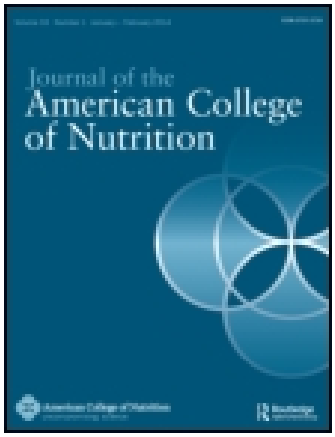

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The Effects of 6-Week Low Glycemic Load Diet Based on Low Glycemic Index Foods in Overweight/Obese Children - Pilot Study

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Original Research

The Effects of 6-Week Low Glycemic Load Diet Based on Low Glycemic Index Foods in Overweight/Obese Children - Pilot Study

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Key words: obesity, children, low glycemic index, low glycemic load diet, metabolic risk factors

Objective: To evaluate the effectiveness of a 6-week low Glycemic Load (GL) diet intervention based on low Glycemic Index (GI) foods on body weight, body composition, metabolic risk factors and satiety in overweight/obese pre-pubertal children.

Methods: Following a pediatric examination 8 healthy, average age 11 year old, Caucasian, pre-pubertal overweight/obese (BMI = 24, 7 ± 3.8 kg/m^2) children participated in the study. The Low GL diet intervention was based on the replacement of at least 50% of the high GI foods with Low-GI foods. The children with one of their parents participated in weekly nutrition consultations. Body composition, fasting glucose, insulin, cholesterol and triglyceride were measured before and after the study. Dietary changes were made based on weekly 4-day food-diaries.

Results: Despite no change in body weight, there was a significant ($p < 0.05$) reduction in % body fat (29.4 ± 4.2 vs. 25.4 ± 5.3), Waist-to-Hip Ratio (WHR 0.87 ± 0.053 vs. 0.86 ± 0.05), decrease in self-reported hunger level (4.37 ± 0.74 vs. 1.75 ± 0.75) and the total number of risk factors (28 vs. 15). There was a strong negative correlation between fasting glucose and insulin levels at baseline and in the magnitude of change after the study ($r = -0.93$ and $r = -0.85$ respectively; $p < 0.01$).

Conclusions: A 6 week study demonstrated the practicality and effectiveness of this Low GL dietary approach. Despite of the unchanged body weight, Low GL diet consultations positively modified body fat content and cardiovascular risk factors in overweight or obese children.

INTRODUCTION

Obesity is an independent risk factor for the development of cardiovascular disease (CVD) frequently associated with hypertension, dyslipidemia, diabetes, and insulin resistance [1], which are the cluster of syndromes signifies the metabolic syndrome. Metabolic syndrome was defined as the presence of three or more of the following: overweight, high systolic BP, high triglycerides, low HDL cholesterol, high insulin and impaired fasting glucose. Childhood obesity is also risk factor for steatohepatitis and hepatic fibrosis [2].

The prevalence of childhood obesity is rapidly increasing in Western countries [3,4,5] and in Hungary, where 50% of the adults, and 15% of the children are overweight [6,7]. The 7–49% of the children, who are obese, are also at risk for adulthood obesity. Most importantly obese children already have the components of the metabolic syndrome [8].

The treatment of childhood obesity is based on two major factors: changing eating habits and increasing physical activity. Among the many different diet approaches to reduce body weight, conventional low-fat and low calorie diet approach has been disappointing [9, 10] and diets based lowering, stabilizing

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the postprandial blood sugar and insulin levels (glycemic and insulinemic response) has become the center of the latest diet trends and research. Low-GI food as part of low-GL diets may benefit weight control by promoting satiety and by promoting fat oxidation [11–15]. In low-GL diets the person learns to consume most of the carbohydrate foods from low-GI and eat high-GI foods in moderation, will not develop the feeling of missing food, has satiety and can follow these diet plans for a long time. Low-GL diets bring marked weight benefits, loss of adiposity and reduced food intake in obese adults and children [15–17]; showed strong correlation on reducing type 2 Diabetes Mellitus and CVD [18–21] have been consistent inducing short and long-term positive result [3,22–24].

Besides changes in the diet, psychological factors play major role in the successful treatment of childhood obesity. Parental support has been shown to be significantly powerful to induce eating behavioral changes and adherence in children. [25,26]

There have been relatively few studies in the literature, which focuses on the relationship of low-GL diet and risk factors of metabolic syndrome in overweight non-diabetic children. Therefore, the purpose of this study is to examine the effect of a short term 6-week low-GL diet consultation, which focus on basic nutrition education, provides practical help on cooking methods and active participations of the parents -on body weight, body composition, components of metabolic syndrome (glucose, insulin and lipid profile) and satiety in overweight pre-pubertal children living at home.

SUBJECTS AND METHODS

Subjects

Four overweight and five obese children (3 girls, 6 boys; mean age 11.05 ± 1.1 years) volunteered for the study. Inclusion overweight was defined according to Hungarian Pediatrician Guidelines of the body mass index (BMI) equal to or greater than age- and sex specific cut-off points of 90th percentile, the risk of overweight was 75–90th percentile and obese is >97th percentile [27,28]. The cut-off points in our study correspond to in the United States 85th percentile for overweight and 95th percentile of BMI for obese category [28]. According to the reference value of Hungarian Pediatrician Institute the normal BMI for boys is 18.1 ± 3.33 kg/m^2 and for girls 17.8 ± 3.13 kg/m^2. Therefore the cut off point for children in Hungary for overweight is defined when the BMI is >24.8 kg/m^2 [27] corresponding to the International cut-off points for BMI for overweight and obese through 2–18 years of age, which is a BMI of 25 and 30 kg/m^2 for adults [28]. All participants with known-disease were excluded. The study was conducted by the approval of the Semmelweis University Regional and Institutional Committee of Science and Research Ethics Budapest, Hungary. Participants and parents provided written informed consent, before testing commenced.

Prior to laboratory testing and Pediatrician physical examination, the parents and the children attended on an information session for family and medical history. The participants with their parents filled out 4-day food record (two week-days and the two week-end days).

Methods

Anthropometric. Anthropometric and body composition measures were taken before and after the low-GL diet trial. Height was measured using a calibrated wall-mounted stadiometer (Dilmed kft, Hungary) Body mass, total body fat and muscle mass were estimated by using multi-frequency bioelectrical impedance analysis (BIA) (InBody 3.0, BioSpace, Korea). BMI was calculated by dividing the weight by the height squared (kg/m^2). Anthropometric measures were taken after an overnight fast and children were asked to avoid pursuing any vigorous physical activity on the previous two days. Circumference and skin-fold measures were taken on the right side of the body according to the ISAK guidelines [29]. The waist measurements were taken at L4 to measure corresponding visceral fat [30]. Participants wore light underwear for these to measurements.

Physical Exam. Standardized physical examination was conducted by a Pediatrician. Resting blood pressure was taken (Sphygmanometer) three times while seated and the average of the last two was calculated. According to the Hungarian Pediatric Guidelines the threshold for hypertension is 95th percentile of the age and sex matched values. The threshold for hypertension value of 11 years old children is 125/80 Hg/mm [31].

Biochemical Measurements. Fasting blood was obtained to determine biochemical parameters before and after the study. Plasma glucose was measured by hexokinase method (GLUCOSE liquiUV^{mono}, Human GmbH, Germany), and insulin concentration was determined by radioimmunoassay (Elecsys 1010, Roche Diagnostics GmbH, Germany). Total Cholesterol, HDL-Cholesterol (Boehringer Enzymatic method) and triglyceride were measured by direct laboratory analysis (Enzymatic Calorimetric PAP Diagnosticum Rt, Hungary), and LDL-Cholesterol was calculated using by the Friedwald Formula described elsewhere [32].

Assessment of Food Intake and Daily Physical Activity. Subjects and their parents were asked to specify details of children's and their own food intake before, and after the study for 4 days (2 week-days and both day of the weekend). The same 4-day food records were continuously collected at the end of each week at the nutritional consultations. Only complete records were used for analysis and data were analyzed by NutriComp® software (Hungary).

The participants were asked to rank their daily hunger level between 0 and 5. The daily overall feeling of hunger level was recorded at the beginning at the end of the study. The number zero meant *"feeling no hunger at all"* and 5 *"always very hungry"*.

The parents were asked to report the time their children spent with physical activity, watching TV and playing computer games or internet for one week at the beginning and the end of the study. The children also wore pedometer (HJ-112-E, Omron, Japan) for one week at the middle of the study to assess daily physical activity. The pedometer was fixed on the waist of the pants at awaking and taken off before going to bed. The data was recorded at the end of each day.

Adherence. The objective measure of adherence was the full participation on the consultations. Adherence to the diet was measured through the food record and was revealed on the individual consultation, when specific questioned were asked about the food record.

Intervention. Each participant with his/her parents attended on weekly nutritional consultations. The nutritional consultations included a 20-minute group nutrition class followed by a 20-minute individual consultation. The group consultation included a simple lecture for nutritional education, how to alter traditional Hungarian foods for a favorable GI (see detailed lecture titles in the Appendix 1, 4 and meal design Appendix 2 (Fig. 1)) and tasting of newly developed low-GI baking goods (see sample recipe in Appendix 3 (Fig. 2)). During the individual consultation

APPENDIX 2

LOW GI EATING GUIDELINE [48]

1. Eat 5-6 times a day every 3 hours
   3 meals (breakfast, lunch, dinner) & 2 snacks
   Size of main meal is 2 handful, size of snack 1 handful
   Don't let more than 5 hours between meals
2. Eat within 1 hour of awakening. Breakfast is your most important meal. Eat low GI foods
3. Eat a small snack in the afternoon and before bedtime
4. Drink lemon water when you eat high GI food esp. for school lunch
5. Eat before you become hungry
   When you are hungry your blood sugar level is too low. Remember when you stressed and have high anxiety you don't feel hunger and your body is using your muscle for energy
6. Consume 50-70% of your carbohydrates from low-GI foods.

Designing one meal [48]
Food Distribution on plate 22 cm diameter

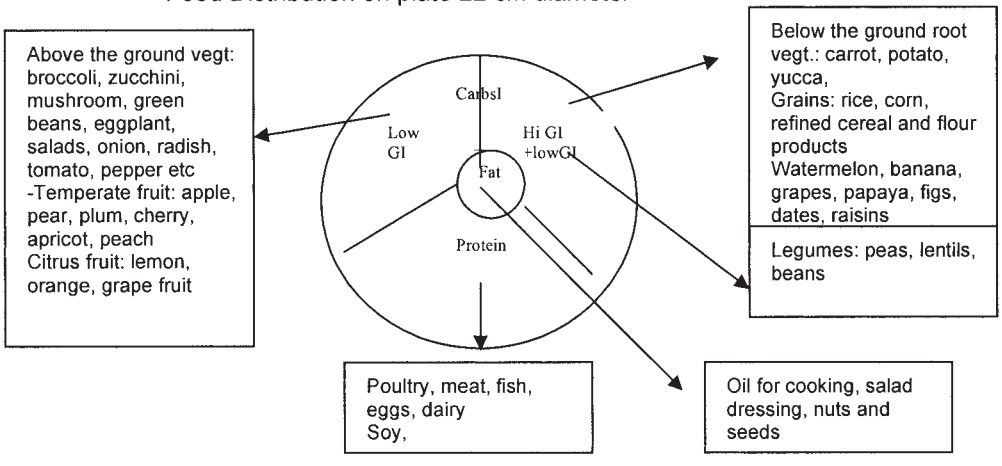

Fig. 1. Appendix 2.

APPENDIX 3

Sample Low GI Recipes [48]

GI Balanced Chocolate muffin

Ingredient:
Makes 12 muffins
5 large eggs,
1 tsp vanilla extract
1 tsp ghee or butter /margarine
3 tbs sugar, 2 tbs fructose
1 large apple cored
5 tbs cooked yellow split peas
5.5 oz (160 g) flour
1/2 tsp baking powder
Salt
3.5 oz (100 g) dark chocolate, chopped
3 tbs coco powder
butter and flour for the baking pan

Preparation time: 10 minutes

1. Preheat oven 200 °C
2.In blender: eggs, sugar, vanilla extract, butter, apple and cooked yellow split peas; Mix on high speed for 1 minute
3. In mixing bowl: mix flour with baking powder and salt, then coco powder and chocolate pieces
4. Add the mix in the blender to the dry mix in the mixing bowl. Mix well
5. Pour batter to buttered and floured baking pan or paper muffin cups

Baking time: 30- 35minutes

Variation: For a basic vanilla sponge cake make cake without chocolate and coco powder. You may add plum, cherry, apricot or peach peaces to the dough for a fruit cake
Store in fridge or freeze it. After refrigeration the best to preheat brownies in microwave 10 second.

Chickpeas Crêpe or Pancake

Ingredients: 10 crêpe or 15 small pancakes (4 in diameter)

2 eggs
4 tbs cooked yellow split peas
7-10 oz (2-3 dl) club soda (seltzer)
¼ tsp baking soda
5 tbs flour
1 tbs corn starch
salt
1 tsp olive oil

1. In blender on high speed mix the ingredients for 1 minute
2. Set aside the pancake mix for 20 minutes
1. For pancake keep the mixture thicker, for crepes add more seltzer water
2. Put batter to hot, lightly oiled no-stick pan and cook on medium heat.

Variation: Add one large apple or zucchini to blender to make apple or zucchini pancakes

Fig. 2. Appendix 3.

the 4-day food record and the possible difficulties were discussed, suggestions were made to exchange high-GI to low-GI foods.

The diet intervention was based on the exchanging at least 50% of the high-GI foods to low-GI foods as previously shown that GI averages out in mixed meals [33–35] and using portion control reducing the overall GL of the diet [36]. Our eating guideline encouraged the addition of fiber (exchanging white bread to whole meal bread) legumes (lentil, peas, beans) and focused on designing meals using low-GI carbohydrate foods. Low-GI high carbohydrate foods or high-GI low carbohydrate foods can have the same GL. By choosing foods with lower GI an individual automatically creates a lower GL meal [36].

It has been shown that acidity reduces the GI [33,34] the addition of acidity (lemon juice in water or vinegar for salad dressing) were used when consuming high-GI food (potato, rice) especially when eating in school cafeteria. Those children who ate in the school cafeteria were asked to drink premixed 15 oz (250ml) water with 2 tbs. of fresh lemon juice with lunch. The GL was controlled through the suggested portion size (see Appendix 2 (Fig. 1) for guideline), as an indirect control of GL and calorie intake. It was suggested to use a smaller plate (8.5 in or 22 cm diameter) with two handful of food served for main meals. The suggested size of the snacks was one handful. The total amount of sucrose and sucrose containing foods (jam,

chocolate, candy) was suggested to 2–3 teaspoon per day. Instead of drinking commercial juices it was recommended to consume fresh fruit and drink water.

Each participant received a handout description of the rationale for the low GL diet written in lay language, sample menu plans, recipes and a summary GI table (2002 International Table of GI [37]) of the most commonly consumed foods labeled *Low*- and *High*- GI foods. See Table 1 for examples of high and low GI foods and Table 2 for a sample menu plan. It was encouraged to parboil pasta and rice (See cooking tips Appendix 4) and include animal protein in the main meals [33,34].

As part of the parental support, the parents consumed the same diet, designed and prepared meals with the children. The parents were asked to teach their children basic cooking techniques and make the special recipes obtained on the consultations. Sampling of the foods made of the special recipes (high fiber pastries using yellow split peas, see Appendix 3 (Fig. 2)) were available on the Nutrition consultation.

Physical activity has not been changed and the children participated in regular Physical Education lessons 2–3 times a week.

Statistical Analysis. Statistical analyses were performed with Statistics 6.0 software (StatSoft Inc., Tulsa, OK). Values are reported as means ± SD. $P < 0.05$ was considered significant for all the data analysis. All parameters were tested for normal distribution and failing that logarithmic transformation was performed. Student's t-tests for dependent samples were used to evaluate whether the changes according to the program were significantly different from zero. Pearson's product-moment correlation coefficient was used to determine significant relationships between the outcome changes.

RESULTS

Nine children enrolled and 8 completed the 6-week study. The mean age of the children was 11 years with a BMI score of 24.7 ± 3.8 kg m^2.

Table 1. Examples of Low and High GI Foods Used in this Program

Low GI Foods
- Legumes (beans, chick pea, lentils)
- Whole grains (oat, barley, bulgur wheat, cracked wheat, semolina, basmati rice, all bran)
- Temperate fruits (apples, berries, pears, apricot, peach, plums etc.)
- Citrus fruits (oranges, grapefruit, tangerine, pine apple)
- "Above the ground" vegetables (squash, mixed vegetables, green beans, broccoli, tomato juice, tomato sauce, vegetable soups, asparagus, cauliflower, spinach, cabbage and onions, leafy greens, all above ground growing vegetables and carrots
- Breads (pumpernickel, whole grain)
- Cereals: muesli with whole grain flakes, raw bran
High GI Foods
- Potatoes, millet, rice and rice products, corn cereal
- Breads and pastry made of white, and refined flour

Table 2. Sample Daily Menu [47]

Breakfast
Oatmeal muesli 4 tbs. with 7 oz (2 dl) low fat milk
Mid morning snack
Sandwich: Whole meal bread with mustard 2 slices of turkey or palm size low GI pastry
Lunch
Vegetable soup (broth based)
Spaghetti (Al-dente) with chicken Bolognese sauce (with 2 tbs. of added lentil in the sauce)
Drink lemon water when eating high Gl food in school cafeteria
Afternoon snack
Plan yogurt with fresh fruit or 1 pc of 3 in diameter pancake with 1 tsp jam (see Appendix 3 (Fig. 2))
Dinner
Chicken paprikas (chicken breast cooked with onions, peppers and tomato) with handful rice-peas and cucumber salad
Bed time snack
Stewed apple (1 big) with cinnamon or 1 handful of whole meal crackers with 4 oz low fat milk

Despite the unchanged body weight (59.43 ± 13.9 vs. 59.21 ± 14.6 kg) and BMI score (24.7 ± 3.8 vs. 24.5 ± 3.68 kg/m^2) during the study, there was a significant reduction in % body fat (29.4 ± 4.2 vs. 25.4 ± 5.3; $p < 0.05$). The body composition values measured by BIA showed favorable but non-significant changes: a decrease in fat mass (18.21 ± 6.16 vs. 16.07 ± 5.95 kg), an increase in muscle mass (38.8 ± 9.12 vs. 40.25 ± 9.68 kg), an increase in fat free mass (41.61 ± 9.6 vs. 43.15 ± 10.21). There was a significant improvement in waist-to-hip ratio (0.87 ± 0.05 vs. 0.86 ± 0.05; $p < 0.05$). The 3 children, whose BMI increased had a lower BF %, higher fat free and muscle mass. (Table 3A and 3B)

There were favorable changes in the measures of lipid and carbohydrate metabolism. Even though the total cholesterol remained unchanged, there was a slight reduction in serum triglyceride (1.125 vs. 0.987 mmol/l) and an increase in HDL-Chol (1.08 ± 0.3 vs. 1.4 ± 0.4mmol/l). Besides the reduction in fasting glucose (5.31 ± 0.74 vs. 4.96 ± 0.33 mmol/l), fasting insulin values were reduced by 15% (15.75 ± 9.4 vs. 13.12 ± 5.7 mU/ml). There was a favorable reduction in HOMA-IR value after the 6-week low-GL diet, however the reduction was not significant (3.96 ± 3.33 vs. 2.91 ± 1.36). See Table 4.

There were no changes in the blood pressure measures before and after the study (115/69 and 113/68 Hg/mm, respectively). See Table 4.

By examining the correlation among the pre and post-test values, there was a strong negative correlation among fasting glucose and insulin levels at baseline and in the magnitude of change after the study ($r = -0.93$ and $r = -0.85$ respectively; $p < 0.01$). The higher was the baseline value the more it decreased to the end of the study.

There was a meaningful decrease in the number of total risk factors after the study (28 vs. 15) Table 4B summarizes the risk

Table 3A. The Effect of 6-Week Low-GL diet on Body Composition and Anthropometric Measures in Overweight/ Obese Children

	Baseline Mean ± SD	After 6-week Low-Gl diet Mean ± SD
Body Weight (kg)	59.43 ± 13.92	59.21 ± 14.66
BMI (kg/m^2)	24.7 ± 3.8	24.5 ± 3.683
BIA		
Body Fat (%)	29.4 ± 4.18	25.4 ± 4.93*
Fat Mass (kg)	18.21 ± 6.16	16.07 ± 5.95
Muscle Mass (kg)	38.8 ± 9.125	40.25 ± 9.67
Fat-Free Mass (kg)	41.61 ± 9.6	43.15 ± 10.21
Waist-to-Hip Ratio	0.87 ± 0.053	0.86 ± 0.05*

* ($p < 0.05$).

factors in each participants. Out of the three children with abnormal high blood sugar level at baseline two had a normalized level after the 6-week low-GL diet. Insulin level decreased in five children and the two children with abnormal high insulin level one normalized at the end of the study. Out of the four children with abnormal low HDL-Chol, two children's HDL-Chol level were normalized at the end of the study. Out of the three children with abnormal high triglyceride level one had normalized value at the end of the study.

The number of children who had metabolic values of reaching abnormal levels decreased to the end of the study. One child had 4 risks factors, another child had 3 risks and one more child had 2 risk factors and three children had one risk factor at the beginning of the study. One child who had 3 metabolic risk factors had normal values at the end of the study. The child with 4 risk factors had 3, and the child with 2 risk factors had one risk factor at the end of the study.

There was a reduction of risk factor for WHR (out of 5 children 2 had reduced WHR) Based on the evaluation of the age-matched 268 boys and 244 girls in Budapest, the cut-off point of risk factor WHR value was >0.87 and >0.82 respectively, which considered as the value >85 percentile (unpublished data of National Institute for Food Safety and Nutrition).

Based on the self-report, there was no significant difference in the time with physical activity at baseline and the end of the study (3.28 hr/week vs. 3.25 hr/week respectively), the time spent with watching TV (95 min/day vs. 88 min/day) and time spent on computer (55 min/day and 64 min/day). The participants took 5849 ± 1256 steps /day (3.88 ± 0.84 km) which corresponded to 25.87 ± 3.37 km /week.

The result of the dietary analysis before and after the 6-week low-GL diet showed no change in caloric intake (2061 ± 640 vs. 1950 ± 385 Kcal). There were favorable but non-significant change in macronutrient intake: protein intake increased (79.74 ± 19.73 g vs. 86.8 ± 20.27g), fat intake decreased (87.95 ± 35 g vs. 79.46 ± 15.8 g), carbohydrate intake decreased (236.9 ± 75.9 g vs. 213.7 ± 46.3 g) and the fiber intake slightly increased (18.84 ± 6.77 g vs. 24.72 ± 11.74 g). The self-reported hunger score significantly decreased at the end of the study (4.37 ± 0.74 vs. 1.75 ± 0.75 $p < 0.01$).

DISCUSSION

The present pilot-study examined the effect of a 6-week low-GL diet on the body composition, metabolic risk factors and satiety. Even though the unchanged BMI there was a significant decrease in % body fat, WHR, hunger level and the number of risk factors ($p < 0.05$). The changes in circumference-measures were non-significant (not reported data). It is important to mention, that three out of the eight children reported a "looser pants" by week 3.

There was a favorable increase in HDL-Chol levels. Out of four children with risk factor for HDL-Chol improved to non-risk category in 2 children. It is important to note this positive change because it is well know that low HDL-Chol levels is a risk factor, even in childhood, for atherosclerosis.

Table 3B. The Effect of 6-Week Low-GL Diet on BMI, BIA Body Fat % and Waist to Hip Ratio Measures in Each Participant

	Baseline			After 6-Week Low Gl Diet		
	BMI (kg/m^2)	BIA BF %	Waist to Hip ratio	BMI (kg/m^2) after low Gl diet	BIA BF %	Waist to Hip Ratio
1.	20.3	32.4	0.86	19.95	30.3	0.82
2.	27.4	28	0.87	27.06	21.3	0.86
3.	33	32.9	0.96	31.45	27.1	0.94
4.	23.7	26.3	0.79	23.4	22.2	0.78
5.	27.9	36.8	0.95	28.79	33.6	0.93
6.	20.8	22.3	0.87	21.04	21	0.87
7.	19.1	24.1	0.81	19.26	20.9	0.78
8.	25.7	32.1	0.91	24.6	32.1	0.90
Mean	24.8	29.3	0.87	24.4	25.4	0.86
SD	4.70	4.18	0.05	3.56	5.33	0.05

BF% = Body Fat percent.

BIA = Bioelectric Impedance Analysis.

L4 = Lumbalis vertebra number 4.

Table 4A. The Effect of 6-Week Low-GL Diet on the Parameters of Metabolic Syndrome in Overweight/Obese

	Baseline		After 6-week Low-GI diet	
		Number of children with risk		Number of children with risk
Glucose (mmol/l)	5.31 ± 0.74	3 (>5.5)	4.96 ± 0.33	1 (>5.5)
Insulin (mU/ml)	15.75 ± 9.4	2 (>20)	13.12 ± 5.7	1 (>20)
HOMA-IR	3.96 ± 3.3	3 (>4)	2.91 ± 1.36	2 (>4)
T Chol (mmol/l)	4.47 ± 0.74	3 (>4.5)	4.537 ± 0.34	3 (>4.5)
HDL-Chol mmol/l)	1.08 ± 0.3	4 (<1.1)	1.39 ± 0.47	2 (<1.1)
LDL-Chol (mmol/l)	2.53 ± 1.2	4 (>2.5)	2.53 ± 0.46	4 (>2.5)
Triglyceride (mmol/l)	1.125 ± 0.47	3 (>1.1)	0.987 ± 0.48	2 (>1.1)
Blood Pressure				
SDP	115 ± 12.24	3 <125	113.55 ± 6.94	3 <125
DBP	69.37 ± 8.21	3 <80	68.75 ± 5.82	2 <80

Insulin resistance as a factor for Metabolic syndrome, has been linked to many important consequences, including Type 2 diabetes, hypertension, dyslipidemia, acanthosis nigricans and polycystic ovarian syndrome. Although there are some genetic causes for insulin resistance, the most common cause is an excess of nutrition. Both excess glucose and excess fat can cause insulin resistance in muscle and fat tissues and excess fat can cause insulin resistance in the liver [38]. Therefore, the best approach for treatment is the increase of physical activity and healthier diets. Previously, dietary approach for long-term result, such as calorie restriction has been failed [9,10]. However, reducing the GI of foods and the GL of the diet even for a short-term 6-week improved the BMI and metabolic factors [39] in overweight / obese children to motivate them for a healthy eating.

The mean daily caloric intake did not change, the mean daily carbohydrate intake decreased by 23 g, protein increased by ~6 g; fat intake decreased by ~8 g and dietary fiber increased by 5 g over our 6-week study. Additionally, it is important to note that all 8 parents described the diet as easy to understand.

The present support, that low-GL diet is beneficial on reducing metabolic risk factors: lipid and carbohydrate metabolic measures [14,26,40] even when there was no significant

Table 4B. Summary of Risk Factors in Each Participant Before and After 6-Week Low Gl Diet

	WHR	GLU	INS	HOMA-IR	HDL	LDL	TG	BP Syst	BP Diast
1.	X	0	0	0	X	0	X	0	0
	0	0	0	0	X	X	X	0	0
2.	X	X	X	X	0	0	0	X	X
	0	0	0	0	0	0	0	X	0
3.	X	0	0	0	0	0	0	X	0
	X	0	0	0	0	0	0	0	0
4.	0	0	0	X	0	X	0	X	0
	0	0	0	X	0	0	0	0	0
5.	X	0	0	0	X	X	0	0	0
	X	0	0	0	0	X	0	0	0
6.	0	0	0	0	X	0	0	0	0
	0	0	0	0	0	0	0	0	0
7.	0	X	0	0	0	X	X	0	0
	0	0	0	0	0	X	0	0	0
8.	X	X	X	X	X	X	X	0	0
	X	X	X	X	X	X	0	0	0

WHR = Waist to Hip Ratio (girls risk > 0.82 boys risk > 0.87).
GLU = Fasting Glucose risk > 5.5 mmol/l.
INS = Fasting Insulin risk > 20 mU/ml.
HDL = High Density Lipoprotein risk < 4.5 mmol/l.
LDL = Low Density Lipoprotein risk > 1.1 mmol/l.
TG = Triglyceride risk > 2.5 mmol/l.
BP = Blood Pressure (risk SBP >125, Hgmm, DBP >80 Hgmm).
X = marks the presence of risk factor.
0 = lack of risk factor.
Top mark indicates before, bottom mark after the diet treatment in each set.

body weight loss [26,41,42]. The correlation of the carbohydrate metabolic measures revealed, that the higher the baseline value of the fasting glucose and insulin levels were, the more they decreases at the end of the study. This result suggests that low-GL diet is able to promote a large initial reduction in metabolic risk factors.

It needs to be noted that the three children whose BMI did not decrease, their body fat decreased, which may have been a result of an increased fat free and muscle mass. This finding is important because it is generally accepted that muscle mass positively correlates with the improvement in insulin sensitivity [43].

One of the significance of low-GL diet is the reduction of hunger. Low-GI meal reduces hunger between meals, reduces the amount of food eaten in the subsequent meal therefore reduces voluntary food intake [44–46]. The significant reduction in hunger level is a key point of the present study. A diet with high satiety may be considered to have high adherence. Therefore, reducing hunger is a novel point of in any diet study. Calorie restricted diets lower Basal Metabolic Rate (BMR) [47] may compromise growth in children, therefore it is counter productive. Diets based on low-GI foods even when it is lower in calories cause a significant less reduction in muscle mass and BMR when compared to the same calorie-restricted but high-GI food-diet [47].

Low-GL diet is also a feasible dietary approach in primary care setting. In a 12-week study Young et al. (2004) used a brief instruction (written handout) and missed lack of continuous follow-up, which resulted in less then 50% adherence rate [26]. The high adherence rate in the present study may have been due to the extensive involvement of the parents, weekly education process and weekly food record.

Technically, both overweight and obese children responded well for the treatment. The success was dependent of the magnitude of parental support and motivation. The weekly group-, individual consultations, teaching food substitution, healthy food preparations and providing food tasting (for recipes see Appendix 3 (Fig. 2)) were important factors to induce changes to the diet and maintaining motivation. Six out of the eight participants had the new foods in their diet on regular bases.

In this 6-week study the significant findings indicated practicality and effectiveness of this dietary management approach reducing hunger and metabolic risk factors. Six weeks is probably not long enough to affect other parameters measurably with only 8 subjects. Hunger plays key role in regulating food intake and by reducing hunger, food intake is voluntary reduced [12]. The present study agrees that long-term success; weight loss and normalized metabolic risk factors through dietary change may be reached with providing satiety [12–14,21,22].

Parents and the children, formerly living on traditional Hungarian cuisine (high fat and high-GI foods), accepted and practiced our suggestions: lowered GL by making moderate dietary changes in the structure of the diet without focusing on changing the calorie intake for 6 weeks. The important findings are decreased body fat, less hunger and reduction of risk factors even in the presence of unchanged body weight. Children in this age, who are not hungry and have appropriate parental support, can make modifications to their diet and keep them for life, which may be fundamental in the long-term favorable changes in the CVD risk factors in childhood.

Low-GL diet is a useful treatment for overweight children and suggests that it is suitable for further long-term studies.

APPENDIX 1

Nutritional Consultation Curriculum

1. Introduction to GI
   a. Macronutrients: Which Foods are Carbohydrates Protein and Fat
   b. What is GI
   c. Factors decreasing GI
      i. Carbohydrate type
      ii. Acidity
      iii. Fiber
      iv. Food processing
      v. Cooking method
      vi. Portion
   d. Design sample menu

   Handout of GI and sample menu plans included
   Individual consultations
2. Why do we need to drink enough water? The role of hydration for body temperature and detoxification

   Building sample menu plan
   Recipes
   Individual consultation
3. Eating out
   a. Restaurant and parties
   b. Holiday foods: food for celebration
   c. Modifying typical Hungarian ethnic foods to lower GI

   Sample menu plans
   Sharing new recipes
   Individual consultation
4. Blood sugar level and weight loss
   a. Low GI baking: modifying cakes and breads

   Sample menu plans
   Sharing new recipes
   Individual consultation
5. Blood sugar and disease
   a. Diabetes mellitus
   b. Insulin insensitivity
   c. Weight gain
   d. Mood and food
   e. Eating when bored, angry, excited or afraid or TV

   Sharing new recipes
   Individual consultation

6. Intellectual eating habits
   a. Chewing
   b. Eat with utensils
   c. Sit down to eat
   d. Never eat when upset

   Sharing new recipes

   Individual consultation

APPENDIX 4

Cooking tips [48]

1. Use bean or peas flour to thicken sauces or soups
2. Half of mashed potato, or potato croquet cooked yellow split peas
3. Substitute rice or white bread in stuffing, meat balls and stuffed food with cooked mashed yellow split peas or cooked lentils
4. Make béchamel from eggs, kefir and cooked yellow split pea mixed in blender
5. Substitute cream or sour cream with yogurt or kefir, at least 50%
6. Mix rice with green peas, lentil or beans at least 50%
7. Serve fried food with vegetables instead of rice or potato
8. Cook - parboil pasta and rice Al-dente

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