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Determining The Relationship Between Diet Inflammatory Index Score, Depression and Chronotype In Individuals with Metabolic Syndrome: An Example of a Training and Research Hospital

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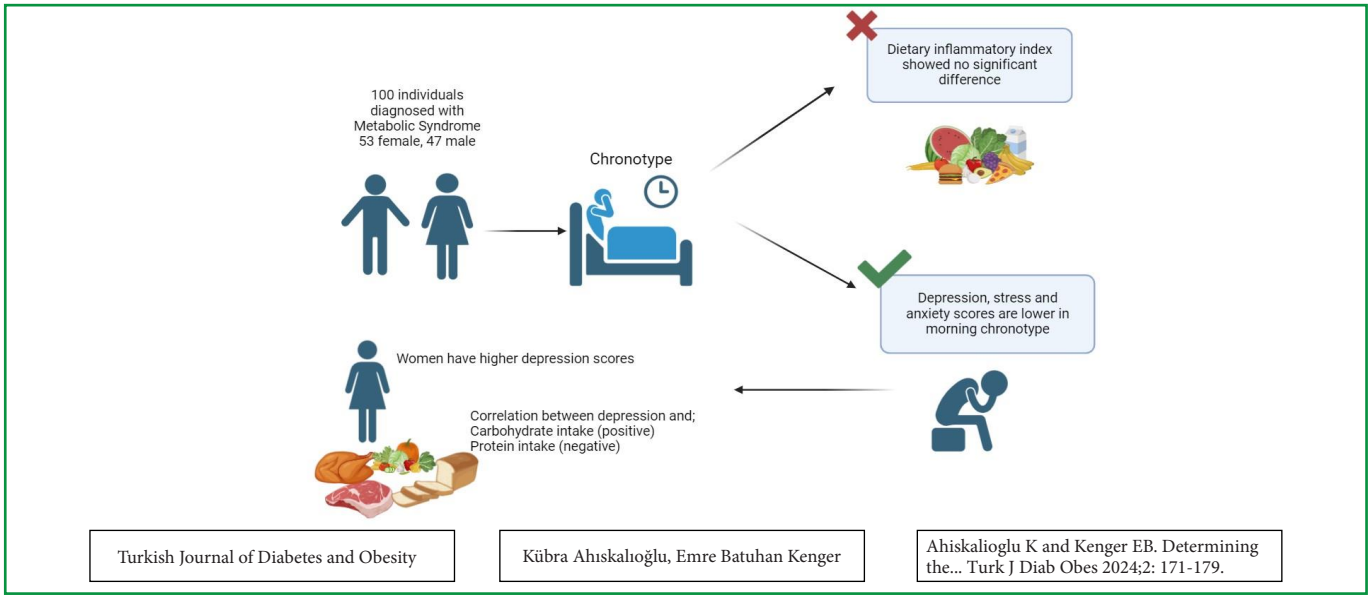
GRAPHICAL ABSTRACT



ABSTRACT

Aim: This study aimed to examine the relationship between the depression, chronotype and Dietary Inflammatory Index score in individuals diagnosed with metabolic syndrome.

Material and Methods: This study included 100 individuals with metabolic syndrome. The Depression-Anxiety Stress Scale was utilized to assess the depression, stress, and anxiety levels of the participants. Chronotypes were determined using the Morningness-Eveningness Questionnaire, and the Dietary Inflammatory Index (DII) was calculated based on a three-day food consumption record. ANOVA, independent samples t-tests and Pearson correlation coefficients were used in statistical analyses.

Results: Of the participants, 53.0% were women and 47.0% were men. Evening type was significantly higher for depression score (10.64±3.91; p: 0,001) than morning type and intermediate type; anxiety (10.38±3.51; p: 0.001) and stress scores (13.12±3.89; p: 0.013) were significantly higher than morning type. Female participants had significantly higher depression scores (9.68±4.39) compared to male participants (8.00±3.35) (p=0.033). Analysis of the Dietary Inflammatory Index (DII) scores revealed that women had a more

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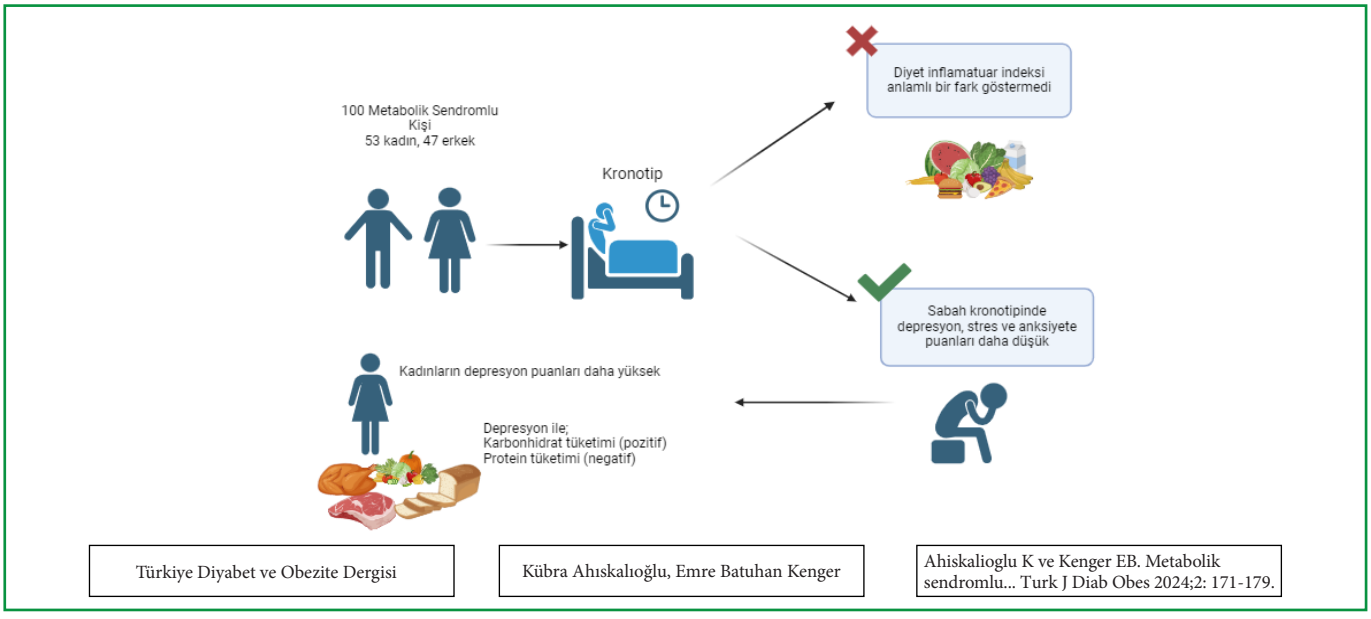
pro-inflammatory diet (3.23±5.69). Additionally, depression score was positively correlated with carbohydrate consumption (r: 0.264; p: 0.002) and negatively correlated with the percentage of energy from protein (r: -0.336; p: 0.001).

Conclusion: The study revealed that the majority of individuals with metabolic syndrome exhibit an evening chronotype and are at increased risk for depression, anxiety, and stress. Additionally, it was found that these individuals tend to follow a pro-inflammatory diet. Therefore, it is recommended that the treatment of individuals with metabolic syndrome includes the assessment of their chronotypes, nutritional habits, and psychological states.

Keywords: *Chronotype, Dietary inflammatory index, Depression and anxiety, Metabolic syndrome*

Metabolik Sendromlu Bireylerde Diyet İnflamatuar İndeks Skoru, Depresyon ve Kronotip Arasındaki İlişkinin Belirlenmesi: Bir Eğitim Araştırma Hastanesi Örneği

GRAFİKSEL ÖZET



ÖZ

Amaç: Bu çalışma, metabolik sendromlu bireylerde diyet inflamatuar indeks skoru, depresyon ve kronotip arasındaki ilişkinin belirlenmesi amacıyla yapılmıştır.

Gereç ve Yöntemler: Bu çalışmaya 100 metabolik sendromlu birey dahil edilmiştir. Katılımcıların, depresyon, stres ve anksiyete durumlarını değerlendirmek için Depresyon-Anksiyete Stres Ölçeği ölçeği, kronotiplerini belirlemek için sabahçıl-akşamcıl anketi ve Dİİ'lerini belirlemek için üç günlük besin tüketim kaydı yöntemi kullanılmıştır. İstatistiksel analizlerde ANOVA, bağımsız örnekler t-testleri ve Pearson korelasyon katsayılarından yararlanılmıştır.

Bulgular: Katılımcıların %53'ü kadın ve %47'si erkektir. Akşamcıl tip depresyon skoru için (10,64±3,91; p: 0,001) sahahçıl ve ara tipe göre; anksiyete (10,38±3,51; p: 0,001) ve stres skorları için (13,12±3,89; p: 0,013) sabahçıl tipe göre anlamlı şekilde yüksek çıkmıştır. Kadın katılımcıların depresyon skorları (9,68±4,39) erkeklere (8,00±3,35) göre anlamlı olarak daha yüksek bulunmuştur (p:0,033). Diyet inflamatuar indeks skorları incelendiğinde, kadınların daha pro-inflamatuar (3,23±5,69) bir beslenme tarzına sahip oldukları belirlenmiştir. Ayrıca, depresyon skoru ile karbonhidrat tüketimi arasında pozitif (r: 0,264; p: 0,002), enerjinin proteinden gelen yüzdesi ile ise negatif yönde (r:-0,336; p:0,001) korelasyon saptanmıştır.

Sonuç: Çalışma, metabolik sendromlu bireylerin çoğunluğunun akşamcıl tipte olduğunu ve bu bireylerin depresyon, anksiyete ve stres açısından risk altında olduğunu göstermiştir. Ayrıca bireylerin pro-inflamatuar bir beslenme tarzına sahip olduğu saptanmıştır. Metabolik sendromlu bireylerin tedavisinde kronotiplerinin belirlenmesi, beslenme alışkanlıklarının ve psikolojik durumlarının değerlendirilmesi önerilmektedir.

Anahtar Sözcükler: *Diyet inflamatuar indeksi, Depresyon ve anksiyete, Kronotip, Metabolik sendrom*

INTRODUCTION

Metabolic syndrome (MetS) is emerging as a significant public health concern globally, often manifesting without noticeable symptoms (1). MetS, hyperglycaemia, abdominal obesity, is a clinical picture characterised by the coexistence of several major risk factors such as hypertension and dyslipidaemia. The National Cholesterol Education Program III (NCEP-ATP III) diagnosis for metabolic syndrome is cardiovascular-centered and must include 3 or more of the risk factors. These risk factors; abdominal obesity (female: >88 cm; male: >102 cm), high blood pressure (≥130/85 mmHg), low high-density lipoprotein (HDL) (male: < 40 mg/dL; female: <50 mg/dL) hypertriglyceridemia (> 150 mg/dL), high fasting blood sugar (≥100 mg/dL) (2-4). Approximately one-quarter of the global population is affected by MetS, and the chronic conditions associated with this syndrome were estimated to account for approximately $543 billion in healthcare costs in the United States in 2017 (5,6). In Turkey, the prevalence of MetS was reported to be 32.9% in general, 38.3% in women and 26.8% in men (7).

MetS, which has multiple pathophysiological underpinnings, encompasses insulin resistance, chronic inflammation, and abdominal fat accumulation associated with increased adipose tissue. Inflammation is essential in the onset and advancement of MetS (8). Elevated inflammatory cytokine activity initiates both prothrombotic and proinflammatory processes (9). In obesity, cells in adipose tissue, liver, muscle, and pancreas shift from an anti-inflammatory to a pro-inflammatory state, resulting in the recruitment of macrophages and other immune cells (10). Additionally, MetS-related complications are triggered by the imbalance in the inflammatory components of adipose tissue (11).

Depression is also thought to be linked with MetS. Adipokines are reported to play a crucial role in the common pathophysiology between obesity and depression (12). Depression and anxiety levels were found to be significantly higher in obese individuals than in non-obese individuals (13). It has also been shown that depression score is significantly higher in individuals with diabetes (14). Additionally, numerous environmental factors are shared between depression and diabetes. The observation that individuals with depression, even those who are otherwise physically healthy, have a 1.5- to 2-fold higher risk of cardiovascular complications further underscores the link between depression and cardiovascular health (15).

Circadian rhythm disorder, increasingly prevalent among lifestyle factors related to MetS, has been shown to contribute to the development of both MetS and depression (16). All components of MetS have been associated with abnormal circadian rhythms, and it has been reported that individuals who work shifts are significantly more likely to develop overweight and diabetes mellitus due to circadian rhythm disruption (17).

In light of this information, this study aimed to determine the relationship between the Dietary Inflammatory Index (DII) score, depression, and chronotype in individuals with MetS. It is crucial to identify disturbances in sleep patterns and associated depression in individuals who are already experiencing an inflammatory process due to MetS. This identification can help to emphasize the importance of their eating habits and sleep patterns.

MATERIAL and METHODS

Study Design

This cross-sectional study was carried out to explore the relationship between the Dietary Inflammatory Index (DII) measurements and the levels of depression, stress, anxiety, and chronotype in individuals with MetS. All participants volunteered for the study, provided verbal consent after receiving information about the study, and subsequently signed written informed consent forms. Ethical principles, including confidentiality, protection of privacy, non-maleficence/beneficence, and respect for personal rights, were strictly adhered to throughout the study period. Permission to use the scale was obtained from the relevant authors.

Place, Time and Sample Selection of Research

The sample for this study comprised adults diagnosed with MetS (18) who volunteered to participate and were followed up at the Internal Medicine Polyclinic Hospital in Istanbul between May and June 2023. The sample size of the study was calculated in G*Power 3.1.9.4. power analysis programme (19). Power analysis determined that at least 82 participants were needed for this research to achieve a power level of 1-ß=0.95 (20).

Data Collection Tools of the Research

The Depression Anxiety Stress Scale 21 (DASS-21) was used to assess the depression status of individuals who volunteered to participate in the study. Furthermore, the Morningness-Eveningness Questionnaire was utilized to identify participants' chronotype, and a three-day food consumption record was collected to calculate the Dietary Inflammatory Index (DII).

Morningness-Eveningness Questionnaire

The questionnaire consists of a total of 19 questions and evaluates individuals' sleep and wakefulness patterns, performance levels, and lifestyles. Chronotypes are determined

based on the score calculated from the survey responses. Specifically, a total score between 59 and 86 categorizes an individual as a 'morning type,' a score between 42 and 58 as an 'intermediate type,' and a score between 16 and 41 as an 'evening type.' The Turkish adaptation and reliability studies of the Morningness-Eveningness Questionnaire were conducted by Pündük et al. (21). The Cronbach's alpha value for the morningness-eveningness questionnaire was 0.838 in this study.

Depression Anxiety Stress Scale 21

DASS-21 was adapted to Turkish in 2018. Following an explanatory factor analysis, the 21-item scale was organized into three subscales: depression, anxiety, and stress. Each item on the scale is scored from 0 (Never) to 3 (Always). To determine the overall score, the scores from each subscale are summed. It is indicated that higher scores correspond to an increased risk of depression, anxiety, and stress (22). The Cronbach's alpha value for DASS-21 was 0.798 in this study.

Diet Inflammatory Index

The DII was developed to establish a scoring system for specific nutrients that are believed to influence inflammation either positively or negatively. Negative DII scores reflect an anti-inflammatory diet, whereas positive DII scores reflect a pro-inflammatory diet (23).

Assessment of Data

Statistical analysis was performed using SPSS (Statistical Package for the Social Sciences) version 26.0. A significance threshold of $p<0.05$ was used. Descriptive statistics for continuous variables included mean, standard deviation, minimum, and maximum values, while categorical variables were summarized with frequency and percentage distributions. The Kolmogorov-Smirnov and Shapiro-Wilk tests were used to verify the normality of the data distribution. Consequently, ANOVA was employed for comparisons among three or more groups, and independent samples t-tests were used for comparisons between two groups. Pearson correlation coefficients were utilized for relationship analyses.

RESULTS

Among the participants, 53.0% were female and 47.0% were male. Furthermore, 74.0% of the participants were married, and 26.0% were single. Table 1 provides the demographic details of the participants.

Table 2 presents the percentage distributions of participants based on their DASS-21 scores and chronotype groups. The analysis of depression scores indicated that 13.0% of participants fell into the normal range, 15.0% were classified as severe, and 14.0% were in the very severe range. For anxiety scores, 10.0% of participants were in the normal range, 20.0% in the severe range, and 41.0% in the very severe range. Regarding stress scores, 12.0% of participants fell into the normal category, 27.0% were in the severe category, and 19.0% were in the very severe category. Examination of the chronotype scores indicated that 18.0% of participants were morning types, 32.0% were intermediate types, and 50.0% were evening types.

Table 1: Demographic characteristics of the participants.

Variables	Female (n=53)	Male (n=47)	Total (n=100)
Age (year±SD)	45.92 ± 9.25	47.83 ± 9.12	46.96 ± 9.16
Body Weight (kg±SD)	76.45 ± 6.84	91.49 ± 7.17	83.81 ± 10.03
Height (cm±SD)	160.13 ± 5.42	174.26 ± 4.74	166.73 ± 8.62
Body Mass Index (kg/m^2±SD)	29.85 ± 2.75	30.14 ± 2.17	30.10 ± 2.36
Body Mass Index Categories, n (%)			
Overweight	31 (31.0)	21 (21.0)	52 (52.0)
Obese	22 (22.0)	26 (26.0)	48 (48.0)
Marital Status n (%)			
Married	44 (44.0)	30 (30.0)	74 (74.0)
Single	9 (9.0)	17 (17.0)	26 (26.0)
Education Level, n (%)			
Primary school	6 (6.0)	6 (6.0)	12 (12.0)
Middle school	28 (28.0)	16 (16.0)	44 (44.0)
High school	18 (18.0)	21 (21.0)	39 (39.0)
University	1 (1.0)	4 (4.0)	5 (5.0)

***SD:** Standart Deviation

Table 3 shows the DASS-21, chronotype, and DII scores of the participants according to gender. The depression scores of female participants were found to be significantly higher than those of male participants (p<0.05). Conversely, male participants had significantly higher stress scores (p<0.05). Analysis of the DII scores indicated that women had a more pro-inflammatory diet, though this difference approached but did not reach statistical significance (p=0.066).

Table 4 presents the DASS-21 and DII scores of participants categorized by their chronotype groups. The anxiety, depression, and stress scores of participants varied significantly across the chronotype groups, with the "evening type" group exhibiting significantly higher scores in all three areas (p<0.05). However, the DII scores did not significantly differ among the various chronotype groups.

Significant differences in anxiety scores were identified between morning types and evening types, as well as between morning types and intermediate types. For depression scores, notable differences were found between morning types and evening types, and between evening types and intermediate types. In terms of stress scores, significant differences were observed between morning and evening groups.

Figure 1 shows the DII scores of participants according to their BMI groups. Obese individuals (score: 3.17±0.89) seem to follow a more pro-inflammatory diet compared to those who are overweight (score: 1.17±0.87; p=0.114).

The depression score was significantly linked to both protein percentage and carbohydrate intake (p<0.05). There was a notable negative correlation between the depression score and protein percentage (r=-0.336, p<0.01), as well as a significant positive correlation between the depression score and carbohydrate intake (r=0.264, p<0.01) (Table 5).

Table 2: Percentage Distribution Values of Participants for DASS-21 and Chronotype Groups (n= 100).

Parameters		Values (n=100)	
Depression Score, n (%)	Normal	13	(13.0)
	Mild	19	(19.0)
	Moderate	39	(39.0)
	Severe	15	(15.0)
	Extremely Severe	14	(14.0)
Anxiety Score, n (%)	Normal	10	(10.0)
	Mild	14	(14.0)
	Moderate	15	(15.0)
	Severe	20	(20.0)
	Extremely Severe	41	(41.0)
Stress Score, n (%)	Normal	12	(12.0)
	Mild	18	(18.0)
	Moderate	24	(24.0)
	Severe	27	(27.0)
	Extremely Severe	19	(19.0)
Morning-Evening Score, n (%)	Morning Type	18	(18.0)
	Intermediate Type	32	(32.0)
	Evening Type	50	(50.0)

Table 3: DASS, chronotype and DII scores of participants according to gender.

DASS, chronotype and DII scores	Women (n=53)	Men (n=47)	Total (n=100)	P
Depression Score±SD	9.68 ± 4.39	8.00 ± 3.35	8.92 ± 4.03	0.033*
Anxiety Score±SD	9.30 ± 4.29	8.43 ± 4.08	8.95 ± 4.13	0.299
Stress Score±SD	11.28 ± 3.98	12.83 ± 4.17	12.10 ± 4.03	0.041*
Morning-Evening Score±SD	43.30 ± 12.73	45.15 ± 12.95	44.12 ± 12.75	0.474
DII Score±SD	3.23 ± 5.69	0.94 ± 6.59	2.13 ± 6.26	0.066

*T test was used in independent groups. Statistical significance level p<0.05. **SD:** Standart Deviation, **DASS:** The Depression Anxiety Stress Scale, **DII:** Dietary Inflammatory Index

Table 4: DASS and DII scores according to chronotype categories.

DASS and DII scores	Morning Type (n=18)	Intermediate Type (n=32)	Evening Type (n=50)	Total (100)	p
Depression Score±SD	6.27 ± 3.78	7.62 ± 2.94	10.64 ± 3.91	8.92 ± 4.03	0.001*
Anxiety Score±SD	4.44 ± 4.19	9.06 ± 4.07	10.38 ± 3.51	8.95 ± 4.13	0.001*
Stress Score±SD	10.05 ± 4.49	11.37 ± 3.81	13.12 ± 3.89	12.10 ± 4.03	0.013*
DII Score±SD	1.34 ± 7.44	3.53 ± 5.15	1.56 ± 6.31	2.13 ± 6.26	0.312

*One way ANOVA test was used. Statistical significance level p<0.05. For anxiety score, between morning person-evening type and morning person-intermediate type; For depression score, between morning-evening and evening-intermediate types; For the stress score, there are significant differences between the morning and evening groups.*SD: Standart Deviation, DASS: The Depression Anxiety Stress Scale, DII: Dietary Inflammatory Index

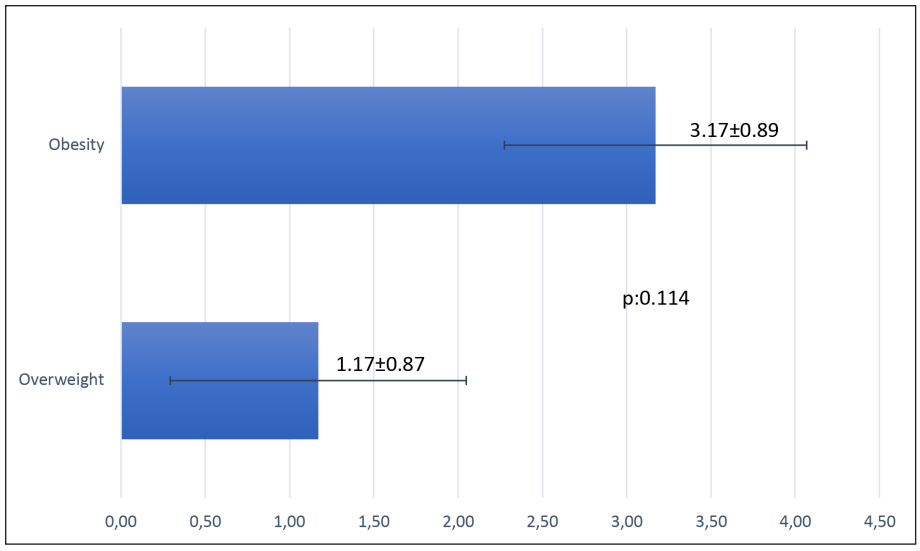


Figure 1: DII scores according to BMI categories.

Table 5: Relationship between depression score and nutrient intakes.

Parameters		Depression Score
Fat (g)	r	0.171
	p	0.090
Fat (%)	r	0.007
	p	0.945
Protein (g)	r	-0.097
	p	0.336
Protein (%)	r	-0.336*
	p	0.001
Carbohydrate (g)	r	0.264*
	p	0.002
Carbohydrate (%)	r	0.171
	p	0.089
Fiber (g)	r	0.051
	p	0.612
Cholesterol (mg)	r	-0.146
	p	0.147

* Pearson correlation was used. Statistical significance level p<0.05.

DISCUSSION

This study was conducted to determine the relationship between DII, depression and chronotype in individuals with MetS.

Eighteen percent of the participants are classified as morning types, 32.0% as intermediate types, and 50.0% as evening types. It has been reported that evening types generally experience more health and behavioral problems compared to morning types. Disturbances in the circadian system can influence energy expenditure, sleep, appetite, and other factors that may lead to obesity (24). Individuals with an evening chronotype have been linked to having a higher BMI, increased triglycerides, reduced HDL-cholesterol levels, elevated HOMA-IR, and a significantly higher overall MetS score (25). The predominance of evening types among the participants underscores its close relationship with MetS, corroborating existing literature. When examining the depression scores of the participants, 13.0% were in the normal category, 19.0% in the mild category, 39.0% in the moderate category, 15.0% in the severe category, and 14.0% in the very severe category. A bidirectional relationship between depression and MetS has been suggested. A study investigating the prevalence of MetS in patients with major depressive disorder found that the prevalence of MetS was 2.4 times higher in this population (26). Another study indicated that individuals with depression are strongly associated with being in a high-risk group for MetS, and consequently, with increased cardiovascular morbidity and mortality (27).

In this study, no significant difference in DII scores was observed between genders. Similarly, Muhammad et al. reported no statistically significant gender-specific difference in a study using the DII score (28). Additionally, it has been reported that a pro-inflammatory diet is associated with an increased risk of future depression (29). In this study, although the difference was not statistically significant, women exhibited a more pro-inflammatory diet compared to men. This dietary pattern may contribute to the higher depression scores observed in women compared to men in the DASS-21 results.

Anxiety, depression, and stress scores showed significant differences among the chronotype groups ($p<0.05$). Daily circadian rhythms are known to influence changes in human physiology and behavior, and there is increasing evidence for a strong association between a disrupted circadian system and mood disorders (30). The evening chronotype exhibited the highest prevalence of all measured psychological symptoms (31). The exact mechanisms linking chronotype to depression are still not entirely clear. It is suggested that individuals with an evening chronotype might be more prone to depression due to a misalignment in their sleep-wake cycle. People who prefer to stay up late and wake up late often have to conform to societal schedules that clash with their natural biological rhythms. This misalignment can cause sleep disturbances and disrupt the rhythmic activity of neurotransmitters, which may contribute to the development of mental disorders (32). These findings are consistent with previous studies suggesting a relationship between the evening chronotype and increased severity of anxiety and depression symptoms. The data obtained in this study align with the existing literature, as anxiety, depression, and stress scores were significantly higher in the "evening type" group.

The study show that no statistically significant relationship was found between DII and BMI. A study evaluating the relationship between DII score and overweight status indicated having a normal body weight does not necessarily correspond to a diet with lower inflammatory potential or higher quality. It was also observed that obese participants had lower DII scores compared to normal-weight participants (33). In contrast, a study conducted in the United States of America (USA) found that a higher DII score was linked to an increased risk of obesity and had a significant impact on obesity (34). In a study conducted in Indonesia, it was concluded that there was no association between the DII score and any anthropometric measurements (28). Additionally, a cross-sectional study in Spain found that the DII score was linked to BMI in women but not in men (35). These studies suggest that the effect of DII on body weight is not yet clear. Studies with larger participants will effectively reveal the relationship between BMI and DII.

The study shows that a positive correlation was found between depression scores and carbohydrate consumption, and a negative correlation with the protein percentage of the diet. This suggests that a poor-quality diet may lead to nutritional deficiencies associated with depression and anxiety disorders (36). The intake of refined, simple, and low-quality carbohydrates has a direct impact on both physical and mental pathophysiology (37). Increasing evidence indicates that carbohydrate intake affects depression (38). Thus, the observed positive relationship between depression scores and carbohydrate intake in this study is consistent with findings reported in the literature.

A negative relationship was found between protein consumption and depression scores in our study, indicating that a higher protein percentage is associated with lower depression scores. Amino acids, the building blocks of proteins, have been shown to have beneficial effects on mental function (39). According to data from a cross-sectional study conducted between 2007 and 2014, total protein intake and the risk of depressive symptoms were inversely related (40). The literature supports the notion that protein intake has an indirect protective effect against the risk of depression, which is consistent with the findings of this study.

This study has several limitations. Firstly, the study is that the number of samples is small. Secondly, the study was conducted in a single state hospital. Multicenter and large-participant studies can increase the generalizability of the findings.

This study investigating individuals with MetS revealed that the majority of participants were evening types, were at risk for depression, anxiety, and stress, and had a pro-inflammatory diet. Additionally, it was observed that depression scores were negatively related to the protein percentage of the diet and positively related to carbohydrate consumption. It is suggested that determining chronotypes, and evaluating eating habits and psychological states will enhance the success of treatment in individuals with MetS.

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Author's Contributions
Conceptualization: **Kubra Ahiskalioglu, Emre Batuhan Kenger,** methodology: **Kubra Ahiskalioglu, Emre Batuhan Kenger,** investigation: **Kubra Ahiskalioglu, Emre Batuhan Kenger,** data curation: **Kubra Ahiskalioglu,** analysis: **Emre Batuhan Kenger,** writing – original draft: **Kubra Ahiskalioglu, Emre Batuhan Kenger,** Writing –review & editing: **Kubra Ahiskalioglu, Emre Batuhan Kenger,** supervision: **Emre Batuhan Kenger**.

Conflict of Interest
None.

Financial Disclosure
No specific funding was received for this study.

Ethical Approve and Informed Consent
Informed consent in writing was obtained from all participants. Permission was received from Istanbul Bahçeşehir University Ethics Committee to conduct the research (approval number 2023-/03, dated 30.03.2023) and the study was conducted in accordance with the principles of the Declaration of Helsinki.

Peer Review Process
Extremely and externally peer-reviewed.

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