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Value of Glycemic Index, Glycemic Load and the Risk of Overweight and Obesity

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Abstract

Obesity, due to the scale dissemination is a major social health problem. There is a systematic increase in the frequency of its occurrence. Overweight and obesity are the result of the coexistence of genetic factors with environmental factors –low physical activity and poor nutrition. Obesity is not only the disease but is also the cause of many other medical conditions such as type 2 diabetes, cardiovascular disease and certain cancers. Proper diet and physical activity play a key role in the treatment of obesity. The study estimates the value of the glycemic index and glycemic load of diet of an excessive body weight people against those with normal body weight in their daily food ration. Results show that the potential cause of weight gain in overweight and obesity could be an average intake of dietary glycemic index and high glycemic load and a relatively low intake of dietary fiber, especially in the diet of people with excessive body weight. Another factor contributing to the occurrence of overweight and obesity could be low physical activity among the said group.

Key Words: Glycemic Index, Glycemic Load, Overweight, Obesity

1. Introduction

Approximately one billion people in the world have excessive body weight, and the number of overweight and obesity continues to grow. In 2002 The World Health Organization (WHO) has placed obesity among the ten largest current threats to the health of the population (WHO, 2000). The most alarming epidemiological data come from the United States, where researchers (Flegal et al., 2002) empirically carried out observations between 1999 and 2000. The study reported that the prevalence of overweight is 64.5%, i.e. there was an increase of about 10% in relation to the data from the years 1988 to 1994. Furthermore, 30.5% of the participants were obese, and 4.7% with morbid obesity. In Europe, the results are even more alarming where more than half of the population is found to be overweight, in which 20-30% are in the state of obesity (see WHO, 2002).

Greater care is needed in treatment overweight and obesity. For instance, treatment of overweight and obesity should be individually adjusted for age, sex, type of obesity and co-existing diseases (Bogdanski and Pupek, 2008). The primary treatment for obesity is a change of eating habits, increased physical activity and lifestyle modification. If these methods do not bring result in a form of weight loss, then there might be a pharmacotherapy introduced as a way of treatment. Surgical treatment is the third alternate option, suggested by Krzyzanowska (2008), which is used only in the case of ineffectiveness of dietary and pharmacologic treatment in case of obesity type II (BMI> 35 kg/m2) or type III obesity (BMI> 40 kg/m2), for people who experienced the development of at least two complications (hypertension, hyperlipidemia, sleep apnea).

Tendency to increase the proportion of people with excessive body weight also emerged in Poland. It is estimated that in the adult population of Polish women over 60% and about 50% of men are overweight or obese (every fifth person with a BMI of 30 kg/m2 or above) (see Biela and Kaczmarczyk, 2005). There are both genetic and environmental factors, which determine development of obesity (Kociniak et al., 2005). In any case, overweight or obesity in a long time differently must maintain a positive energy balance, which is the result of imbalance between spending and the delivering energy. The cause may be excessive supply of energy in relation to energy expenditure during the day, lowering energy expenditure in relation to the commutation of energy from food or the two mechanisms at the same time (Racettee et al., 2003).

However, there exists no previous study, which estimates the value of the index and glycemic load diet among overweight and obese people in Poland. Thus this study contributes to the literature by empirically calculating value of the glycemic index and load of diet of overweight and obese people. The results of the present study may help the practitioners particularly, dietitians and academia alike, to understand the causes of overweight and obesity.

2. Literature Review

Lange et al (2008) assessed the effectiveness of low glycemic index diet in weight reduction of men with overweight and obesity used for 3 months. The study confirmed that a low GI diet was equally effective in reducing body weight as a traditional diet low energy diet and caused weight loss, waist circumference, BMI and lipid profile improvement. Another study by Lange et al (2007) compared the effect of low GI diets and low energy diet in reduction of weigh in overweight and obese women, which is used for 3 months, among both groups of women was a significant decrease in body weight, however the changes were significantly higher only among women with regular menstruation using low-GI diet than among women taking control diet (low energy) (-7.2% vs -4.3 %). There was also significantly higher intake of carbohydrates and dietary fiber in the group of women using a low GI diet . Also Frost et al (1994 & 2004) have observed that a low GI diet provided a significantly greater amount of carbohydrates and dietary fiber, as compared to the diet based on carbohydrate exchangers or recommendations of balanced diet.

However, Ebbeling et al (2005) observed that after 12-months of use of a low GI diet among obese women and men weight loss was significantly higher compared to the group using a diet of low energy (-7.8 % vs -6.1%) but these differences were not statistically significant. Toeller et al (2001) in the study EURODIAB Complications Study, which was conducted among people suffering from type 1 diabetes found that a low GI diet reduces waist circumference, regardless of the amount of carbohydrates, fats and dietary fiber. Observations conducted among obese and overweight, evaluating the effect of four diets differing in glycemic load on weight loss suggest that a diet with a low glycemic load affects weight loss and postprandial glycemia. McMillan-Price et al (2006) suggest that lowering GL diet appeared to increase the rate of reduction of body fat mass, especially among women.

Based on 6 randomized Thomas et al (2007) evaluated the effect of low GI diets / GL on body weight of people with overweight and obesity. In the study group patients received a low GI or GL diet, whereas in the control group used a high GI diet and low energy. After dietary intervention lasted from 5 weeks to 6 months in the group of people using a low GI/GL diet there was significantly higher compared to the control group weight loss, greater reductions in BMI, a greater loss of fat mass, greater reduction in total cholesterol and LDL-cholesterol, a similar reduction in triglycerides. In this study, a diet with a low GI/GL was more effective in reducing body weight.

In a similar study Spieth et al (2000) and Ebbeling et al (2003) evaluated the effectiveness a low GI/GL diet consumed ad libitum in weight reduction among obese children and adolescents, compared with low energy diet with reduced fat content. Both studies showed that diets in which amount of energy is not limited, but they contain a low IG / GL products were more effective and caused greater weight loss after respectively 4 and 6 months of use. Ludwig in the review, which included 16 studies evaluating the effect of a low GI diet for weight loss found that with the exception of one in all studies, these diets exacerbated the feeling of satiety, delayed the emergence of feelings of hunger and reduce food intake (Otto-Buczkowska et al., 2003).

Ludwig et al (1999) in another study in which the effects of single rated meals on metabolic reactions of the organism, that can affect the development of obesity were evaluated. One of the first studies was conducted among teenage boys with obesity. During each of the 3 trials they consume for breakfast and lunch meals at low, medium and high GI which have similar energy value, nutrient content and palatability, and in the next 5 hours the volume of consumption given a choice of food (ad libitum) was evaluated. It has been shown that, compared to a meal with a low GI. after eating IG medium products consumption was about 53 % higher , and after a meal with a high GI higher by 81 %. It was also found that the consumption of high GI meal area under the curve glycemic response was two times larger than the area under the curve glycemic response after a meal with a medium GI , and almost four times higher than after a meal with a low GI . It was also observed higher insulin concentration in the blood, lower glucagon levels, lower postprandial concentrations of fatty acids in the blood, and elevated postprandial adrenaline after high GI meal as compared with a low GI meal.

Similar results were obtained by Ball et al (2003) in a study in which response was observed in 3 different meals: the first with a low GI, made from traditional products, the second also with a low GI complex with bar and cocktail nutrient and the third with a high GI. The same meals were given at breakfast and lunch sessions separated by 24 h interval. Then the response was tested metabolic, hormonal response for the meal and the feeling of satiety. It was found that the area under the curve glycemic response after a meal with a high GI was higher than after meals with a low GI. The feeling of hunger appeared soon after a meal with a high GI.

During restrictive diet, there is often a reduction in basal metabolic rate (BMR), which may hinder the weight loss process. The six-day experiment by Agus et al (2000) studied the physiological adaptations of the body for reduction of energy intake. It has been shown that after application a high GI diet BMR decreased significantly

more (by around 10, 5%) than after application of a low GI diet (approximately 4.6%). Willet et al (2002) showed that a high GI or GL diet has a more adverse effect of overweight and obesity and abnormal glycemic curve. Long-term consumption a high GI/GL diet may lead to overweight and obesity as a result of the accumulation of adipose tissue, stimulated by the action of insulin.

A study by Pereira et al (2002), in which overweight men were on a low GI diet for 6 weeks, based on whole grains, there was improvement of sensitivity for insulin. In 2004, Young et al examined the possibility of practical application of the recommendations of a low GI diet therapy among overweight children in primary health care units. This study confirmed that the implementation of this diet in some patients is feasible. After completion of the study, parents of 15 children confirmed that the recommendation of a low GI diet is not difficult to understand, and most of the children could apply them.

Despite of the lack of quantitative restrictions in low glycemic index diets, energy intake is reduced. In a study of Dumesnil et al (2001) among obese people, there was observed that the energy intake during low GI diet was about 25% less than during diet AHA (American Heart Association). Bouche et al (2002) conducted a study evaluating the effect of a low GI diet in a group of 11 overweight men. It was found that after using this diet amount of body fat was reduced, improved lipid profile, blood glucose and insulin levels improved. According to the authors diet containing low GI products may be useful in prevention of obesity, diabetes and cardiovascular disease. Similar conclusions presented Flier (2001) in the consideration of the mechanisms of the impact of the use of glucose by muscle and adipose tissues. He found that a low GI diet promotes a reduction of adipose tissue. It is also beneficial for improving insulin sensitivity, improves fat metabolism, what aligns dyslipidemia and reduces insulin resistance.

The glycemic index diet also affects concentration of leptin, which is involved in the regulation of body weight. When using a low GI diet leptin levels in serum rapidly declined, and to the lower level (-50 ± 5.5%) compared to a diet with a high GI (-38.3 ± 3.5%), used by the comparable time period (Agus et al., 2000). A diet with a high GI (regardless of the fat content) also modifies the diurnal rhythm of leptin secretion-what results in a higher concentration approximately 1pm, in contrast to the typical evening (around 10pm) increase in concentration (Hermann et al., 2001). Low GI diet may contribute to an increase of adiponectin level, wherein the lower concentrations was observed in subjects with metabolic uncontrolled diabetes. A low GI diet can play a key role in regulation of the level of this cytokine. The level of this cytokine was 13% and 18% lower after the intake of high GI/GL and 19% higher in people whose diet was rich in fiber (Qi et al., 2005).

In the Nurses Health Study was observed a negative correlation between weight gain and the consumption of large amounts of fiber and whole grains (which contains GI diet), and a positive correlation between the consumption of processed grains (high GI diet) and weight gain (Liu et al., 2003). The results of the scientific research suggest that even a single meal can significantly affect the further, subsequent food intake. Even if the results of a low GI/GL diet does not give spectacular loss of weight, they have undeniably better effects on lipid profile, glucose profile, body composition , and the additional benefit is reduction of feeling of hunger.

The methods of prevention and treatment of obesity is still controversial, especially in the case of the recommended diet. Growing evidence points to the effectiveness of a low GI/GL diet in weight control and in obesity prevention/treatment. As in the case of other dietary recommendations should not be guided only by the value of GI/GL product and as part of a healthy diet it is recommended to pay attention to an adequate supply of fiber, protein, vitamins and minerals and limit saturated fat intake. The benefits of a low GI/GL diets cause they are recommended especially for people with diabetes, obese patients with abnormal lipid profile, as well as among healthy individuals for the prevention of metabolic diseases. It also stresses the problems arising from the use of diets with a high GI.

In synthesizing the above argument, the literature suggest that long-term consumption of a high GI/GL diet may lead to overweight and obesity. Therefore, the hypothesis to be tested is:

> *Hypothesis: Ceteris paribus, there is a significant relationship between consumption of high GI/GL diet and overweight, and obesity*

3. Research Design and Methodology

In 1981 Jenkins together with colleagues from the University of Toronto conducted a study on the impact of 62 mostly consumed products on the level of glucose in the blood. The results created a system called the glycemic index (GI), which is characterized by foods containing carbohydrates and describes its effect on postprandial glycaemia (Adamska and Gorska, 2008; Dolna and Ciok, 2005). GI allows scheduling of food products due to

their effect on postprandial blood glucose. High GI foods are characterized by a rapid and high increase in blood glucose after ingestion and have a greater area under the glycemic response curve. By contrast, lower GI value indicates lower increase of blood glucose (see Dolana and Ciok, 2006; Otto-Buczkowska, 2003).

In some cases, only the GI values can be misleading. For example, the GI of 120g watermelon is 72. However, its consumption has little effect on glycemic response, because the total carbohydrate content in this fruit is low - 6g/120g portion (Dolana and Ciok, 2006). Correspondingly, latter in 1997, researchers from Harvard University (School of Public Health) introduced the concept of glycemic load (GL) (Lange et al., 2008). It takes into account both the quality and quantity of carbohydrates contained in the product. It is calculated by multiplying IG value of the product by the amount (g) of carbohydrates that product contains, then the result is divided by 100 (Adamska and Gorska, 2008; Dolana and Ciok, 2006]. Likewise, Foster-Powell et al. based on studies from the years 1981 – 2001created carbohydrate-containing foods in terms of GI and GL in the form of a table containing 1300 items of 750 products (Foster et al., 2002).

3.1 Sample Procedure and Data Analysis

The aim of the study is to estimate the value of the index and glycemic load diet in overweight and obesity and to assess the intake of fiber in their daily food ration. Therefore primary data is required for empirical examination, which is collected from the Medical University of Bialystok Clinical Hospital. A total 110 individuals participated in the study. The study included 100 patients with overweight and obesity from the Medical University of Bialystok Clinical Hospital (56 women and 44 men). The control group were 10 people with normal body weight (6 women and 4 men). The study was carried out in Department of Endocrinology, Diabetology and Internal Medicine. To carry out the study approval from the Bioethics Committee (No. consent RI-002/39/2009) was required and respondents expressed their voluntary written consent to participate in the study and were informed about the confidentiality of the data.

Data was collected between January 2008 and January 2009. Assessment of nutritional status was based on anthropometric survey covering basic body parameters such as height (m), weight (kg) and waist circumference (cm). Measurement of body weight and height were used to calculate body mass index BMI. Nutritional status of patients was assessed by 24-hour recall, carried out in accordance with the guidelines of the Institute of Food and Nutrition in Poland (Charzewska, 1997).

The 24-hours recall was divided into several sections. The first section provide general data such as age, sex, height, weight, and waist circumference etc.. The second section of the questionnaire included the lifestyle of the respondents i.e. the type of work, physical activity. The last part of the questionnaire consisted of questions regarding the meals eaten in the last day, the number and frequency, with particular emphasis on carbohydrate products.

Both qualitative and quantitative composition of consumed products was determined on the basis of data contained in the "Photo Album of products " by Szponar (Szponar et al., 2000). Program Diet 2 was used for the qualitative and quantitative evaluation of their diet, while the GI and GL values were taken from the international glycemic index and glycemic load tables by Foster-Powel et al (2002) with respect to glucose as the reference product.

The results were statistically analyzed, in which the measurable characteristics were calculated by the arithmetic mean and standard deviation, and the qualitative characteristics by their quantified and percentage distribution.

The two groups were compared by Student's t-test. Comparison between qualitative characteristics of the two groups was done by using independence CHI 2 test. Correlation coefficients were calculated too. Significance level of $p < 0.05$ was considered as statistically significant. Calculations were made using SPSS statistical package.

4. Results

Table 1 compares the average values of the selected parameters in the study group and the control. All the results, when ($p < 0.001$) are statistically significant.

Table 1
A comparison of average values of selected parameters in the analyzed and control group.

	Test Parameter	Group	N	MEAN	SD	p<
1	Body Weight	Analyzed	100	92,53	17,901	
		Control	10	64,00	8,844	0,001
2	BMI	Analyzed	100	32,8680	6,16923	
		Control	10	22,0851	1,70809	0,001
3	Waist Circumference(cm)	Analyzed	100	109,82	14,657	
		Control	10	82,00	7,040	0,001
4	Glycemic Index	Analyzed	100	59,4880	9,40824	
		Control	10	56,3360	6,16709	Ns
5	Glycemic Load	Analyzed	100	133,669	72,960	
		Control	10	144,401	47,040	Ns
6	Fiber Intake (g)	Analyzed	100	20,491	9,2282	
		Control	10	25,910	4,0328	0,003

Notes: *ns-non statistically significant

Average body weight (kg) in the study group and control group are 92.53 ± 17.901 kg, and 64 ± 8.844 kg respectively. However, the average body weight in the study group is significantly higher. The average BMI in the study group is 32.868 ± 6.16923, while in the control group 22.0851 ± 1.70809.

Waist circumference (cm) in the study group averaged 109.82 ± 14.657 cm, while in the control group 82.00 ± 7.040 cm. Waist circumference in the study group is larger.

Glycemic index of value in the study group is 59.4880 ± 9.40824 , while in the control group 56.3360 ± 6.16709. There are no statistically significant differences in the results, but the average GI of diet of people in the control group was slightly lower. Similarly, Glycemic load value of diet in the study group averaged 133.669 ± 72.960, while in the control group 47.04 ± 144.401 . There were no statistically significant differences in the results, but the mean GL of the diet of people in the control group was slightly higher than in the analyzed group. Finally, dietary fiber (g) in the analyzed group averaged 20,491 ± 9.2282 g, whereas in the control group, 25.91 ± 4.0328 g. The result are statistically significant ($p < 0.003$) . Average fiber intake in the control group is comparatively higher.

Table 2
Correlations of GI and GL with the selected parameters

	Test Parameter		Glycemic Index of Diet		Glycemic Load of Diet	
			Analyzed Group	*Control Group*	*Analyzed Group*	*Control Group*
1	Body Weight	r	0,055	0,531	0,001	0,807
		p	0,588	0,114	0,993	**0,005**
		<				
		n	100	10	100	10
		p	0,102	0,157	0,011	0,102
		<				
		n	100	10	100	10
2	BMI	R	-0,038	0,376	-0,151	0,784
		p	0,704	0,284	0,133	**0,007**
		<				
		n	100	10	100	10
3	Total Carbohydrates Intake (g/day)	r	-0,015	0,689	0,929	0,971
		p	0,884	**0,028**	**0,001**	**0,001**
		<				
		n	100	10	100	10
4	Age	r	-0,156	-0,314	-0,273	-0,295
		p	0,122	0,377	**0,006**	0,408
		<				
		n	100	10	100	10
5	Glycemic Index of Diet	r	0,314	0,836		
		p	**0,001**	**0,003**		
		<				
		n	100	10		

Sources: Author

Table 2 provides the person correlation matrix of dependent and independent variables. It also shows the correlation value of the index and glycemic load with selected parameters. Positive correlation in the control group ($r = 0.807$) was observed, with the results of significance $p < 0.005$, showing an increase dietary glycemic load values with increasing body weight. There is a positive correlation ($r = 0.784$) in the control group, the statistical significance of the results, $p < 0.007$, that glycemic load values increase with increasing BMI.

Hence, supporting the hypothesis that there is a relationship between consumption of high GI/GL diet and overweight, and obesity. Further indicate a positive correlation is observed in the analyzed group (r=0314), the results of significance $p < 0.001$ showing that with the increase of the glycemic load, value of glycemic index increased too. A similar, positive correlations are observed in the control group ($r = 0.836$), with the results of significance $p < 0.003$-with increasing glycemic load diet increased the glycemic index value.

Negative correlation in the analyzed group ($r = -0.273$) is observed, the significance of the results, $p < 0.006$, the value of glycemic load diet decreased with age. On the other hand, a positive correlation ($r = 0.689$) in the control group, with statistical significance $p < 0.028$ which says that with increase of carbohydrates content (g) in the diet, value of glycemic index increased too.

5. Findings.

The primarily finding of this study is that high GL/GI diet is associated with increased body weight. These results are consistent with the earlier research. Willet et al (2002), for instance, showed that a high GI or GL diet has a more adverse effect of overweight and obesity and abnormal glycemic curve. Furthermore the authors posit that long-term consumption of a high GI/GL diet may lead to overweight and obesity as a result of the accumulation of adipose tissue, stimulated by the action of insulin. Hermann et al (2001) suggest that a diet with a high GI (regardless of the fat content) also modifies the diurnal rhythm of leptin secretion-what results in a higher concentration approximately 1pm, in contrast to the typical evening (around 10pm) increase in concentration. Likewise, Qi et al (2005) have opined that low GI diet may contribute to an increase of adiponectin level, wherein the lower concentrations was observed in subjects with metabolic uncontrolled diabetes. A low GI diet can play a key role in regulation of the level of this cytokine. The level of this cytokine was 13% and 18% lower after the intake of high GI/GL and 19% higher in people whose diet was rich in fiber.

On the other hand, the Nurses Health Study conducted by Liu et al (2003) observed a negative correlation between weight gain and the consumption of large amounts of fiber and whole grains (which contains GI diet), and a positive correlation between the consumption of processed grains (high GI diet) and weight gain. The results of the scientific research suggest that even a single meal can significantly affect the further, subsequent food intake. Even if the results of a low GI/GL diet does not give spectacular loss of weight, they have undeniably better effects on lipid profile, glucose profile, body composition , and the additional benefit is reduction of feeling of hunger.

Additionally, positive correlations are observed in the normal weight group, indicating that when value of glycemic load increases, the glycemic index value also increases. Similar positive correlation is observed among people with excessive body weight-with increase of the glycemic load value, the value of glycemic index also increases. Finally, positive correlation are observed in the normal weight group, which means an increase in carbohydrates content (g) in the diet, results in increased value of glycemic index.

6. Conclusions

The diet of people with overweight and obesity, and with normal body weight had an average glycemic index and high glycemic load, which suggests the need to change their diet in order to prevent obesity and prevention of the metabolic complications. Dietary fiber intake by overweight and obesity in the sample participants was significantly lower and close to the lower limit of the recommended intake by the guidelines of the Institute of Food and Nutrition in Poland. While the two groups did not meet the recommendations set by American Nutrition Board either. The caloric value and the content of carbohydrates in the diet were associated with the occurrence of overweight and obesity. The development of overweight and obesity in a group of people in the study might be caused also by genetics , or other factors (e.g. high fat content in their diet), which has not been examined in this study.

Analysis of the data indicates the need to take actions in order to change eating habits and current lifestyles of people with normal body weight, in order to prevent obesity and in patients with excessive body weight, in order to prevent complications of obesity. A special attention should be paid to the elimination of products with a high

GI/GL of the diet, adequate fiber intake and increasing physical activity among people with normal body weight, as a continuation of the current diet and lifestyle can adversely affect their future health.

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