

Original Article

The effects of meal glyceemic load on blood glucose levels of adults with different body mass indexes

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ABSTRACT

Aims: The aim was to determine the effect of meal glyceemic load (GL) on blood glucose levels of healthy people with different body mass indexes (BMIs). **Methods:** Thirty healthy controls were included in this study. The participants were divided into two groups according to their BMI as normal group (BMI = 18.5–24.9 kg/m², *n* = 15) and overweight group (BMI = 25.0–29.9 kg/m², *n* = 15). Dietary assessment was done by the 24-h recall method for 3 successive days. Cases were fed by breakfasts with two different GL on consecutive days. Energy values of the test meal, adjusted to meet 25% of daily energy requirements of each case, were identical in low and high GL meal (483 kcal and 482 kcal, respectively). Finger-prick capillary blood samples were taken on 0, 15, 30, 45, 60, 90, and 120 min. **Results:** Average daily energy intake in normal and overweight group was found as 2514.3 ± 223.8 kcal, 2064.1 ± 521.6 kcal and 2211.4 ± 368.7 kcal, 2494.8 ± 918 kcal in males and females, respectively. Blood glucose level was increased and remained more stable in both high GL meal groups compared to low (*P* < 0.05). The effects of GL on BMI classified groups were also found different. High GL meal was found to be more effective for increasing blood glucose level, especially on overweight group (*P* < 0.05). **Conclusions:** The effects of GL meal were found to be different on normal and overweight individuals. The high GL meals were more effective to increase the blood glucose level than low GL meal, especially on overweight people.

Key words: Blood glucose level, body mass index, meal glyceemic load

INTRODUCTION

There is increasing interest in the effect of nutrients on postprandial blood glucose levels in healthy nutrition. The terms of glyceemic index (GI) and glyceemic load (GL) have both been proposed to evaluate dietary carbohydrates (CHOs). The GI and GL are concepts that classify foods depending on acute glyceemic effects

of nutrients. Foods with different CHO content cause different glyceemic response although there is no significant difference between the amount of CHOs.^[1] Low GI and GL diets have protective effects on health, inhibitory effects of chronic disease progression, and reduce symptoms of diseases.^[2] Foods with low GI or low GL cause a slighter rise on the blood glucose level. It is, however, known that these foods improve glyceemic control and insulin sensitivity and reduce the risk of cardiovascular disease and type 2 diabetes. They also have positive effects on body weight and provide a reduction of energy intake and fat storage.^[2-5] The body mass index (BMI) is another factor that affects

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postprandial blood glucose. The blood glucose regulation of individuals with high BMIs tends to deteriorate.^[6] The adverse metabolic effects of elevated dietary GL occurred mostly in overweight individuals (BMI ≥ 30 kg/m²). Studies on the effect of GL on postprandial glucose are generally conducted with diabetic patients and beneficial effects were recorded.^[7-9] Despite the fact that consumption of low GI and low GL foods has positive effects on healthy diet, studies on this individual are limited in Turkey. The main purpose of this study was to evaluate the effects of the GL of meal on blood glucose levels in healthy adults with different BMIs.

METHODS

Subjects

A nonrandomized crossover design was used to compare the effects of high and low GL breakfasts. This study was conducted among 30 adult volunteers, aged 19–35 years with the mean age of 23.8 ± 3.76 years. None of the participants had a history of metabolic and endocrine disease, and also none of them was smoking. All individuals were healthy as assessed by physician. Ethical approval of this study has been granted by the Regional Ethics Committee of the University. They were selected to be two groups according to their BMIs as normal group (BMI = 18.5–24.9 kg/m², $n = 15$) and overweight group (BMI = 25.0–29.9 kg/m², $n = 15$). There was no interference with the usual diet of participants except breakfast.

Data collection and dietary intake

Data were collected by face-to-face interviews using a standard questionnaire. The questionnaire included questions on sociodemographic characteristics and eating habits of the participants. Food intake was performed on 24 h recall base, and dietary records were taken for 3 consecutive days using a photographic atlas of food portion sizes.^[10] Energy and nutrient intakes were calculated with a computer program.^[11]

Study design

Energy requirements to prepare test meals were determined considering the age and sex of individuals.^[12] The energy content of breakfasts was also calculated considering to meet 25% of daily energy requirements of each individual.^[13,14] As calculations mentioned above, the low (GL ≤ 10) and high (GL ≥ 20) GL breakfasts were prepared by a researcher in the food preparation laboratory. GL values of the test meals were calculated with reference to glucose. Energy values of the test meal were identical in both low and high-GL meal (483 kcal and 482 kcal, respectively). The percentage levels of energy supplies from CHO, proteins, and fats were adjusted as 66%, 17%, and 17% in

low GL meal, and 60%, 10%, and 30% in high GL meal, respectively. Menu details are shown in Table 1. Both types of breakfasts were offered to each group of individuals with an interval of 2 days followed by 12 h overnight fasting. Individuals consumed all test meals within 15 min. Finger-prick capillary blood samples were taken at 0, 15, 30, 45, 60, 90, and 120 min.^[15,16] Followed by ingestion of the test foods, the glucose response was determined using capillary rather than venous blood since capillary glucose changes are greater and more reliable.^[17,18] Glucometer (Plus Med Accuro, Bionime Corporation, Taiwan) was used to estimate blood glucose levels.

Anthropometric measurements

The body weights of individuals with minimal clothing without shoes were measured with a body analyzer (Tanita BC 418 BA).^[19] Height was measured with a stable stadiometer. BMI was calculated for each individual. The waist circumferences were measured with a fiber-glass tape which was sensitive to 0.1 cm. All measurements were obtained as described above.^[20] The BMI and waist circumference classification were made according to the World Health Organization (WHO).^[19]

Statistical analysis

Statistical evaluation of results was performed using Statistical Packages for Social Sciences Programme (SPSS version 15.0, Chicago, USA). The results were presented as the mean \pm standard deviation ($\bar{x} \pm S$) values. The table of percentage points was given for qualitative data. The Mann–Whitney U-test was used to compare the differences between two groups. The changes in blood glucose levels of individuals were evaluated with two-way repeated measures ANOVA. $P < 0.05$ was considered to indicate statistical significance in all analyses.

Table 1: Low and high glycemic load meals

	Amount (g)	CHO (g)	GI (%)	Σ GI	Σ GL
Menu 1*					
Whole wheat bread	42	18.4	49	49	9.02
White cheese	30		-		
Egg	50		-		
Black olive	12.5		-		
Crushed walnut	10		-		
Salami	25		-		
Total		18.4		49	9.02
Menu 2**					
White bread	44	23.2	87	55.8	20.2
White cheese	45		-		
Strawberry jam	20	13	51	18.3	6.63
Black olive	12.5		-		
Crushed walnut	15		-		
Total		36.2		74.1	26.8

*Energy: 482 kcal, protein: 20.2 g, fat: 35.8 g, CHO: 20.3 g; the percentages of protein, CHO, fat: 17%, 66%, 17%. **Energy: 483.2 kcal, protein: 1.9 g, fat: 31.4 g, CHO: 36.2 g; the percentages of protein, CHO, fat: 10%, 60%, 30%. GL: Glycemic load, GI: Glycemic index, CHO: Carbohydrate

RESULTS

Anthropometric measurements of subjects

The anthropometric measurements of individuals such as age, weight, height, BMI, and waist circumference are shown in Table 2. The mean age of individuals was 23.10 ± 3.30 and 24.2 ± 4.04 years for males and females, respectively. According to BMI classification provided by WHO, 27.3% of males and 63.2% of female individuals were classified as normal weight. The proportion of overweight individuals was found to be 72.7% of males and 36.8% of females. All males had <102 cm waist circumference. The percentages of waist circumference were equal or above 88 cm 15.8% of women.

Energy and nutrient intake

The percentage of individuals who were in the habit of regularly taking meals was found to be 66.7% and 46.7% in normal weight and overweight individuals, respectively. Breakfast was the most frequent-skipped meal. All individuals in normal weight group and 75% of

overweight group were skipping their breakfast. In normal and overweight groups, average daily energy intake was 2514.3 ± 223.8 kcal, 2211.4 ± 368.7 and 2064.1 ± 521.6 kcal, 2494.8 ± 918 kcal in males and females, respectively [Table 3]. In normal group, the percentages of energy supplies from proteins, CHO and fats were 13.3%, 49%, and 37.7% in males and 13.7%, 46.8%, and 39.5% in females, respectively. These percentages in overweight group were found to be 15%, 48%, and 37% in males, and 13.9%, 46.7%, and 39.4% in females, respectively. In general, it has been seen, respectively, in both genders of different BMI groups that the mean percentages of fat was higher while CHO was lower than recommended. The mean daily intake of energy and macronutrients were determined to be similar between males and females by BMI groups ($P > 0.05$).

Blood glucose levels

Blood glucose levels after consumption of the low and high GL meals by BMI groups are shown in Table 4. There were no statistical differences among initial blood glucose (0 min) values in both groups ($P > 0.05$). The blood glucose levels increased in both BMI groups after consumption of high GL meals. The rise in blood glucose levels of normal weight group significantly increased in 60 min ($P < 0.05$). This increase, however, occurred on and beyond 90 min in overweight group.

DISCUSSION

This study was conducted to evaluate the effects of GL meal on blood glucose in healthy adult people with different BMIs. The presence of obesity aggravates metabolic abnormalities of type 2 diabetes which includes hyperglycemia. Many studies have shown that an increased risk of diabetes with increasing weight.^[21-23]

Table 2: Anthropometric measurements of individuals

	Male (n=11), $\bar{x} \pm S$		Female (n=19), $\bar{x} \pm S$	
Age (years)	23.10±3.30		24.2±4.04	
Weight (kg)	80.50±11.66		63.9±10.81	
Height (cm)	175.10±5.65		163.2±6.08	
BMI (kg/m²)*	n	%	n	%
18.5-24.9 (normal)	3	27.3	12	63.2
25.0-29.9 (overweight)	8	72.7	7	36.8
Waist circumference (cm)*				
<102	11	100	<88	16
≥102	-	-	≥88	3
				15.8

*n (%). BMI: Body mass index

Table 3: Daily dietary energy and nutrient intake in individuals according to gender and body mass index ($\bar{x} \pm S$)

Nutrients	Male ($\bar{x} \pm S$)			P*	Female ($\bar{x} \pm S$)		
	18.5-24.9 (n=3)	25.0-29.9 (n=8)			18.5-24.9 (n=3)	25.0-29.9 (n=8)	P*
Energy (kcal)	2514.3±223.80	2211.4±368.70	0.279	2064.1±521.60	2494.8±918.10	0.432	
CHO (g)	298.7±31.30	252.6±61.60	0.376	234.3±65.80	280.1±91.80	0.432	
CHO (%)	49±1.00	48±8.10	0.776	46.8±4.80	46.7±4.10	0.536	
Dietary fiber (g)	22.3±2.60	20.3±8.90	0.630	19.6±6.40	27±9.70	0.056	
Total protein (g)	82.2±10.10	76.1±8.90	0.376	68.1±19.30	82.4±23.50	0.261	
Protein (%)	13.3±0.60	15±2.10	0.497	13.7±2.60	13.9±1.70	0.536	
Total fat (g)	106.1±5.80	90.3±24.10	0.497	90.4±24.30	113.2±51.10	0.482	
Fat (%)	37.7±1.20	37±4.60	0.776	39.5±3.50	39.4±5.10	0.711	
SFA (g)	36.5±4.30	33.9±7.20	0.497	32.6±10.20	37.8±15.20	0.536	
MUFA (g)	36.3±2.40	31.5±9.00	0.376	31.3±10.10	39.4±18.20	0.432	
PUFA (g)	26.6±3.20	18.6±7.20	0.194	20.7±5.60	29.2±16.70	0.340	
Cholesterol (mg)	291.5±8.90	309.7±80.00	0.630	256.1±88.90	340.5±125.20	0.100	

*P<0.05. P values calculated with the Mann-Whitney U-test. SFA: Saturated fatty acid, MUFA: Mono unsaturated fatty acid, PUFA: Poly unsaturated fatty acid, CHO: Carbohydrate

Numerous studies were put forth the relationship between obesity and insulin sensitivity.^[24,25] Increased BMI is independently associated with diminish of insulin sensitivity. This causes an increase of blood glucose level.

In this study, 72.7% of males and 36.8% of females were classified as overweight. The average energy intake of the female individuals of overweight group was greater than the normal group. However, against long odds, average energy intake of the males in overweight group was lower than in the normal group, no statistically significant difference ($P > 0.05$). In an adequate and balanced nutrition, the contribution of nutrients to energy is also important. A study conducted with university students showed that the percentages of the energy, supplied from CHOs, proteins and fats were found to be 50%, 16%, and 34%, respectively. They also reported that the eating habits of students were composing of high fat, low CHO ratio.^[26] A cross-sectional study among the five state universities in Turkey^[27] showed that the percentages of the energy supplied from proteins, fats, and CHOs were 12.9%, 32.0%, and 55.1% in males, and 13.2%, 35.4%, and 51.5% in females, respectively. In general, in many studies, the percentages of energy from fat were found to be high in this age group. Similarly, in this study, the intake of CHO was found to be low and the intake of fat was found to be high. The energy and macronutrient intakes of the individuals who were evaluated according to BMI status were also similar [Table 3].

In this study, fasting blood glucose levels of individuals were similar [Table 4]. It was determined that high GL meal increased the blood glucose level more than low GL meal. Brand-Miller *et al.*^[28] investigated the effect of meals with same energy content but different GI on the blood glucose response on diabetic individuals. They demonstrated that low GI has formed lower blood glucose response. In another study, that planned similar manner

on type 2 diabetes mellitus (DM) and healthy individuals, low GI meal had a lower blood glucose response in both groups.^[29] Low GI diet has shown to increase postprandial blood glucose level less than high GI diet in another study of adults with type 2 DM.^[30] The postprandial hyperglycemia after the high GL meal thought to be causing adverse effects in terms of health because the blood glucose level remained high for a long time. In the present study, blood glucose levels of overweight group remained high for a long time after high GL meal when compared with the normal group. A study conducted with overweight nondiabetic men found that plasma glucose peaks (at 60 min) were lower with the low GI meal than the high GI meal.^[31] Leathwood and Pollet^[32] reported that plasma glucose levels were lower and remained stable with the low GI meal. However, after the high GI meal, plasma glucose levels rose sharply and peaked at 30 min, then fell below initial level after 3 h. On the contrary, plasma glucose levels raised less, but still stayed above the basal level after the low GI meal.

CONCLUSION

It is concluded that both the amount and source of CHO in this study were important factors for glucose responses and it was dramatically changed according to BMI. The effect of GL meal was found to be different between normal and overweight individuals. The high GL meal was more effective to increase the blood glucose level than low GL meal, especially overweight people. It might be concluded that these effects emerged from feeding with the high GL meal in the short term may occur in long term and adversely affect the health. Additional long-term studies are required to evaluate the effects of GL with obese groups. Low GL foods should take place with healthy eating practices. It is mandatory to explain to individuals the general principles of how to reduce the GL of foods through educational programs.

Table 4: Blood glucose levels of individuals after the different glycemic load of meal according to body mass index ($\bar{x} \pm S$)

Time (min)	Blood glucose level (mg/dl)					
	BMI=18.5-24.9 (kg/m ²)			BMI=25.0-29.9 (kg/m ²)		
	$\bar{x} \pm S$		P	$\bar{x} \pm S$		P
	Low GL meal	High GL meal		Low GL meal	High GL meal	
0	83.0±7.54	82.3±12.49	0.827	89.5±8.77	87.3±4.20	0.460
15	89.1±11.85	95.1±11.27	0.025*	94.8±9.87	99.5±9.54	0.071
30	96.1±14.01	110.2±15.29	0.005*	99.7±11.15	117.0±10.81	0.001*
45	97.9±7.95	106.1±11.87	0.098	105.8±12.03	118.1±17.30	0.017*
60	93.4±10.29	105.5±11.18	0.007*	99.5±7.68	108.6±16.70	0.036*
90	89.7±7.72	93.3±9.72	0.195	94.3±6.96	102.2±7.71	0.007*
120	88.6±7.30	93.3±10.72	0.139	90.9±4.94	94.9±11.95	0.195

* $P < 0.05$. P values calculated with the two-way repeated measures of ANOVA. GL: Glycemic load, BMI: Body mass index

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Conflicts of interest

There are no conflicts of interest.

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