s@medilam.ac.ir

1499-2671
http://dx.doi.org/10.1016/j.jcjd.2015.08.012

de la superoxyde dismutase en ce qui concerne le groupe MD ($p<0.05$). L'activité de la catalase dans les groupes F1, N, NF1 et NF2 a été significativement plus élevée que celle du groupe MD ($p<0.05$). L'activité de la glutathion peroxydase dans les groupes N, NF1 et NF2 a été significativement plus grande que celle du groupe MD ($p<0.05$).
Conclusions : Nos résultats suggèrent que la combinaison de l'extrait de graines de fenugrec et de la natation peut être utile au traitement de l'hyperglycémie et du stress oxydatif cardiaque induit par le diabète de type 1 sur le cœur.

Introduction

Diabetes mellitus is a group of metabolic diseases characterized by hyperglycemia resulting from defects in insulin secretion or insulin action or both. The chronic hyperglycemia of diabetes is associated with the long-term damage to and dysfunction and failure of various organs, especially eyes, kidneys, nerves, heart and blood vessels. Oxidative stress is significantly increased in diabetes because prolonged hyperglycemia increases the generation of free radicals and the depletion of the endogenous antioxidant system. This leads to the damage of cellular organelles and enzymes (1–4).

Cells continuously produce free radicals and reactive oxygen species as part of the metabolic processes. These free radicals are neutralized by an elaborate antioxidant defense system consisting of enzymes such as catalase (CAT), superoxide dismutase (SOD), and glutathione peroxidase (GPX) (5). Diabetes is associated with significant oxidative stress, and oxidative damage to tissues may be a contributory factor in several diabetic complications (6). It has been shown that oxidative stress is elevated during diabetes, and patients with diabetes have increased incidences of cardiovascular disease (7,8). Abnormally high levels of free radicals and the simultaneous decline of enzymes involved in antioxidant defense mechanisms (SOD, CAT and GPX) can be the main causes of the pathogenesis of diabetic cardiomyopathy (9,10).

Thus, the utilization of antioxidant compounds, which are able to scavenge free radicals or modulate oxidative stress, seems to be a logical approach to combat the vascular complications of diabetes.

Trigonella foenum-graecum is an annual herbaceous plant commonly called fenugreek. It is an herb that is widely used for cooking and as a traditional medicine for diabetes in Asia. Preliminary studies have demonstrated that fenugreek seeds have hypoglycemic effects in patients with types 1 and 2 diabetes mellitus and in experimental diabetic animals (11–15). In addition to their hypoglycemic effects, fenugreek seeds have also been reported to reduce diabetes-induced oxidative stress in heart, liver and kidney (16–19).

Yet controversy exists concerning the effects of endurance training on the oxidative status and antioxidant defense systems of the myocardium, which may decrease, increase or even remain unchanged (20,21). Some controversy might arise from the differing methodologies used for determinations and the differences in the models employed (running vs. swimming, rats vs. mice, male vs. female). Among the various forms of treatments for diabetes mellitus, exercise and diet are of vital importance (22,23). Several papers have reported that long-term training programs have improved the antioxidant system in the skeletal muscles of young and adult rats with diabetes (24–26). However, to our knowledge, little attention has been paid to the cardiac antioxidant system.

In several previous studies, the effects of training and fenugreek seed extract on the metabolic traits of type 1 diabetes were examined alone, and the results were controversial. We hypothesized that the combination of fenugreek seed extract and swimming training would lead to a synergistic or additive beneficial effect. However, to our knowledge, no study had been conducted to examine the effect of swimming and fenugreek seed extract in combination on the cardiac antioxidants in streptozotocin (STZ)-induced type 1 diabetes in rats. Therefore, the current study aimed to determine the single or combined effects of fenugreek seed extract and swimming on the body weight, blood glucose levels and activity of cardiac antioxidant enzymes of STZ-induced diabetics in rats.

Methods

Animals

In this study, 70 male Wistar albino rats, weighing 200 to 250 grams and averaging 12 weeks of age, were used. They were housed in metal cages under standard laboratory conditions (12:12-hour light-dark cycle) and were fed regular pellets and distilled water ad libitum. The room had a temperature of 20°C to 25°C, a humidity level of 50% to 60% and average illumination of 150 to 200 lux during the day. The rats were randomly divided into 7 groups: diabetic control (DC), healthy control (HC), swimming (S), fenugreek seed extract (1.74 g/kg) (F1), fenugreek seed extract (0.87 g/kg) (F2), swimming + fenugreek seed extract (1.74 g/kg) (SF1) and swimming + fenugreek seed extract (0.87 g/kg) (SF2). Fenugreek and saline were administered orally by gastric gavage separately. The procedures used were in accordance with the guiding principles of the committee responsible for the care and use of animals.

Induction of diabetes

The administration of STZ resulted in animal models' having type 1 diabetes, which is characterized by severe and chronic hyperglycemia (27). To induce type 1 diabetes, after 12 hours of fasting, the animals received intraperitoneal injections (60 mg/kg body weight) of STZ (Sigma, St. Louis, Missouri, USA) diluted in 1.0 mL of sodium citrate buffer (0.1 M, pH 4.5). Then, 7 days later and after fasting for 12 hours, their blood glucose levels were measured. Blood samples were collected by tail nipping and were assessed for glucose by an electronic glucometer. Animals with levels of fasting blood glucose above 300 mg/dL were considered diabetic. Fasting blood glucose levels and body weights were monitored at the beginning and at the end of the experimental period.

Extraction of aqueous plant material

Fenugreek seeds were purchased from the local herbal market and were cleaned, dried and finely powdered in a grinding machine. Aqueous extraction of fenugreek seeds was performed according to the method described previously by Xuea et al. (19). In brief, 1.5 kg of powdered fenugreek seeds were boiled in 15,000 mL of distilled water (1 g powder/10 mL water) for 30 minutes. The decoction was cooled for 30 minutes at room temperature and then filtered through a coarse sieve twice. Finally, the filtrate was concentrated by flash evaporation at 35°C to form a thick paste with a final mass of 300 grams. The chemical profile of fenugreek seed extract has been described by various authors, and some of the main constituents identified include polyphenols, saponins, flavonoids, alkaloids and fibers (28–31).