Nutrition, Metabolism & Cardiovascular Diseases (2014) **24**, 837–844

Available online at www.sciencedirect.com

Nutrition, Metabolism & Cardiovascular Diseases

journal homepage: www.elsevier.com/locate/nmcd

A whole-grain cereal-based diet lowers postprandial plasma insulin and triglyceride levels in individuals with metabolic syndrome☆

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Received 24 July 2013; received in revised form 7 January 2014; accepted 8 January 2014
Available online 28 January 2014

KEYWORDS
Whole-grains;
Cereal fiber;
Glucose metabolism;
Insulin metabolism;
Lipids

Abstract *Background and aim:* Until recently, very few intervention studies have investigated the effects of whole-grain cereals on postprandial glucose, insulin and lipid metabolism, and the existing studies have provided mixed results. The objective of this study was to evaluate the effects of a 12-week intervention with either a whole-grain-based or a refined cereal-based diet on postprandial glucose, insulin and lipid metabolism in individuals with metabolic syndrome.

Methods and results: Sixty-one men and women age range 40–65 years, with the metabolic syndrome were recruited to participate in this study using a parallel group design. After a 4-week run-in period, participants were randomly assigned to a 12-week diet based on whole-grain products (whole-grain group) or refined cereal products (control group). Blood samples were taken at the beginning and end of the intervention, both fasting and 3 h after a lunch, to measure biochemical parameters. Generalized linear model (GLM) was used for between-group comparisons. Overall, 26 participants in the control group and 28 in the whole-grain group completed the dietary intervention. Drop-outs (five in the control and two in the whole-grain group) did not affect randomization. After 12 weeks, postprandial insulin and triglyceride responses (evaluated as average change 2 and 3 h after the meal, respectively) decreased by 29% and 43%, respectively, in the whole-grain group compared to the run-in period. Postprandial insulin and triglyceride responses were significantly lower at the end of the intervention in the whole-grain group compared to the control group ($p = 0.04$ and $p = 0.05$; respectively) whereas there was no change in postprandial response of glucose and other parameters evaluated.

Conclusions: A twelve week whole-grain cereal-based diet, compared to refined cereals, reduced postprandial insulin and triglycerides responses. This finding may have implications for type 2 diabetes risk and cardiovascular disease.

Abbreviations: ARs, alkylresorcinol homologues; CVD, cardiovascular disease; FFA, free fatty acids; GI, glycemic index; GLP-1, glucagon like peptide-1; Homa-IR, homeostatic model assessment-insulin resistance; LPS, lipopolysaccharides; T2D, type 2 diabetes.

☆ The study was registered with ClinicalTrials.gov identifier NCT00945854.

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http://dx.doi.org/10.1016/j.numecd.2014.01.007

Introduction

Diet is an important lifestyle component able to influence the development of chronic diseases. Based on observational studies, a large body of evidence has shown that increased whole-grain consumption is consistently associated with a reduced risk of developing type 2 diabetes (T2D) and cardiovascular diseases (CVD) [1]. However, the mechanisms for this association have not been completely elucidated. The benefits of habitual whole-grain and cereal fiber intake can be mediated by improving one or more risk factors, such as insulin resistance, dyslipidemia, inflammation or oxidative stress. However, intervention studies investigating the effect of whole-grain in the regulation of glucose/insulin metabolism have thus far provided conflicting results. Some clinical trials have shown an improvement in insulin sensitivity [2–4], while other studies have reported no effect on either glucose or insulin metabolism [5–7]. Similarly, there is conflicting data on the effects of increased whole-grain consumption on markers of inflammation [8,9]. As for the effects of whole-grain consumption on lipid metabolism, there is general consensus that whole-grain cereals rich in β-glucans, such as oats and barley, are able to reduce fasting plasma concentrations of both total and LDL cholesterol [10,11]. However, clinical trials utilizing whole-wheat and/or whole-grain rye products have reported mixed results [5,7,12,13].

It is possible that the benefits of whole-grain consumption on reduction of T2D and CVD risk could also be mediated by mechanisms that have not yet been investigated, such as postprandial metabolism. A large body of evidence indicates that metabolic abnormalities in prediabetic insulin-resistant subjects and in diabetic patients are more closely related to the postprandial condition than to the fasting state [14]. Indeed, an increase in blood glucose, insulin and lipid concentrations in the postprandial period are risk factors for adverse cardiovascular events that can also be detected in the absence of altered fasting parameters [15]. It can be hypothesized that whole-grain intake exerts its metabolic effects mainly during the postprandial period with minimal impact, at least in the short/medium term, on fasting parameters. In this regard, very few studies have investigated specifically the effects of whole-grain cereals on postprandial metabolism or suggested a beneficial impact of whole-grain on glucose/insulin metabolism. In fact, in acute experimental settings, a reduction in insulin response has been reported with whole-kernel rye/whole-rye bread when compared with white wheat bread [16,17]. This has been confirmed in longer term experimental conditions that demonstrated a reduction of both insulin and glucose postprandial responses after a 2–4 weeks of whole-grain rye or wheat diet in overweight men [18]. A reduction in 2-h glucose response to OGTT after a 12 week diet based on whole-grain cereal products was observed in another study performed in individuals with metabolic syndrome [9,19]. However in this study consumption of whole-grain cereal products was associated with increased fatty fish and bilberry intake and when the impact of whole-grain was evaluated per se the diet failed to show any significant effect on metabolic parameters.

To clarify the impact of whole-grain on postprandial metabolism, the present study aimed at evaluating the effects of a 12-week intervention comparing a whole-grain-based diet to a refined cereal-based diet on postprandial glucose, insulin and lipid metabolism in individuals with metabolic syndrome, and no weight loss. This study was part of a randomized, controlled, two center (Naples, Italy and Kuopio, Finland) intervention study in which the principal endpoint was peripheral insulin sensitivity [20]. This paper reports data on postprandial metabolism obtained by the Italian research group.

Methods

Population

One hundred and eleven individuals were assessed for eligibility in the study; thirty-five candidates did not meet the inclusion criteria, and fifteen declined to participate. Overall, sixty-one men and women aged between 40 and 65 year, with metabolic syndrome were recruited for a dietary intervention. At screening, the health status and medical history of the subjects were examined by interview, clinical examination and routine laboratory tests. In addition, a 75 g oral glucose tolerance test (OGTT) was carried out to evaluate glucose tolerance and exclude participants with undiagnosed diabetes. The diagnosis of metabolic syndrome was based on the National Cholesterol Education Program Criteria [21]. Subjects were excluded if they were diagnosed with diabetes and/or renal failure (serum creatinine $>$1.5 mg/dl), liver abnormalities (ALT/AST ratio twice normal values), anemia (Hb $<$12 g/dl), any other chronic disease, if they used any drug known to influence glucose and lipid metabolism and inflammation, had very high levels of physical activity, or alcohol intake above 40 g/day.

All participants provided written informed consent, and the study was approved by the Ethics Committee of the Federico II Naples University.

Study design

The study was based on a randomized, controlled, parallel group design and consisted of a 4 week run-in period, during which participants were stabilized on their own diet, and a 12-week test period, fully described previously [20]. At the end of the run-in period, participants were randomly assigned to one of two groups, the first assigned to a diet based on whole-grain cereal products (whole-grain group), and the other to a diet based on refined cereal products (control group). Randomization was carried out with stratification for sex, age (5 year increments) and body mass index (BMI) (25–30, 30–35 kg/m^2) by means of a computerized random allocation list. Allocation was carried out by personnel not involved in the study; investigators and dieticians were aware of the participants'