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The effect of breakfasts varying in glycemic index and glycemic load on dietary induced thermogenesis and respiratory quotient

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KEYWORDS
Glycemic index;
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Abstract *Background and aim:* Glycemic index (GI) and Glycemic Load (GL) are parameters of carbohydrate bioavailability able to influence risk of chronic diseases. GL can be lowered either by reducing carbohydrate intake or by reducing the GI of the carbohydrate moiety of a mixed meal. These two approaches might have a different impact on Dietary-Induced Thermogenesis (DIT) and preferential substrate oxidation in the postprandial period, which are variables known to be involved in the regulation of body weight and body composition. This dietary, crossover intervention trial was designed to evaluate the effect on DIT and Respiratory Quotient (RQ) of three isocaloric breakfasts different in GI and/or GL (high GI and high GL [HGI—HGL] vs. low GI and low GL [LGI—LGL]; vs. high GI and low GL [HGI—LGL]) followed by a standard meal.
Methods and results: RQ and DIT were measured in 16 lean young males by indirect calorimetry for 8 h. DIT resulted significantly higher after the LGI—LGL compared to the HGI—HGL breakfast ($p < 0.05$). Postprandial changes in RQ differed among all breakfasts ($p < 0.001$). RQ increased from baseline after the two breakfasts with highest carbohydrate content and significantly more after the HGI—HGL than after the LGI—LGL ($p < 0.02$), whereas it decreased after the HGI—LGL breakfast, which contained a higher amount of fat.
Conclusions: Reducing the GL of a meal by reducing GI seems an effective strategy to increase energy expenditure while maintaining a good rate of lipid oxidation. This might be related to different profiles of postprandial hormones affecting substrate oxidation.

Abbreviations: GI, Glycemic index; GL, Glycemic load; DIT, Dietary induced thermogenesis; HGI, High glycemic index; LGI, Low glycemic index; HGL, High glycemic load; LGL, Low glycemic load; RQ, Respiratory quotient; CHO, Carbohydrates; BMI, Body mass index; ΔR, Differential respiratory quotient.

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Introduction

Obesity is an increasing health problem in both developed and developing countries [1]. Currently, there is much interest in the potential of low glycemic index (GI) foods in the management of obesity [2,3]. It has been hypothesized that low-GI (LGI) foods may affect weight control promoting satiety and promoting fat oxidation at the expense of carbohydrate oxidation [4].

Obesity is related to high energy intake, low energy expenditure, or a mixture of both factors [5]. One of the contributors to energy expenditure, other than basal metabolism and physical activity, is Dietary Induced Thermogenesis (DIT). DIT depicts the amount of energy required for absorption, the initial steps of metabolism, and storage of nutrients. In healthy subjects with a mixed diet, DIT represents about 10% of the total amount of energy consumed over 24 h [6]. Even if it represents a small percent of total daily energy expenditure, relatively low DITs could play a role in the development and/or maintenance of obesity in the long term. Indeed, DIT appears to be lower in subjects prone to obesity and in postobese individuals as compared to normal weight never obese controls [7]. Similarly, fuel partitioning in the postprandial state, as assessed by the Respiratory Quotient (RQ), is able to predict long-term weight changes [8]. Fatty meals induce higher fat oxidation (i.e., lower RQ) as compared to high-carbohydrate meals [9]. However, in obese and postobese subjects, a temporary increase in the amount of dietary fat is not associated with an increase in lipid oxidation as high as in normal weight never obese individuals [10]. This suggests that adequate fat oxidation may be a mechanism to prevent weight gain that it is impaired in obesity-prone subjects [11].

Stevenson and colleagues investigated the effects of mixed high-carbohydrate (CHO) meals with different GI on substrate metabolism utilization during subsequent exercise in women [12] and males [9]. The results suggested that meals composed of LGI CHO could be more beneficial for maintaining a favourable metabolic milieu during the postprandial periods by reducing plasma glucose and serum insulin concentrations and by increasing the total amount of fat oxidized. Some studies have examined the effect of high glycemic index (HGI) and LGI CHO pre-exercise meals on exercise metabolism. Wee [13] and De Marco [14] observed that there was a significant shift in substrate utilization from CHO to fat when a LGI meal is ingested before exercise compared with that for a HGI meal.

Another parameter involved in weight control is glycemic load (GL). It is demonstrated that lowering glycemic load of the diet is an effective method of promoting weight loss and improving lipid profiles [15]. GL, derived by multiplying the amount of carbohydrate by GI, can be reduced acting on one of the two factors [16]. Although both approaches seem able to improve glucose control, they might have different effects on many metabolic variables, including postprandial energy metabolism and substrate oxidation.

The aim of this study was to evaluate the impact of three breakfasts different in GI and/or GL on postprandial energy metabolism measured as DIT and RQ. The breakfasts were designed in order to reduce GL with two different dietetic approaches. The first approach was to decrease GL by acting on carbohydrate quality, the second was to reduce GL by limiting carbohydrate quantity.

Methods

Study population

The volunteers were recruited among the students attending the Faculty of Agriculture of the University of Parma. The inclusion criteria were: male, age >18 and <30 years, body weight within normal range (BMI > 20 and < 25 kg/m^2), weight stability (less than ±5% change) in the 6 months prior to the study, never smokers. All subjects gave an informed consent before participation in the study, which was approved by the ethical committee of The University of Parma.

Test meals

Composition and nutritional content of the test meals are provided in Table 1. Meals were carefully chosen so that each was matched for GI and GL value. The GI of the mixed meals were previously tested in 10 healthy volunteers using glucose as reference and following the protocol of Brouns and colleagues [17]. The HGI—HGL (high glycemic index — high glycemic load) breakfast test was rich in carbohydrate (81.8 g/100 g) and with a GI = 67. In HGI—LGL (high glycemic index—low glycemic load) breakfast test, carbohydrate quality was equivalent (GI = 68), but carbohydrate quantity was lower (47.4 g/100 g) and lipid content higher (21 g/100 g vs. 4.5 g/100 g). LGI—LGL (low glycemic index—low glycemic load) breakfast test had low GI (44) and thus had the same glycemic load of the breakfast with higher lipid content (GL = 36 and GL = 32 respectively). The standard lunch consisted of pasta with meat sauce (300 g, 499 kcal), 1 slice of bread (24 g, 67 kcal), canned meat (120 g, 80 kcal) and cheese (56 g, 139 kcal) for a total of

Table 1 Energy and nutrient values for the three breakfasts. The snack consisted in a biscuit bar containing 25% of extruded cereal and legume flour and 30% extruded oat flour. [E = energy; CHO = carbohydrate; PRO = protein; LIP = lipids; GI = glycemic index of the meal; GL = glycemic load of the meal. HGI—HGL = high GI—high GL; HGI—LGL = high GI and low GL; LGI—LGL = low GI—low GL].

	HGI—HGL	HGI—LGL	LGI—LGL
Meal composition (g)	Crisp bread 75 Jam 30	Crisp bread 45 Jam 30 Butter 23	Snack 60 Jam 60
E (kcal)	402	400	397
CHO (g/100 g)	81.8	47.4	81.7
PRO (g/100 g)	8.6	5.3	6.4
LIP (g/100 g)	4.5	21.0	4.9
CHO (% E)	81.4	47.4	82.4
PRO (% E)	8.6	5.3	6.5
LIP (% E)	10.1	47.3	11.1
GI	67	68	44
GL	55	32	36