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The relationship of the dietary inflammatory index, glycemic load and glycemic index on sleep quality and anthropometric measurements in college students

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Abstract

Purpose – This study aims to determine the relationship between dietary inflammatory index (DII), healthy eating index (HEI), glycemic index and load (GI/GL) with sleep quality and anthropometric measurements in college students.

Design/methodology/approach – This was a cross-sectional study. With a type I error of 0.05, a type II error of 0.20, and a minimum power of 90%, the required sample size was calculated to be at least 112 students. However, considering that there might be missing data and that the study was being conducted to increase the power of the study, 500 students were recruited for the study. A total of 500 students (124 males, 376 females) aged 18–25 years were recruited for the study. The students' socio-demographic characteristics, anthropometric measurements (body weight, height, neck, waist and hip circumferences), sleep quality and three-day food consumption records were examined. Sleep quality was evaluated by the Pittsburgh Sleep Quality Index (PSQI).

Findings – The total PSQI score median value was 7 (1–17). In total, 65.4% of the students had poor, and 34.6% had good sleep quality. The minimum DII score was −9.67, and the maximum DII score was 10.41. The mean of DII was 2.51 ± 3.26. DII scores were evaluated by dividing them into quartiles. In DII Quartile 1, representing the anti-inflammatory diet, values were between −9.67 and +0.18; in DII Quartile 2, values were between +0.23 and +2.47; in DII Quartile 3, values were between +2.55 and +4.50; DII Quartile 4, representing the proinflammatory diet, values were between +4.52 and +10.41. Waist circumference and waist-to-hip ratio significantly differed between quartiles (Q1 < Q2 < Q3 < Q4 and Q2 < Q3 < Q4, respectively) ($p < 0.05$). GL and HEI-2015 scores significantly differed between quartiles (Q1 < Q2 < Q3 < Q4

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"This study was derived from the master's thesis titled 'The Effect of Dietary Inflammatory Index, Glycemic Load and Glycemic Index on Sleep Quality in University Students'".

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and Q1 > Q3 > Q4, respectively) ($p < 0.05$). There was a significant positive correlation between DII and GL ($r = +0.189$, $p < 0.001$) and a significant negative correlation between DII and HEI-2015 ($r = -0.213$, $p < 0.001$).

Originality/value – The study's original aspect is that food consumption records were obtained instantaneously from the participants via social media, and the relationship of multiple indices (DII, HEI-2015, GI, GL) with each other and with sleep quality and anthropometric measurements were evaluated.

Keywords Dietary inflammatory index, Glycemic index, Glycemic load, Healthy eating index, Sleep quality

Paper type Research paper

Introduction

Low-grade and chronic inflammation plays an important role in the development of numerous chronic diseases such as metabolic syndrome (MS), non-alcoholic steatohepatitis (NASH), type 2 diabetes, cancer, depression and cardiovascular diseases (Wang *et al.*, 2023; Rohm *et al.*, 2022). Diet plays an important role in regulating chronic inflammation (Grant, 2023). Some indices, such as dietary inflammatory index (DII), healthy eating index (HEI), glycemic index (GI) and glycemic load (GL), explain the role of diet in inflammation.

Inflammatory mediators are key in the interaction between sleep and the immune system (Irwin, 2019). Cytokines are involved in both inflammation and sleep regulation (Haspel *et al.*, 2020; Al-Sharif and El-Kader, 2021). Studies have found links between proinflammatory cytokines like IL-6 and TNF-α and poor sleep quality, including insufficient sleep (Friedman, 2011; Hong *et al.*, 2005), late waking (Okun *et al.*, 2011) and short sleep duration (Pérez de Heredia *et al.*, 2014).

Studies have found that college students often consume high-energy, fat, refined carbohydrates and processed foods, leading to unhealthy eating behaviors (Bede *et al.*, 2020; Ramón-Arbués *et al.*, 2019; Syed *et al.*, 2020). However, most research on DII has focused on its relationship with diseases in middle-aged and elderly populations (Phillips *et al.*, 2018; Denova-Gutiérrez *et al.*, 2018; Canto-Osorio *et al.*, 2020).

Sleep interacts with the immune system through inflammation-related mediators, which play a key role in immunity (Irwin, 2019; Du *et al.*, 2023). Studies on college students have shown changes in sleep duration and quality in recent years, with an increase in sleep-related disorders (Li *et al.*, 2018; Friedrich and Schlarb, 2018). Health-related indicators, including sleep quality, influence anthropometric measurements, such as body mass index and neck and waist circumferences (Becker *et al.*, 2018). The dietary inflammatory index, glycemic load and glycemic index are measures of diet quality that may impact sleep quality and anthropometric measurements among college students (Becker *et al.*, 2018; Moraleda-Cibrián *et al.*, 2024). Recent studies have highlighted the need to investigate further the relationship between dietary factors, sleep quality and anthropometric measurements in this population (Becker *et al.*, 2018; Becerra *et al.*, 2018). Based on this knowledge, this study aimed to explore the relationship between DII, HEI, GI/GL, sleep quality and anthropometric measurements in college students.

The study hypothesizes that as university students' dietary inflammatory index increases, glycemic load and glycemic index will increase, healthy eating index and sleep quality will decrease and health-related anthropometric measurements will be negatively affected.

Materials and methods

Study design and participants

This cross-sectional study was conducted at Cappadocia University, Nevşehir, Türkiye during the spring semester of the 2018–2019 academic year. Inclusion criteria were being

healthy, volunteering and being a college student aged 18–25. Exclusions included those on a diet, those over 25 years old, those using regular medication or nutritional support and those pregnant or breastfeeding.

The universe of the study was 1200. Initially, the study sample was calculated based on the study conducted by Kim *et al.* (2018), which found a positive statistical relationship between DII and GI scores. The type I error was 0.05, and the type II error was 0.20, with a minimum power of 90%; at least 112 students needed to be included in the study were calculated. However, considering that there might be missing data and that the study was being conducted to increase the power of the study, 500 students were recruited for the study. At the end of the study, the Power and Sample Size (PASS 11, NCSS Statistical Software) package program was used again to calculate the power. It was determined that the final power of the study was 99.8% when the type I error was taken as 0.05 and the type II error as 0.002.

The study's aims and design were shared with students on social media, and 750 volunteers (random sampling) agreed to participate. However, some data were excluded due to incomplete measurements or food records. Ultimately, the study was completed with 500 participants.

The participant flow chart of the research can be summarized as follows in Figure 1.

Measures

Students' sociodemographic characteristics were collected through a 25-question survey covering age, sex, smoking, alcohol use, sleep habits, bedtime, wake-up times and caffeine consumption. To avoid potential biases, the researcher completed the sociodemographic data form by asking the participants questions face-to-face.

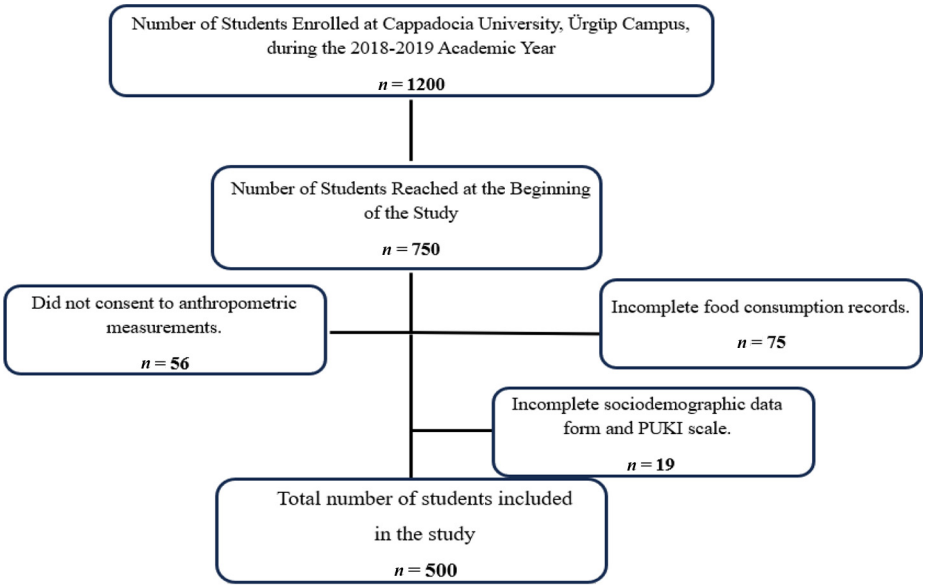

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Figure 1. Participant flow chart

Food consumption record

The students were asked to record all the foods and beverages they consumed on a three-day food consumption record form, two days during the week and one day on the weekend (three consecutive days). While taking the three-day food consumption record, WhatsApp (WhatsApp Inc. California, USA), an online-based social communication tool, was also used. The researcher sent a message to the students every hour asking them to send me a photo of the food or beverage they consumed, and a record was taken. Thus, food consumption records were collected instantly and reliably. The energy, macro and micronutrient intakes of the students were calculated by entering the food consumption records into the Nutrition Information Systems (BeBiS) (Schmind M, BEBIS, 2011) full version Version 8.1 (Pacific Limited Company, İstanbul, Turkey) program prepared for Turkish foods. The students' three-day food consumption record information was used to calculate the DII, GI, GL and HEI-2015 scores.

The instant recording of food consumption via the WhatsApp application prevented potential biases and provided access to more reliable data. In addition, requesting photographs of the food and beverages consumed increases data reliability.

Calculation of the dietary inflammatory index

The DII, developed by Cavicchia *et al.* (2009) and validated globally by Shivappa *et al.* (2014), is a literature-based index of 45 foods and nutrients that assesses their impact on inflammation. Proinflammatory foods/nutrients receive a score of "+1", anti-inflammatory foods/nutrients "−1" and foods/nutrients that do not affect inflammatory markers are given a score of "0" (Shivappa *et al.*, 2014). A high DII score indicates a proinflammatory diet, while a low score reflects an anti-inflammatory diet (Shivappa *et al.*, 2014).

In the current study, the DII scores of the students were calculated by evaluating the three-day food consumption records and determining the consumption amount of the relevant food/nutrient for 34 foods and nutrients. Thirty-four foods and nutrients were energy, carbohydrate, protein, total fat, saturated fatty acids (SFA), monounsaturated fatty acids (MUFA), polyunsaturated fatty acids (PUFA), n-3 fatty acid (FA), n-6 FA, cholesterol, fiber, caffeine, Vitamins A, C, E, D, thiamine, riboflavin, niacin, Vitamin B_6, folate, Vitamin B_{12}, iron, magnesium, zinc, selenium, caffeine, green/black tea, alcohol, onion, garlic, pepper, thyme and ginger (Shivappa *et al.*, 2014).

Calculation of the healthy eating index (HEI-2015)

The Healthy Eating Index-2015 (HEI-2015) is based on the "2015–2020 American Dietary Guidelines (Krebs-Smith *et al.*, 2018; Guenther *et al.*, 2014)." Students' food intake was classified, and nutrient amounts per 1000 kcal were calculated. The HEI score, out of 100, reflects diet quality: ≤50 indicates "poor," 51–80 suggests "needs improvement" and ≥80 indicates "good" diet quality (Krebs-Smith *et al.*, 2018; Guenther *et al.*, 2014).

Calculation of the glycemic index and glycemic load

Daily GI and GL values were calculated using Bao *et al.* (2009, 2011). A GI of ≤55 was classified as "low," 56–69 as "moderate" and ≥70 as "high" (Bao *et al.*, 2009, 2011). A GL of <80 was "low," 80–119 was "moderate" and ≥120 was considered a "high" GL diet (Bao *et al.*, 2009, 2011).

Anthropometric measurements

The researcher measured body weight, height, neck, waist and hip circumferences following the technique. All anthropometric measurements were taken in the morning when the students were relaxed, hungry and wearing only minimum clothing (Bernal-Orozco *et al.*, 2020). Body mass index (BMI), waist-to-hip ratio (WHR) and waist-to-height ratio (WHtR) were calculated. Students with a BMI <18.5 kg/m^2 were evaluated as underweight, 18.5–24.9 kg/m^2 as normal, 25.0–29.9 kg/m^2 as overweight and ≥30.0 kg/m^2 as obese (Bernal-Orozco *et al.*, 2020).

Determination of sleep quality

The Pittsburgh Sleep Quality Index (PSQI) assessed students' sleep quality over the past month (Ahrberg *et al.*, 2012). The scale ranges from 0 to 21, with a score of 5 or below indicating "good" sleep quality and above 5 indicating "poor" sleep quality (Ahrberg *et al.*, 2012). The researcher read the PSQI questions to the participants face-to-face to prevent possible biases.

Ethical procedures

This study was conducted according to the guidelines laid down in the Declaration of Helsinki. Approval from the Cappadocia University Scientific Research and Publication Ethics Committee (number/date ETK.FR.001 / 29.01.2019), administrative permission from the college administration, and written consent from the students were obtained for the study.

Statistical analysis

The students' data were analyzed using IBM SPSS Statistics 22.0 (Statistical Package for the Social Sciences, SPSS Inc. Chicago, USA). Normality was tested with the Shapiro−Wilk test, and chi-square analysis was used for categorical variables. Frequency, percentage, median, min-max, mean and standard deviation values were reported. Parametric variables were compared using one-way ANOVA, with Tukey or Tamhane T2 tests applied based on variance homogeneity. Kruskal−Wallis analysis was used for nonparametric variables, with Dunn's Method for group comparisons. Pearson correlation analyzed relationships between DII, GI, GL, PSQI scores and anthropometric measurements, with significance at $p < 0.05$ and 95% confidence interval (Cichoń, 2020).

Limitations and strengths of the research

Around 500 students participated in the study; 124 were males, and 376 were females. The study's limitation is the apparent gender inequality among the students participating. Studies that ensure gender equality can provide more reliable data. This is a cross-sectional study; cross-sectional studies may be insufficient to identify causality. Longitudinal studies are needed to explain the causality relationship more clearly.

Taking the food consumption record instantly from the participants via social media constitutes the study's strength. The detailed evaluation of the 34 foods and nutrients included in the dietary inflammatory index and the evaluation and interpretation of multiple indices (DII, HEI-2015, GI, GL) together are other strengths of the study. In addition, to the best of our knowledge, this is the first study to provide a detailed evaluation of the 34 foods and nutrients included in the dietary inflammatory index and the evaluation and interpretation of multiple indices (DII, HEI-2015, GI, GL), sleep quality and anthropometric measurements together.

Results

In this study, data from 500 students was evaluated. The mean age of the students was 20.73 ± 1.43 years (min:18, max:25 years). Around 124 males (24.8%) and 376 females (75.2%) completed the study. Slightly more than half of the participants (56.8%) never smoked, and most were nondrinkers (74.8%). The median value of participants' PSQI score was 7 (min:1, max:17). A majority of participants (65.4%) had poor sleep quality and spent time on the screen before sleep (97.4%) (Table 1).

Table 2 shows students' anthropometric measurements by DII quartiles. The average BMI was 22.78 ± 3.81 kg/m^2, and most participants (68.8%) had normal body weight. There were significant differences in BMI, NC, WC, WHR, WHtR and BMI classification based on the DII quartiles.

Participants in the highest DII quartile, which means a more proinflammatory diet, had a significantly higher percentage of energy from carbohydrates and saturated fatty acids ($p <$ 0.005 and <0.001, respectively). Participants in the lowest DII quartile means a more anti-inflammatory diet, had a significantly higher percentage of energy from polyunsaturated fatty acids, and had significantly higher consumption of omega-3, omega-6, fiber, Vitamins A, C, E, D, B_1, B_2, niacin, Vitamin B_6, folate, Vitamin B_{12}, iron, magnesium, zinc, caffeine, onion, garlic and pepper ($p < 0.05$). (Data not shown)

Participants' HEI-2015, GI and GL values by DII quartiles are shown in Table 3. Participants' GI values ranged from 28.89 to 85.45, GL values ranged from 46.52 to 292.37 and HEI-2015 scores ranged from 22.89 to 109.68. Participants in the DII quartile 4 had higher values for the GL in the DII quartile 1, and this difference was significant (130.58 vs 117.04, respectively, $p = 0.009$). Participants in the lowest DII quartile had higher scores for the HEI-2015 in the highest DII quartile significantly (54.21 vs 47.57, respectively, $p < 0.001$).

The correlation between DII and HEI, GI and GL values is shown in Table 4. There was a positive, weak and significant correlation between the participants' DII score and GL value ($r = +0.189$, $p < 0.001$); a negative, weak and significant correlation was found between the DII score and the HEI-2015 score ($r = -0.213$, $p < 0.001$); a negative, weak and significant correlation was found between the HEI-2015 score and GL ($r = -0.357$, $p < 0.001$).

The study's main findings are summarized in Figures 2 and 3.

All tables and figures were created by the authors. Artificial intelligence assistants such as NapkınAI and ChatGPT were used to create the figures.

Discussion

This study assessed the relationship between DII, HEI-2015, GI and GL with sleep quality and anthropometric measurements in 500 college students (124 males, 376 females) aged 18–25 at Cappadocia University, conducted between February and June 2019.

Waist circumference (WC) was significantly higher in the fourth quartile, indicative of a proinflammatory diet, compared to other quartiles. In addition, a positive, weak and statistically significant correlation ($r = +0.2914$, $p < 0.001$) between DII and waist circumference supports this finding (data not shown). A recent study examining the relationship between WC and inflammation determined that every 10 cm increase in WC causes an increase of 0.1 mg/dL in CRP level (Tucker, 2022). In the study conducted by Stepanikova *et al.* (2017), in which the relationship between systemic inflammation and WC was questioned, a significant relationship was found between WC and CRP and IL-6 markers, which are indicators of proinflammatory status. WC indicates intra-abdominal obesity, highly associated with inflammation (Stepanikova *et al.*, 2017). For this reason, these values are expected to be high in the fourth quarter, representing the proinflammatory diet.

Table 1. Some socio-demographic characteristics and sleep parameters of students

Variables	Total (n = 500) $\bar{x} \pm$ SD
Age (year)	20.73 ± 1.43
Sex	*n/%*
Male	124 (24.8%)
Female	376 (75.2%)
Marital status	*n/%*
Single	6 (1.2%)
Married	494 (98.8%)
Living status	*n/%*
Living with his/her friends	220 (44.0%)
Living in dormitory	193 (38.6%)
Living with his/her family	87 (17.4%)
Education	*n/%*
Associate degree	70 (14%)
Undergraduate	430 (86%)
Income status	*n/%*
Income < expense	147 (29.4%)
Income = expense	224 (44.8%)
Income > expense	129 (25.8%)
Smoker	*n/%*
No	284 (56.8%)
Yes	195 (39.0%)
Former	21 (4.2%)
Drinker	*n/%*
No	374 (74.8%)
Yes	126 (25.2%)
	$\tilde{x}$ (Min-Max)
Total PSQI scores	7 (1–17)
PSQI classification	*n/%*
Good sleep quality	173 (34.6%)
Bad sleep quality	327 (65.4%)
Spend time on the screen before sleep	*n/%*
Yes	487 (97.4%)
No	13 (2.6%)
	$\tilde{x}$ (Min-Max)
Screen time before sleep (min)	60 (2–480)
Platforms screen time spent before sleeping	*n/%*
Social media	446 (89.2%)
Online game	135 (27.0%)
Shopping	109 (21.8%)
Other	71 (14.2%)
Drink caffeinated beverages before sleeping	*n/%*
Yes	163 (32.6%)
No	337 (67.4%)

(*continued*)

Table 1. Continued

Variables	Total (n = 500) $\bar{x} \pm$ SD
Type of caffeinated beverage consumed before sleeping	*n/%*
Coffee	96 (19.2%)
Tea	68 (13.6%)
Cola	41 (8.2%)
	$\tilde{x}$ (Min-Max)
Weekday sleep time (h/day)	8.00 (2.00–13.00)
Weekend sleep time (h/day)	9.00 (3.00–14.00)

Source(s): Authors' own creation

It was determined that the WHR increased significantly as the diet showed proinflammatory properties. In the study conducted by Wirth *et al.* (2016), which was quite similar to the findings of this study, WHR was 0.78 ± 0.07 in the first quartile, 0.79 ± 0.07 in the second and third quartiles, 0.80 ± 0.07 in the fourth quartile and between quartiles, the difference was significant. In the findings of a multicenter study conducted with 5,427 school-age students, the WHR increased significantly as the DII value increased (Aslani *et al.*, 2019). In another study (Sokol *et al.*, 2016), which evaluated the relationship between DII, WHR and metabolic syndrome, in 3,862 individuals, WHR was significantly higher in the proinflammatory diet group compared to the anti-inflammatory diet group. Just like WC, WHR indicates intra-abdominal obesity, which is highly associated with inflammation (Corrêa *et al.*, 2022). For this reason, these values are high in the fourth quarter, representing the proinflammatory diet.

The American Academy of Sleep Medicine and the Sleep Research Society (AASM) recommend that adults regularly get at least 7 h of sleep a night for optimal health (Watson *et al.*, 2015). Sleeping less than 7 h a night also causes weakened immune functions, decreased performance and increased accident risks (Watson *et al.*, 2015). The study found that college students averaged 8.00 h of sleep on weekdays and 9.00 h on weekends, meeting recommended sleep durations. But, sufficient sleep duration does not always mean good sleep quality. However, 65.3% of males, 65.4% of females and 65.4% of all students had poor sleep quality. Factors affecting sleep quality include screen time before bed, consumption of caffeinated beverages and the type and amount of caffeine. In total, 97.4% of students spend about 60 min on screens before sleep, and 32.6% consume caffeinated beverages shortly before bed (questioned 45 min before).

The PSQI scores of the students participating in the study were 7.00 ± 3.32, 7.23 ± 3.48, 7.00 ± 3.30 and 7.59 ± 3.60 in the first, second, third and fourth quarters, respectively. Although the PSQI score in the first quartile, representing the anti-inflammatory diet, was lower than the PSQI score in the fourth quartile, no significant difference was found between the quartiles. Contrary to this finding, in a study conducted on 1,936 adult Italian individuals, the sleep quality of individuals decreased significantly as the diet showed proinflammatory properties (Godos *et al.*, 2019). In another recent study conducted on obese female students, the PSQI score increased significantly as the diet inflammatory score of the participants increased (Bazyar *et al.*, 2021). The same result was found in a similar study conducted on overweight and obese women (Setayesh *et al.*, 2023). A study conducted on 379 college students found no significant relationship between the DII score and sleep quality (Masaad *et al.*, 2021). The results of the studies are different. Factors such as caffeine consumption,

Table 2. Students' anthropometric measurements by dietary inflammatory index (DII) quartiles

Variables	Total (n = 500) $\bar{x}$ ± SD	DII Quartile 1 (−9.67 to +0.18) (n = 125) $\bar{x}$ ± SD	DII Quartile 2 (+0.23 to +2.47) (n = 125) $\bar{x}$ ± SD	DII Quartile 3 (+2.55 to +4.50) (n = 125) $\bar{x}$ ± SD	DII Quartile 4 (+4.52 to +10.41) (n = 125) $\bar{x}$ ± SD	p
BMI (kg/m^2)*	22.78 ± 3.81	24.32 ± 4.59 [a]	22.98 ± 3.85 [a]	22.64 ± 3.28 [a]	21.19 ± 2.59 [a]	<0.001
NC (cm)*	29.09 ± 3.81	30.38 ± 4.00 a,b	29.25 ± 3.63 [a]	28.95 ± 3.65 [b]	27.77 ± 3.54 [a]	<0.001
WC (cm)*	78.75 ± 11.39	73.47 ± 8.17 [a]	78.96 ± 11.10 [a]	79.87 ± 11.19 [a]	82.70 ± 12.73 [a]	<0.001
WHR *	0.80 ± 0.06	0.78 ± 0.05 [a]	0.78 ± 0.05 [a]	0.80 ± 0.06 [a]	0.81 ± 0.06 [a]	<0.001
WHtR*	0.47 ± 0.07	0.44 ± 0.04 [a]	0.47 ± 0.05 [a]	0.48 ± 0.09 [a]	0.48 ± 0.07 [a]	<0.001
*BMI Classification***	*n* / %	*n* / %	*n* / %	*n* / %	*n* / %	
Underweight	40 (8.0%)	6 (4.8%)	10 (8.0%)	11 (8.8%)	13 (10.4%)	
Normal	344 (68.8%)	69 (55.2%)	89 (71.2%)	82 (65.6%)	104 (83.2%)	<0.001
Overweight	84 (16.8%)	31(24.8%)	18 (14.4%)	29 (23.2%)	6 (4.8%)	
Obese	32 (6.4%)	19 (15.2%)	8 (6.4%)	3 (2.4%)	2 (1.6%)	

Note(s): *One-way ANOVA test **Pearson chi-square test [a,b]Post hoc test Tukey; $p < 0.05$; a,b there is a significant difference between groups with the same letter on the same line
Source(s): Authors' own creation

Table 3. Students' HEI-2015, GI and GL values by DII quartiles

Variables	Total (n = 500) $\tilde{x}$ (Min-Max)	DII Quartile 1 (−9.67 to +0.18) (n = 125) $\tilde{x}$ (Min-Max)	DII Quartile 2 (+0.23 to +2.47) (n = 125) $\tilde{x}$ (Min-Max)	DII Quartile 3 (+2.55 to +4.50) (n = 125) $\tilde{x}$ (Min-Max)	DII Quartile 4 (+4.52 to +10.41) (n = 125) $\tilde{x}$ (Min-Max)	p
GI**	61.30 (28.89–85.45)	61.85 (32.81–80.01)	61.99 (44.86–78.22)	60.78 (37.46–85.45)	60.75 (28.89–82.22)	0.562
GL**	124.67 (46.52–292.37)	117.04 (46.52–228.64) [a]	128.80 (47.25–234.09) [a]	129.27 (60.48211.05)[a]	130.58 (65.73–292.37) [a]	*0.009*
HEI-2015 score**	52.55 (22.89–109.68)	54.21 (30.73–109.68) [a]	52.99 (32.23–96.92)	54.05 (22.89–80.01) [a]	47.57 (25.48–81.70) [a]	*<0.001*

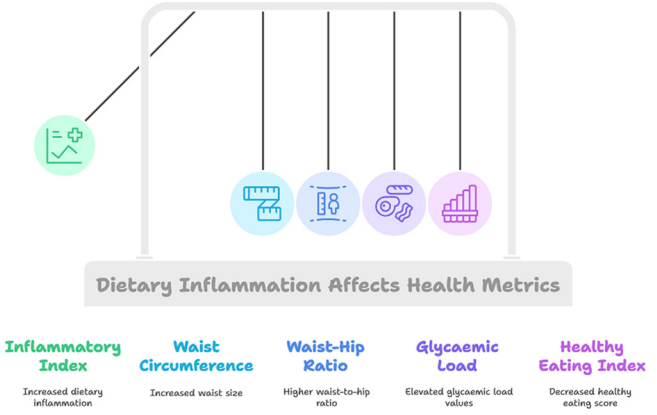
Note(s): *One-way ANOVA **Kruskal−Wallis test [a]Post hoc test Dunn−Bonferonni; $p < 0.05$; a, there is a significant difference between groups with the same letter on the same line

Source(s): Authors' own creation

Table 4. Correlation between DII and HEI, GI and GL

Variables	Total (n = 500)		Male (n = 124)		Female (n = 376)	
	rho	p	rho	p	rho	p
DII-GI*	0.002	0.957	−0.021	0.813	0.003	0.959
DII-GL*	+0.189	*<0.001*	+0.291	*0.001*	−0.096	0.064
DII-HEI*	−0.213	*<0.001*	−0.088	0.332	−0.282	*<0.001*
HEI-GI*	−0.070	0.117	−0.155	0.086	−0.047	0.358
HEI-GL*	−0.357	*<0.001*	−0.356	*<0.001*	−0.345	*<0.001*

Note(s): *Pearson correlation analysis. Values are adjusted for age, race, sex, BMI, percent body fat, smoker, drinker and physical activity level
Source(s): Authors' own creation



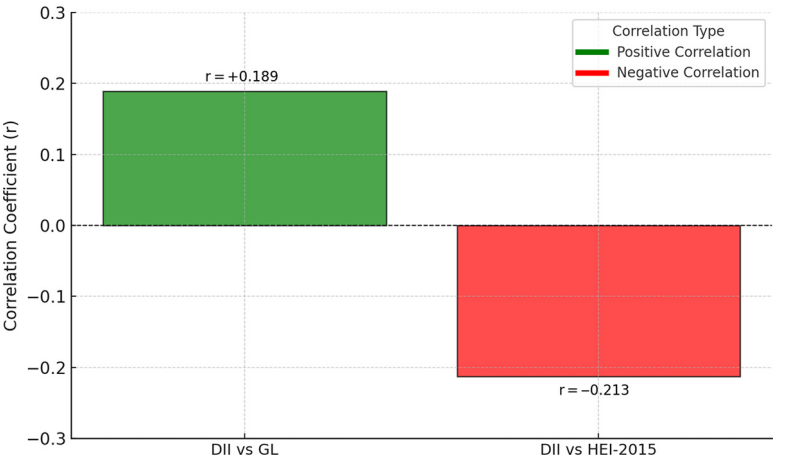
Source(s): Authors' own creation

Figure 2. Association between DII and WC, WHR, GL and HEI-2015

work status, routine habits and psychological state influence sleep quality. The observed differences in results are likely due to these factors.

In the study, while the DII increased, the HEI-2015 score decreased, and the difference between quarters was significant ($p < 0.05$), and there is a negative, significant correlation ($r = -0.2135$, $p < 0.001$) between DII and the HEI-2015 score. In a study on individuals with rheumatoid arthritis, a significant negative correlation was found between the DII and HEI-2015 (Jandari *et al.*, 2021). In another study conducted on 4,365 middle-aged healthy individuals, similar to this finding, as the DII increased, the HEI decreased significantly (Asadi *et al.*, 2020). This is an expected result, in line with the knowledge that an increase in the diet inflammatory index indicates an unhealthy diet, and an increase in the HEI 2015 score indicates a healthy diet.

Studies show that a high GI diet induces inflammation. High GI diets are characterized by hyperglycemia, and hyperglycemia is known to induce oxidative stress and increase the level of proinflammatory cytokines such as IL-6 and TNF-α in both healthy and impaired glucose-intolerant individuals (Esposito *et al.*, 2002; Dandona *et al.*, 2006). Elevated proinflammatory



Source(s): Authors' own creation

Figure 3. Correlation between DII, GL and HEI-2015

cytokine levels cause disruptions in insulin signaling, which can lead to insulin resistance (Piya *et al.*, 2013). Hyperglycemia associated with insulin resistance causes the accumulation of advanced glycosylation end products, producing proinflammatory cytokines in vascular endothelial cells (Lopez-Garcia *et al.*, 2004). Considering the effect of hyperglycemia on inflammatory pathways, providing and maintaining normoglycemia plays a key role in minimizing proinflammatory mechanisms (Kim *et al.*, 2018). Studies have determined a positive relationship between the GI and GL values of the diet and inflammation biomarkers (Milajerdi *et al.*, 2018; Bulló *et al.*, 2013). Because a low GI diet gradually reduces hyperglycemia and hyperinsulinemia by reducing the rate of glucose absorption in the body, this contributes to reducing the degree of systemic inflammation (Joslowski *et al.*, 2015).

Contrary to expectations, no significant relationship was found between DII and GI in the study. The GI value also increases as the DII score increases, but the difference between quartiles was insignificant. In terms of GL, there is a significant difference between the fourth and the first and second quartiles, and a negative and weak correlation was found between the DII score and GL ($r = -0.1887$, $p < 0.001$). The fact that simple carbohydrates are only one of the components that contribute to the DII score and that the factors associated with the high GI constitute only a small part of the total inflammatory capacity of the diet is thought to be the reason for the lack of a significant relationship between the DII and the GI. On the other hand, it is thought that the reason for the relationship between DII and GL is that the consumption amount of foods with high GI is higher than the consumption frequency.

Just as in the DII, a negative correlation was found between HEI-2015 and GL in the study, but no significant correlation was found between HEI-2015 and GI. HEI-2015 focuses on the consumption amount of the food rather than the consumption frequency of the food, and it makes a score based on how much (g or %) the individual consumes the relevant nutrient in the energy received in a day. Therefore, it is estimated that the reason for not detecting a relationship between HEI-2015 and GI is that the consumption amount of foods with high GI is higher than the consumption frequency.

Conclusion

The dietary habits of university students are generally proinflammatory, which increases the risk of many diseases, especially inflammation-related diseases. Nutrition education, including compulsory nutrition courses, peer education and family awareness, is critical to prevent this situation. The desired goal can be achieved through courses added to the curricula during the university education period and education that have become a public health policy.

In the future, the links between dietary habits, sociodemographic factors, sleep quality and anthropometric measurements should be investigated, especially through longitudinal studies. Cross-sectional studies are insufficient to establish causality, so longitudinal studies should be prioritized.

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