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THE EFFECT OF FOOD WITH DIFFERENT GLYCAEMIC INDEX ON THE BLOOD GLUCOSE LEVEL

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ABSTRACT

Blood glucose levels are affected by many factors including the type of foods consumed, processing technology and cooking method. Hormone insulin lowers blood glucose to its constant level, while glucagon, growth hormone, adrenalin and glucocorticoids have the opposite effect. High steepness of the blood glucose level rise after meals may be unfavourable for the organism. Sugars are transferred into the blood at different speeds according to the type of food. Therefore the aim of this study was to confirm experimentally the effect of food on blood glucose levels in men and women of different ages. Two types of low, medium and high-glycaemic index (GI) foods were given to 4 men and 4 women of different age (from 35 to 65 years). All volunteers were healthy, slightly overweight, and without any regular sporting activity. None of them had any idea about their daily carbohydrates consumption and what the term glycaemic index meant. The volunteers came to the GI determination fasted in the morning. Their rise in blood glucose level was monitored by glucometer before the meal and after 1 and 2 hours of the consumption of baked potatoes (GI 85), white bread bun (GI 70), boiled potatoes (GI 64), rye bread (GI 62), potato dumplings (GI 52) and white cooked spaghetti (GI 41). Fasting blood sugar levels of volunteers highly depended on their age (p <0.0001) and gender (p <0.0001). The blood glucose values increased with age and were higher in men than in women. Significant influence of food GI on blood glucose levels in both men and women in all the age categories was observed (p <0.0001). An interaction between age and gender was also statistically highly significant (p <0.0001). One hour after consuming food the blood glucose values were significantly different from the values of fasting (p = 0.0035). The differences of these values did not depend on the age (p = 0.0574) and sex (p = 0.8256) of volunteers, but there was a significant difference on the GI value of food (p <0.0001). Significant interactions were also found in case of sex*age (p = 0.0002), age*GI (p <0.0001) and age*sex*GI (p <0.0001). Medium correlation was found between the GI values of food and the rise of blood glucose levels after 1 h (r = 0.6468). After the consumption of high-GI foods the values of glycaemia did not returned to their fasting levels even after 2 hours. There was still significant difference (p = 0.0032), but the values after 2 h were also statistically different from those after 1 hour (p <0.0001). The response to a particular type of consumed food depended on age (p = 0.0018) and especially the GI of foods.

Keywords: glycaemia; glycaemic index; age; gender; time after consumption

INTRODUCTION

Blood sugar (blood glucose) levels in the human body are normally maintained by regulatory mechanisms within a constant range. In a healthy fasting person its values lie between 3.5 to 5.5 mmol.L^{-1} **(Gaerth, 2003)**. Many factors affect these levels including physical activity, psychological stress, drugs, cyclical changes in metabolites during the day, week, month and year, pregnancy, age, gender and race. Blood glucose level increases several times during the day after food intake. Insulin acts by means of homeostatic mechanism and lowers blood glucose to its constant level, while glucagon, growth hormone, adrenalin and glucocorticoids have the opposite effect. They increase the level of sugar in the blood when it is in shortage. Blood sugar level usually reaches a maximum within 30 to 60 minutes after meal consumption to approximately 6.8 mmol.L^{-1}. It then gradually decreases about two hours after a meal to its normal fasting levels.

Blood glucose levels are affected by the types of foods consumed **(Rovner et al., 2009)**. The composition, content and type of carbohydrates, and also its processing technology, cooking method and the length of storage can influence blood glucose levels. Glycaemic index (GI) of food is defined as the incremental area under the two-hour blood glucose response curve following a 12-hour fast and ingestion of 50 g of reference food (either glucose giving GI units or white bread giving BE units) and multiplied by 100 **(Svačina and Bretšnajdrová, 2008)**. The GI value of glucose is 100 by definition.

Food may be classified into three groups according to their GI. Firstly low-GI foods (GI 55 or less) releases glucose more slowly and steadily, which leads to more suitable postprandial blood glucose readings. Secondly medium-GI foods (GI 56 – 69) rise blood glucose levels moderately. Thirdly high-GI foods (GI 70 and above) causes a rapid rise in blood glucose level and is suitable for recovery after exercise. Values of glycemic indexes for common foods may be found in **Foster-Powell et al. (2002)** or on http://www.glycemicindex.com.

Carbohydrates are transferred into the blood at different speeds according to the type of food and the type of carbohydrate present. High steepness of the blood glucose level rise after meals may be unfavourable for the organism. If the blood sugar raises slowly it can be gradually transferred into the cells and therefore does not contribute to the development of undesirable complications **(Frost and Dornhorst, 2005)**.

Selection and consumption of carbohydrate-containing foods according to their GI can greatly influence the metabolism and physiology of the human body. This can be used for the prevention and treatment of some chronic diseases such as diabetes mellitus or obesity. Physical and mental performance can also be affected by the level of food GI **(Jenkins et al., 2004)**. The low-GI foods can help to keep the blood glucose level in the desired range and thereby prevent complications of diabetes **(Frost and Dornhorst, 2000)**. The low GI of food has a positive effect on HDL cholesterol and insulin sensitivity, which is related to the prevention of cardiovascular disease **(Dickinson and Brand-Miller, 2005)**.

A high-GI food is a risk factor for coronary heart disease **(Denova-Gutiérrez et al., 2010)**. Results of **Randi et al. (2008)** with 5830 volunteers aged 20 – 70 years also indicate a link between high-GI diet and a higher risk of thyroid cancer. Postprandial rise of glucose also corresponds to the decrease of antioxidants in blood serum. Low-GI diet may therefore have a positive impact on reduction of oxidative cell damage **(Jenkins, 2002; Leeds, 2002)**. The consumption of foods with high GI also has an impact on the reduction of attention, the ability to remember and ability to concentrate **(Dickinson and Brand-Miller, 2005)**. According to **Mondazzi and Arcelli (2009)** and **Little et al. (2010)**, the GI can also be an important factor in sports nutrition and weight-reduction diets.

Results of **Kong et al. (2014)** showed that overweight girls and boys aged 15 to 18 years on the diet with a low glycemic index exhibited a significant reduction in body weight and BMI. In addition waist circumference (WC) was significantly reduced. **Papadaki et al. (2010)** found that a high-protein diet with low glycemic index was effective for reduction of obesity in children aged 5 to15 years. Similar conclusions were reported by **Gogebakan et al. (2011)** who focused on adults. The results of their study showed that a high-GI diet coupled with a sedentary lifestyle leads to an increase in body weight, body fat and WC especially in women. This was not seen in the case of women with higher physical activity. These changes were also not observed in men having a high-GI diet. This indicates some differences between men and women in relation to a diet with a high glycemic index and the development of obesity.

The aim of this study was to confirm experimentally the effect of food with different GI on blood glucose levels in men and women of different ages.

MATERIAL AND METHODOLOGY

Tested volunteers

Eight volunteers (4 men and 4 women) were involved in the experiment. They have no special education in health and nutrition sciences. One men and one woman of the same age were allocated into one of four groups (35, 45, 55 and 65 years). All of them were healthy; theirBody Mass Indexes were 30-34.9 (class I obesity) **(WHO, 2000)**. No individual participated in any sport activity. Prior to the experiment, the volunteers filled out a short questionnaire. The results showed that none of them had any idea about their daily carbohydrates consumption and what the term glycaemic index meant. The volunteers came to the GI determination fasted in the morning. Sampling was carried out using a finger glucometer (Accu-Chek Performa Combo, Roche Ltd.). The glycemic index was determined in the blood before the meal consumption, 1 h and 2 h after the consumption of 50 g of selected food.

Tested food samples

Two kinds of food with low, medium and high GI were chosen for the experiment. Baked potatoes (GI 85) and white bread bun (GI 70) were selected from the category of high-GI food. Boiled potatoes (GI 64) and rye bread (GI 62) were the representatives of the medium-GI category. Potato dumplings (GI 52) and white cooked spaghetti (GI 41) were chosen as low-GI meal. Each person repeated the experiment three times with each food. Altogether there were obtained 432 results (from 8 persons, 6 different foods measured three times in 3 intervals: 0, 1 and 2 h).

Statistical analysis

The data obtained were analysed using statistical software Statistica 12.0 (StatSoft Inc.). Analysis of variance (a multi-dimensional ANOVA with interactions) was performed and the significant differences in the means were separated using the Tukey's test. The data were expressed as an average of triplicates ±0.95 confidence interval. For all statistical tests, a 5% level of significance was used.

RESULTS AND DISCUSSION

Fasting blood sugar levels of volunteers depended on their age ($p < 0.0001$) and gender ($p < 0.0001$). The blood glucose values increased with age (Fig. 1) and were higher in men (6.3 ±0.5) than in women (5.2 ±0.3). An interaction between age and gender was also statistically highly significant ($p < 0.0001$). The blood glucose level was above the limit values for the average healthy person in case of older volunteers, which may indicate a greater likelihood of health complications including diabetes **(Frost and Dornhorst, 2000)**. According to their BMI all volunteers were slightly obese. Consumption of high-GI food could contribute to this status **(Kong et al., 2014)**.

One hour after consuming food the blood glucose values were significantly different from the values of fasting ($p = 0.0035$). The differences of these values did not depend on either age ($p = 0.0574$) and sex ($p = 0.8256$). There was however, a significant difference depending on the GI value of food ($p < 0.0001$). Significant interactions were also found in case of sex*age ($p = 0.0002$), age*GI ($p < 0.0001$) and age*sex*GI ($p < 0.0001$). Differences in blood glucose levels corresponded with the GI values of

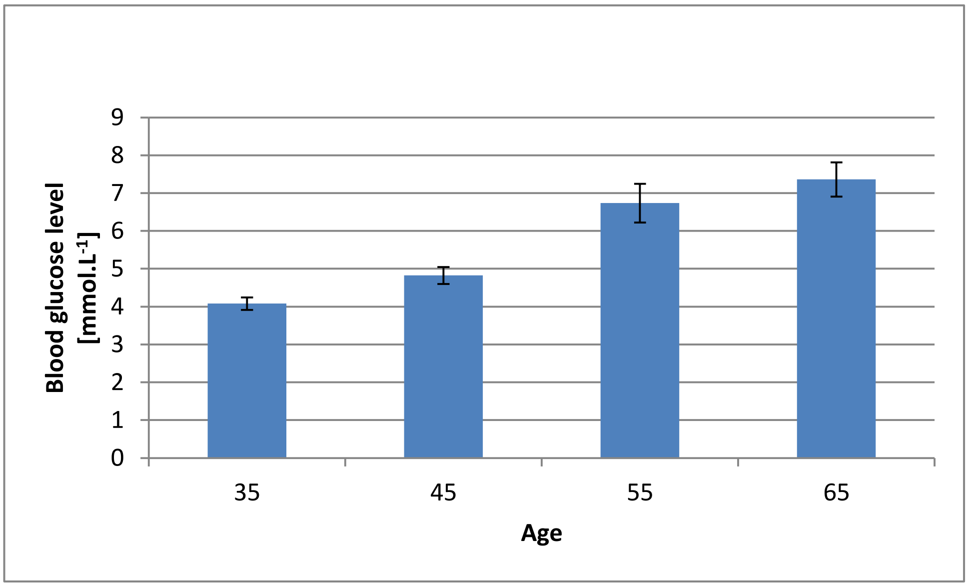

Figure 1 The blood glucose levels of fasting volunteers from different age groups.

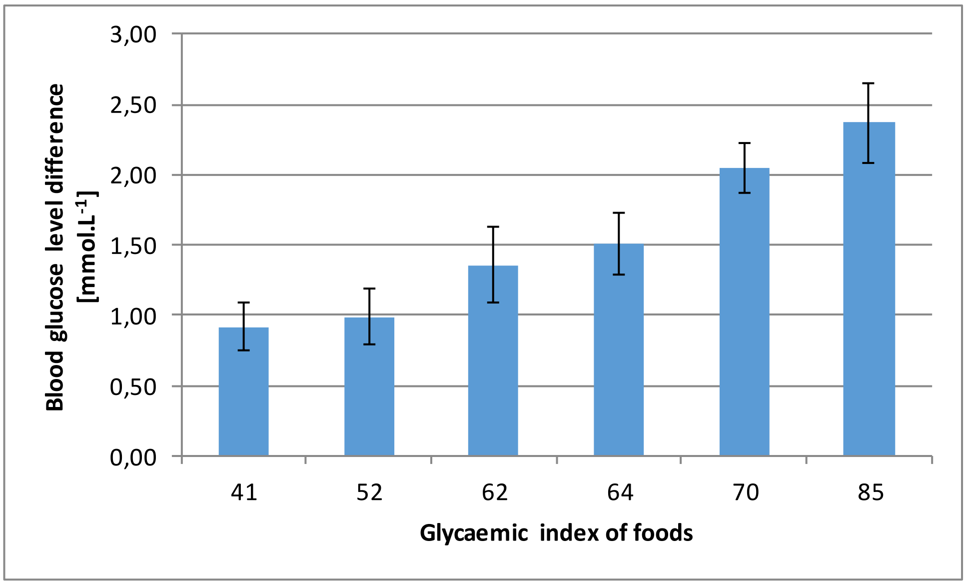

Figure 2 The blood glucose levels differences (1 h after meal – fasting values) in relation with the GI values of food.

foods (Fig. 2). The correlation coefficient between GI and blood glucose level was r = 0.6468. These results are consistent with the findings of **Taki et al. (2010)**. It was confirmed that a high-GI food increases blood sugar to higher levels.

According to the literature, blood glucose levels return to the fasting baseline usually within 2 hours after food consumption. In this study, however, there was still significant difference between the values after 2 h and fasting level ($p = 0.0032$). The values after 2 h were also statistically different from those after 1 hour ($p < 0.0001$).

The response to a particular type of consumed food depended on age ($p = 0.0018$) and especially the GI of foods (Fig. 3). It was noted that after consuming of high-GI food, the glucose levels return to its original state much slower than after medium and low-GI meals. This is in line with the conclusion of **Frost and Dornhorst (2000)**, who observed that foods with a low glycemic index value help maintain blood glucose in the desired range of values and thus contribute to reducing the risk of health problems including obesity and diabetes **(Jenkins, 2002; Leeds, 2002; Denova-Gutiérrez et al., 2010)**.

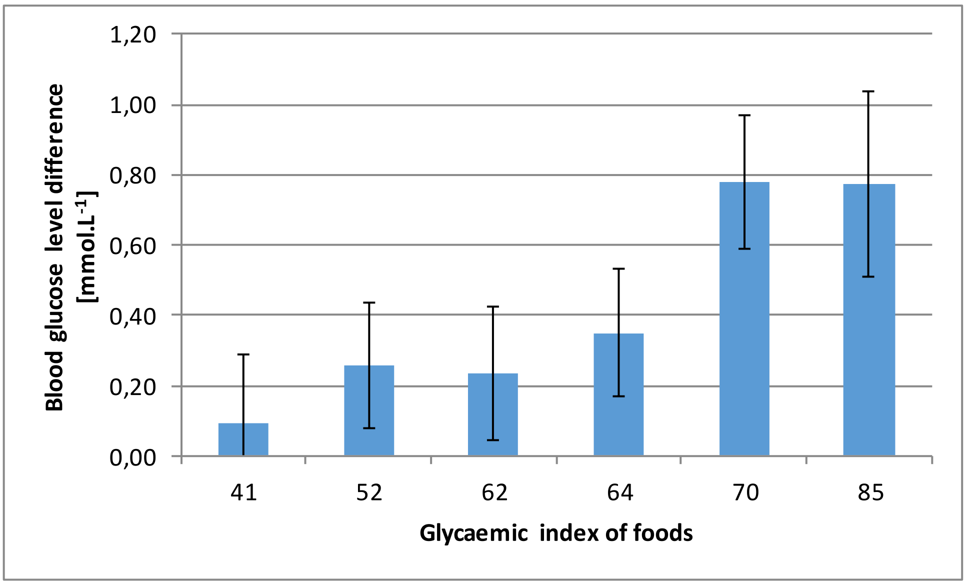

Figure 3 The blood glucose levels differences (2 h after meal – fasting values) in relation with the GI values of food.

CONCLUSION

A significant influence of food GI on blood glucose levels in both men and women in all the age categories was confirmed in this study. Sex was observed to be significant in fasting glycaemia levels only. Different responses of men and women after consumption of food were not demonstrated. Medium correlation was found between the GI values of food and the rise of blood glucose levels after 2 h. The values of glycaemia after eating foods with high GI did not return to their original values after 2 hours.

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