Dietary Glycemic Index, Glycemic Load and Anthropometric Measurements in Adolescents

Adolesanlarda Diyetin Glisemik İndeksi, Glisemik Yükü ve Antropometrik Ölçümler

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ABSTRACT Objective: Diets containing foods that are low in glycemic index (GI) or glycemic load (GL) may influence especially the appetite and other body mechanisms that affect excessive weight gain in adolescence. This study was carried out to determine the relationship between dietary GI and GL and body weight, height, body mass index (BMI) and waist circumference (WC) in 14-18 year-old adolescents. **Material and Methods:** One thousand one hundred and four voluntary adolescents (469 girls and 635 boys) aged between 14-18 years were included in the study. GI and GL were calculated from a 24-hour dietary recall taken from individuals. Anthropometric measurements (body weight, height, BMI, WC) were also measured for all adolescents and evaluated using the WHO Growth Reference for 5-19 Years-2007. **Results:** According to the evaluation of BMI for age, prevalences of underweight, overweight and obesity were 13.6%, 17.3% and 3.8% in boys and 15.9%, 13.1% and 1.7% in girls, respectively. The dietary GI differed significantly between boys and girls and was higher in obese adolescents than in other BMI groups ($p< 0.05$). However, no significant difference was found between dietary GL based on BMI classification ($p> 0.05$). It was determined that in both genders the dietary GI was positively correlated with anthropometric measurements ($p< 0.05$), while the GL was found inversely correlated with body weight and height ($p< 0.05$). **Conclusion:** As a result a significant relationship was found between GI and anthropometric measurements. It is considered that a low GI diet may be useful in the prevention of obesity and subsequent chronic adulthood diseases in adolescents.

Key Words: Adolescent; glycemic index; body mass index

ÖZET Amaç: Glisemik indeksi (Gİ) veya glisemik yükü (GY) düşük olan besinleri içeren diyetlerin uygulanması, adolesanlarda aşırı ağırlık kazanımını etkileyen başta açlık mekanizması olmak üzere vücut mekanizmalarını etkileyebilmektedir. Bu çalışma, 14-18 yaş arasındaki adolesanlarda diyetin Gİ ve GY'ü ile vücut ağırlığı, boy uzunluğu, beden kitle indeksi (BKİ) ve bel çevresi (BÇ) arasındaki ilişkiyi saptamak amacıyla yürütülmüştür. **Gereç ve Yöntemler:** Çalışmaya yaşları 14-18 yıl arasında olan 1104 gönüllü adolesan birey (469 kız ve 635 erkek) dahil edilmiştir. Gİ ve GY bireylerin 24 saatlik besin tüketimlerinden hesaplanmıştır. Ayrıca, çalışmaya alınan tüm adolesanların antropometrik ölçümleri (vücut ağırlığı, boy uzunluğu, BKİ, BÇ) yapılmış ve DSÖ'nün 5-19 yaşlar için Büyüme Referansı-2007'ye göre değerlendirilmiştir. **Bulgular:** Yaşa bağlı BKİ değerlendirmesine göre, erkeklerin %13.6'sı düşük kilolu, %17.3'ü fazla kilolu ve %3.8'i obez olarak bulunmuş, kızların ise %15.9'u düşük kilolu, %13.1'i fazla kilolu ve %1.7'si obez olarak saptanmıştır. Diyetin Gİ'i erkek ve kızlar arasında anlamlı farklı bulunmuş ve obez adölesanlarda diğer BKİ gruplarına göre daha yüksek olduğu belirlenmiştir ($p< 0.05$). Bununla birlikte, BKİ sınıflamasına göre diyetin GY'ü bakımından anlamlı bir farklılık bulunmamıştır ($p> 0.05$). Diyetin Gİ'si ile antropometrik ölçümler arasında her iki cinsiyette pozitif bir ilişki saptanırken ($p< 0.05$), GY ile vücut ağırlığı ve boy uzunluğu arasında ters orantılı bir ilişki bulunmuştur ($p <0.05$). **Sonuç:** Çalışma sonucunda, Gİ ve antropometrik ölçümler arasında anlamlı bir ilişki olduğu tespit edilmiştir. Düşük Gİ içeren diyetlerin adolesanlarda obezitenin ve dolayısıyla kronik hastalıkların önlenmesinde etkili olabileceği düşünülmektedir.

Anahtar Kelimeler: Ergen; glisemik indeks; vücut kitle indeksi

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Adolescence coincides with a period of rapid growth and development and includes the transition from childhood to adulthood. Spear[1] defines the age of 10-19 years as adolescence, and 15-24 years as the period of youth. According to the Turkish 2009 Address-Based Population Registration System, 35% of the population in Turkey consists of those younger than 20 years old, with 24% in the 5-19 year age group.[2]

The acceleration of growth is apparent in adolescence, with rapid changes in anthropometric measurements. Standard data that can be used for the assessment of anthropometric measurements and the nutritional status of individuals in this age group are limited. The body mass index (BMI) for age is recommended for the assessment of adolescent body weight.[3]

Excessive and ineligible nutrition and insufficient physical activity may cause increased obesity in childhood and adolescence. One third of preschool children and approximately half of adolescents are obese in developed countries.[4] Recent studies have demonstrated that, the prevalence of overweight and obesity were 10.3-21.8% and 1.6-6.1%, respectively, in Turkey.[5-7]

Early diagnosis of obesity, which is defined as a chronic disease, especially in childhood, and prompt treatment initiated by taking the required measures are important for the prevention of complications in childhood and adulthood.[4,8]

In recent years an increase in body fat mass and muscle tissue in childhood and adolescence has been accompanied by an increase in height. In many countries, children are taller than ever before, have a heavier body structure and have puberty earlier.[8] It is thought that these changes in the growth process can be associated with changes in dietary habits.[9]

Modern life has brought changes in nutritional habits such as increased carbohydrate (CHO) intake and an increase in the consumption of food with a high glycemic index (GI) and glycemic load (GL). This type of diet is considered to be another factor in the universality of obesity.[9]

High GI and GL diets cause hyperinsulinemia and insulin resistance by increasing blood glucose levels.[10] In this case, more carbohydrate and less fat are oxidized, resulting in more energy storage in adipose tissue. After high insulin response, a rapid drop in blood glucose levels occurs, and the feeling of hunger returns faster than normal. After a high GI and GL meal food intake increases and in the long terms this result in weight gain.[11] However, low GI/GL diets have positive effects on glycemic control, insulin sensitivity and body weight, improve cardiovascular risk factors and reduce the risk of type 2 diabetes mellitus (DM).[9]

Recent studies highlight the effect of GI and GL on body composition. An inverse relationship between GI/GL and BMI has been reported.[11,12] However, there are conflicting reports in the few studies that examined the relationship between waist circumference (WC) and GI/GL.[12] While Slabber et al. found significant weight loss after three months on a low GI diet in obese women, and Bouche et al. reported that a low GI diet resulted in more body fat loss when compared to high GI diets.[11,13] Another study that investigated the effects of a low GI diet on children and adolescents found that this type of diet led to a greater reduction in BMI over four months when compared to a low fat diet.[14]

The present study was conducted in order to determine the relationship between dietary GI and GL values and the one-day dietary recall and body weight, BMI, and WC of 14-18 year-old Turkish adolescents.

MATERIAL AND METHODS

DESIGN AND SAMPLE

A cross-sectional study was conducted on a total of 1104 adolescents (469 girls and 635 boys) aged 14 to 18 years (mean ± SD:15.8 ± 1.24 year old). Subjects were randomly included in the study from healthy adolescent volunteers living in Ankara, the capital city of Turkey. Data were collected in face to face interviews from March 2009 to September 2010 by the researchers. Adolescents and their parents gave informed written consents which adhered to Declaration of Helsinki protocols (World Medical Association).

ANTHROPOMETRIC MEASUREMENTS

Height (cm), body weight (kg), and WC (cm) were measured by the researchers. The weight measurements were performed early in the morning while the subject was in fasting state, and was wearing light clothes. A portable scale was used to measure body weight to the nearest half-kilogram. Height measurements were performed using a 2 m long inflexible steel measuring stick with the subject's heels, back and shoulders lying against the wall, the feet together and the head in the Frankfort plane. Height was measured to the nearest 0.1 cm. WC was measured above the iliac crest and below the lowest rib margin at minimum respiration and measured with a flexible tape.[15] BMI was calculated as weight (kg) divided by height squared (m^2). The anthropometric measurements were assessed using the WHO Growth Reference for 5-19 Years-2007 (www.who.int/-growthref/en/). The children were classified into five categories of BMI for age Z score (BAZ): underweight, at risk of underweight, normal weight, overweight and obese, in accordance with the cut-off points of <(-2 SD), (-2SD) to (-1SD), (-1SD) to 1SD, 1SD to 2SD and ≥2SD Z-scores, respectively.[16]

DIETARY ASSESSMENTS

Dietary datas were collected from adolescents during a face-to-face interview with researchers. During the interview, food models and photos of common Turkish dishes of various portions, as well as household cups and measures, were used to assess the type and amount of foods and beverages consumed during the previous day. The energy and macro nutrient compositions of the diets were calculated using Nutrition Information System (BeBiS 5) program.[17] This database contains Turkish food composition tables for all food.

Daily dietary glycemic index and glycemic load were calculated from the 24 hour dietary recall data. Of the total 112 food and beverage items reported in the 24 hour dietary recall, 16 contain no carbohydrate. To determine the glycemic index, each food item from the 24 hour dietary recall was matched directly to foods in the international table of glycemic index. Glucose was used as the reference. When a direct match could not be found, a GI value was imputed from similar foods in the international table.[18] The GL for each food was calculated by using available carbohydrate as GL = GI x (carbohydrates (g) in one serving)/100.

The recommended formulas[19] for calculating overall dietary glycemic index and glycemic load are the following:

Overall dietary glycemic index =

and

Dietary glycemic load = ,

where GI*i* is the glycemic index for food *i*, CHO*i* is the carbohydrate content in food *i* (g/day), and *n* is the number of foods eaten per day.

GI values were grouped into three categories. Dietary GI was classified as high (≥70), intermediate (69–56), and low (≤55).[20,21]

STATISTICAL ANALYSIS

All values were expressed as the mean () ± standard deviation (SD). Data were analyzed using the Statistical Package for Social Sciences Software for Windows 10.0 (SPSS Inc. Chicago, IL, USA). The Kolmogorov-Smirnov test was used to determine whether outcome variables were normally distributed. The relationships between energy and macro nutrient intake, anthropometric measurements and GI and GL classifications were analyzed by one-way ANOVA and Pearson correlation coefficients. The Tukey method was used to find the responsible groups for any difference. The level of significance was set as $p< 0.05$.

RESULTS

The study included 469 boys and 635 girls between the ages of 14 and 18 with the mean age of 15.8 ± 1.22 and 15.8 ± 1.26 years for boys and girls, respectively. In the evaluation of BAZ, 13.6% of boys were classified as underweight or at risk of underweight, 17.3% of boys as overweight and 3.8% of boys as obese, while 15.9% of the girls were classed as underweight or at risk of underweight, 13.1% as overweight and 1.7% as obese.

The 50th percentiles of GI and GL were 61.4 and 113.1 versus 52.6 and 125.1 in boys and girls, respectively (Table 1).

The dietary GI of obese adolescents was higher than that in other groups ($p< 0.05$) both in girls and boys, although there was no significant difference in the dietary GL and BMI classification ($p> 0.05$) (Table 2).

The differences in adolescents' body weight, WC, BMI and BAZ values and dietary GI classification were significant ($p< 0.05$). Adolescents had the highest values for these measurements in the dietary group with a high GI (≥70) (Table 3). According to GI classification differences between boys and girls for all anthropometric measurements were not significant ($p> 0.05$).

Daily energy, carbohydrate, protein, and fiber intake and the percentage of energy from fat and carbohydrates varied between the groups ($p< 0.05$) when dietary energy and macro nutrient intake levels were examined according to the classification of GI. The daily energy, protein and fat intakes of the GI≥70 group were higher than the other groups, and the percentage of energy from carbohydrate, and the carbohydrate and dietary fiber intakes of the GI≤55 group were the lowest ($p< 0.05$) (Table 4). The energy, protein, carbohydrate and dietary fibre intakes of boys in the GI≥70 group were higher, and the percentage of energy from carbohydrates of boys in the GI≤55 group were lower than the other groups ($p< 0.05$). Girls in the GI≥70 group had a higher energy intake but those in the GI≤55 group had lower carbohydrate and percentage of energy from carbohydrate intakes ($p< 0.05$).

A positive correlation was observed between dietary GI and body weight, height, BMI, and WC in adolescents (r:0.122, $p< 0.01$; r:0.062, $p< 0.05$; r:0.102, $p< 0.01$; r:0.094, $p< 0.01$ and r:0.073, $p< 0.05$ respectively). GL was inversely correlated with body weight and height (r:-0.083, $p< 0.01$; r:-0.061, $p< 0.05$) respectively. As the GI increased, total energy, carbohydrates, and percentages of energy from carbohydrates and protein in the diet also increased in both genders (r:0.222, $p< 0.01$; r:0.295, $p< 0.01$; r:0.265, $p< 0.01$; and r:0.170, $p< 0.01$, respectively). Dietary GL increased with the intake of percentage of energy from fat (r:0.069; $p< 0.05$). GI and GL decreased significantly as fiber intake increased in the diet of adolescents (r:-0.162, $p< 0.01$; r:-0.060, $p< 0.05$, respectively) (Table 5).

TABLE 1: GI and GL percentiles, age and gender of adolescents.

		GI Percentile					GL Percentile				
Age (year)	n	5	25	50	75	95	5	25	50	75	95
Boys											
14	70	20.6	38.4	65.3	106.9	194.5	35.9	84.2	113.6	147.6	234.1
15	141	24.5	41.6	61.6	91.9	180.3	59.7	96.4	117.4	167.0	271.9
16	102	22.5	37.1	57.5	91.3	152.4	38.7	82.8	110.9	166.8	296.9
17	110	24.5	39.0	67.4	88.5	180.2	43.4	71.4	108.5	155.1	239.1
18	46	21.3	41.8	57.6	87.5	151.5	40.4	80.3	131.1	168.3	247.0
Total	469	23.9	40.2	61.4	90.4	175.4	43.3	81.5	113.1	161.3	249.8
Girls											
14	99	21.2	34.8	56.7	76.2	134.2	51.6	91.6	128.7	185.7	232.6
15	190	26.2	40.4	56.3	75.0	119.7	46.3	88.5	124.9	178.8	297.4
16	144	23.9	34.5	51.1	72.0	177.8	38.4	78.7	115.5	162.7	258.1
17	125	23.1	34.7	51.0	74.6	118.0	43.5	84.8	129.4	167.7	298.3
18	77	19.0	32.1	48.9	69.4	112.2	44.9	94.4	138.5	188.0	263.2
Total	635	23.8	35.8	52.6	74.1	124.7	46.1	86.6	125.1	175.6	260.6

GI: Glycemic index; GL: Glycemic load.

TABLE 2: Energy, macro nutrient intakes and GI- GL values, gender and BMI classification ($\bar{x}$ ± SD).

	BMI classification				
	Underweight	Normal	Overweight	Obese	p
Boys					
Energy (kcal)	1821 ± 680	1947 ± 767	2020 ± 1010	2332 ± 1369	0.133
CHO (g)	224.2 ± 93.3	247.0 ± 112.0	251.3 ± 158.6	284.1 ± 193.2	0.272
Protein (g)	63.3 ± 27.9	66.7 ± 25.9	70.8 ± 36.3	74.7 ± 47.4	0.285
Fat (g)	71.3 ± 35.9	72.6 ± 37.5	77.7 ± 35.5	96.0 ± 49.6	0.094
CHO %	49.2 ± 10.5	51.9 ± 10.1	50.7 ± 10.4	53.2 ± 10.1	0.249
Protein %	13.8 ± 3.2	14.6 ± 4.0	14.7 ± 4.7	14.7 ± 3.9	0.682
Fat %	34.6 ± 9.7	33.5 ± 9.1	36.1 ± 9.7	39.0 ± 10.3	0.096
Fiber (g)	20.0 ± 12.8	18.9 ± 9.6	18.6 ± 7.9	18.1 ± 6.3	0.075
GI	52.4 ± 27.7[a]	78.2 ± 46.8[a]	72.1 ± 51.9[a]	84.0 ± 40.3[b]	<0.001*
GL (g/day)	135.6 ± 73.6	126.9 ± 69.3	133.5 ± 69.1	139.1 ± 69.4	0.161
Girls					
Energy (kcal)	1562 ± 592	1668 ± 683	1738 ± 606	1641 ± 681	0.410
CHO (g)	198.8 ± 86.3	210.1 ± 92.0	216.4 ± 72.0	219.0 ± 82.3	0.639
Protein (g)	49.4 ± 28.0	52.9 ± 22.7	52.0 ± 23.6	55.3 ± 21.4	0.418
Fat (g)	59.0 ± 25.8	60.7 ± 44.0	65.9 ± 34.7	68.1 ± 32.7	0.278
CHO %	52.1 ± 9.1	51.5 ± 8.9	52.1 ± 9.2	56.8 ± 11.8	0.173
Protein %	12.0 ± 4.3	13.4 ± 4.0	13.3 ± 3.5	13.9 ± 4.1	0.369
Fat %	33.3 ± 11.5	34.6 ± 9.3	33.9 ± 7.9	35.0 ± 8.6	0.387
Fiber (g)	18.9 ± 9.6	17.7 ± 8.8	16.2 ± 7.2	14.7 ± 5.9	0.195
GI	54.5 ± 26.9[a]	60.4 ± 36.2[a]	66.8 ± 48.4[a]	87.0 ± 37.9[b]	0.034*
GL (g/day)	132.8 ± 61.5	143.0 ± 80.7	137.3 ± 77.2	155.2 ± 79.1	0.742

BMI: Body mass index; CHO: Carbohydrate; GI: Glycemic index; GL: Glycemic load.
*One-way ANOVA, p<0.05.
[a,b]Values with different superscripts mean p<0.05, with same superscripts mean p> 0.05.

TABLE 3: Age, anthropometric measurements (mean ± SD) and GI classification.

	GI classification			
	≤55	56-69	≥70	p
Age (year)	15.9 ± 1.3	15.7 ± 1.2	15.8 ± 1.2	0.064
Height (cm)	164.2 ± 9.6	164.0 ± 8.6	165.7 ± 8.9	0.051
Body weight (kg)	55.6 ± 10.6[a]	56.4 ± 10.5[a]	57.6 ± 11.8[b]	0.018*
WC (cm)	70.8 ± 9.2[a]	69.9 ± 8.7[a]	72.0 ± 9.7[b]	0.026*
BAZ	-0.07 ± 1.0[a]	0.06 ± 1.0[b]	0.08 ± 1.0[b]	0.034*
BMI (kg/m^2)	20.5 ± 3.0[a]	20.9 ± 2.9[a]	21.2 ± 3.2[b]	0.045*

GI: Glycemic index; WC: Waist circumference; BAZ: Body mass index for age Z score; BMI: Body mass index.
*One-way ANOVA, p<0.05.
[a,b]Values with different superscripts mean p<0.05, with same superscripts mean p> 0.05.

DISCUSSION

There is a growing interest in the role of GI and GL in the regulation of body weight. It has been hypothesized that they may be operative in weight regulation in two ways: by promoting satiety and by promoting fat oxidation at the expense of carbohydrate oxidation.[9,22]

TABLE 4: GI classification, energy and macro nutrient intake of adolescents (mean ± SD).

	GI classification			
	≤55	56-69	≥70	p
Energy (kcal)	1660.1 ± 722.6[a]	1704.7 ± 617.3[a]	1977.3 ± 765.1[b]	<0.001*
Protein (g)	55.7 ± 27.3[a]	56.1 ± 20.4[a]	63.9 ± 26.1[b]	<0.001*
Protein %	14.0 ± 4.1	14.0 ± 4.3	13.7 ± 3.8	0.480
Fat (g)	68.6 ± 32.9	66.1 ± 30.7	69.0 ± 40.5	0.669
Fat %	37.0 ± 8.1[a]	34.3 ± 7.9[b]	30.7 ± 9.5[c]	<0.001*
CHO (g)	199.7 ± 98.9[a]	214.0 ± 86.4[a]	264.1 ± 104.8[b]	<0.001*
CHO %	48.9 ± 8.8[a]	51.7 ± 8.4[a]	55.6 ± 9.9[b]	<0.001*
Fiber(g)	17.1 ± 9.2[a]	17.4 ± 8.1[a]	20.4 ± 9.8[b]	<0.001*

GI: Glycemic index; CHO: Carbohydrate.
*One-way ANOVA, p<0.05.
[a,b,c]Values with different superscripts mean p<0.05, with same superscripts mean p> 0.05.

A higher dietary GI has been proposed as a risk factor for weight gain and obesity.[23] Positive relationships between GI, GL, and obesity have been found in several studies.[24,25] Most previous cross-sectional studies in children and adolescents (aged 6-17 years), though not all, have found independent associations between dietary GI or GL and measures of body composition.[23,24]

Several studies presented descriptive data reporting inverse relationships between GI, GL and BMI, but these were generally focused on other outcomes.[12,13] One study indicated that GI was inversely related to BMI when estimates were not adjusted for energy intake.[10] In another study, the dietary GI was found to be similar in Danish girls and boys aged 10 and 16 years, whereas 16 year-old boys had a higher daily dietary GL compared with girls or younger boys.[26] In this study the dietary GI and GL of 14-18-year-old Turkish adolescents were similar in both genders (p> 0.05) and there were significant differences according to BMI classification and GI in both genders (boys: p< 0.001, girls: p=0.034), but no differences in terms of GL (p> 0.05) (Table 2).

Most studies have indicated that GL is either unrelated or inversely related to BMI with regard to GL,.[12,23,24] In our study, BMI and body weight varied significantly between the groups (p< 0.05) based on GI classification. In particular, individuals with a dietary GI higher than 70 had the highest BMI values (21.2 ± 3.20) and body weight (57.6 ± 11.8) (Table 3). Dietary GI was positively correlated with BMI (r:0.102, p< 0.01) and body weight (r:0.122, p< 0.01). For GL, a correlation was found only with body weight (r:-0.061, p< 0.05) (Table 5) which compares favourably with a cross-sectional

TABLE 5: Correlations of dietary GI and GL values between anthropometric measurements, energy and macro nutrient intake of adolescents.

	GI		GL (g/day)	
	r	p	r	P
Age (year)	-	0.122	-	0.945
Height (cm)	0.062*	0.040	-0.083**	0.006
Body weight (kg)	0.122**	<0.001	-0.061*	0.042
WC (cm)	0.094**	0.002	-	0.617
BAZ	0.127**	<0.001	-	0.718
BMI (kg/m2)	0.102**	0.001	-	0.512
Energy (kcal)	0.222**	<0.001	-	0.293
Protein (g)	0.170**	<0.001	-	0.233
Protein %	-	0.493	-	0.583
Fat (g)	-	0.213	-	0.686
Fat %	-0.271**	<0.001	0.069*	0.021
CHO (g)	0.295**	<0.001	-	0.123
CHO %	0.265**	0.058	-	0.055
Fiber(g)	-0.162**	<0.001	-0.060*	0.046

GI: Glycemic index; GL: Glycemic load; WC: Waist circumference; BAZ: Body mass index for Age Z score; BMI: Body mass index; CHO: Carbohdyrate.
* p<0.05 ** p<0.01.

study of 6334 subjects aged 30-60 years.[27] In the univariate analyses of the entire population, GL was inversely correlated with BMI while no correlation was observed for GI. After full adjustment (including energy intake), both GI and GL were positively associated with BMI.[27] In another study conducted in a Mediterranean population of 8.195 Spanish adults aged 35-74 years; BMI was inversely related to dietary GI and GL.[28]

Despite the evidence of benefits for other outcomes, our results support the hypothesis that high GI and GL are positively related to obesity. Underreporting did not explain the inverse energy intake relationship between dietary GL and BMI, which was observed in subjects with plausible energy intakes. Further research in other populations with different intake patterns, using longitudinal data on weight change, is required to elucidate any independent effects of dietary GL and GI on obesity. The discrepancy with respect to these results remains to be elucidated. One possibility may be the heterogeneity in intake patterns of underlying dietary GL.

A few studies have investigated GI and GL in relation to WC, again showing inconsistent results.[12,29-31] Among other measures of obesity, in the EURODIAB IDDM Complications Study[29] a lower dietary GI was associated with lower WC in 1,458 European men with type I Diabetes, however no relationship was found in 1,410 women.[29] Similarly in the Whiteall II study, WC was inversely correlated with GI and GL in the 7.321 men aged 39 to 63,[5] but not among women.[30] Inverse associations between energy-adjusted dietary GL and BMI and WC have been reported in other studies.[12,30] Another cross-sectional study on 979 adults with normal and impaired glucose tolerance from the Insulin Resistance Atherosclerosis Study reported no relationship between GI and GL and WC.[31]

In the present study, the individuals who had a dietary GI higher than 70 had the highest WC values (72.0 ± 9.7) (Table 3). Dietary GI was positively correlated with WC (r:0.094, $p< 0.01$) but there was no relationship with GL ($p> 0.05$) (Table 5).

The role of GI in body weight regulation has been attributed to the direct anabolic effects of insulin or indirectly through modifications in appetite resulting in a higher energy intake in response to a higher GI diet.[32,33] Dietary GI and GL are also associated with higher energy intakes. Adjusting for energy intakes had no impact on GI.[28]

Although total CHO intake encompasses a wide range of food groups, including grains, cereals, fruits, vegetables, and sweets, it appears that foods that are higher in sugar content or those that have a higher GI and GL tend to be the more controversial CHO contributors to obesity and related diseases.[34]

Some studies suggest that, among healthy adolescents, changes in the amount of consumed energy and macronutrient had no impact on the concurrent development of percentage of body fat or BMI (12,23). In the present study, there were no significant differences in dietary energy and macro nutrient intakes ($p> 0.05$) in relation to BMI classification (Table 2).

Several studies have demonstrated a positive correlation between GL and dietary protein and fat intake which probably can be explained by the fact that the amount of dietary protein and fat increases concurrently with the increase in total CHO and energy. However, the negative correlations between GL and percentage dietary fat and protein probably reflect the fact that there is an increase in the amount of high glycemic CHO with the reduction in dietary fat and protein.[31,34]

In the high GI group (≥70), daily energy (kcal) and protein (g) intakes were significantly higher than the other GI groups ($p<0.01$). On the other hand, daily CHO (g), percent of CHO from energy (%) and dietary fiber intakes were higher and percent of fat from energy (%) intakes were significantly higher than the low GI group (≤55) ($p< 0.05$) (Table 4). On the contrary, a study on the mean daily dietary GI value and the total CHO intake in children aged 10-16 years no significant differences were found between age groups or gender.[26]

The dietary GI was positively correlated with dietary energy (r:0.222, $p< 0.01$), protein (r:0.170, $p< 0.01$) and CHO (r:0.295, $p< 0.01$) intakes. Dietary GL was also positively correlated with the percentage of fat from energy (%) (r:0.069, $p < 0.05$) (Table 5). However it should be mentioned that the correlation was weak. Similarly, Slyper et al. showed that the only significant correlations evident were negative correlations between HDL cholesterol and glycemic load (in relation to white bread), percentage of carbohydrate, total dietary sugar, total carbohydrate, and fructose.[35] GL was moderately correlated with many other dietary constituents, including total, saturated, monounsatured, and polyunsatured fats; total protein; and milk protein and GL were not considered in most previous dietary studies.

In another study, a total of 129 overweight or obese young adults (BMI ≥25) were assigned to one of four reduced-fat, high-fiber diets for 12 weeks. Diets 1 and 2 were high CHO (55% of total energy intake), with high and low GIs, respectively; diets 3 and 4 were high protein (25% of total energy intake), with high and low GIs, respectively. It was found that both the high-protein and low-GI regimens increased body fat loss, but that cardiovascular risk reduction was optimized by a high-CHO and low-GI diet.[36]

The presence of large amounts of protein or fat may significantly reduce the glycemic response by increasing insulin secretion and slowing gastric emptying.[37] However, in the study by Henry et al., protein showed only a moderate negative association with the GI value and that there was no association between GI value and fat content per 100 g of the test foods or per serving size tested.[37] Another study showed that there was no relationship between the amounts of fat or protein in foods and their GI values.[38]

CONCLUSION

We concluded that there was a significant relationship between glycemic index and anthropometric measurements of adolescents. A low-GI diet may be useful in the prevention of obesity and related chronic condition in adolescents. This hypothesis could be tested further in large-scale randomized controlled trials and the effectiveness of low-GL and low-GI could be evaluated. Researchers and health professionals should calculate and evaluate the country specific GI and GL data using appropriate serving sizes foods.

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