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Research article

Effects of chronotype on Mediterranean diet adherence and appetite status in young adults

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Abstract

Chronotypes are classified as morning, evening, and intermediate types, and individuals with evening chronotypes are thought to have less healthy diets. Studies on the chronotypes of young adults at risk for disordered eating and sleep habits and the effects of chronotypes on nutrition are limited. Our study aimed to evaluate appetite status and Mediterranean diet scores according to chronotypes in young adults. The study was conducted in a cross-sectional design on 362 healthy young adults aged 18-35 years. Participants' appetite status, chronotype categories, and adherence to the Mediterranean diet were determined using scales. The data from the study were analysed using SPSS 28.0 software. According to the results of the study, morning chronotype individuals (7.69±0.31) adhere to the Mediterranean diet more than evening chronotype individuals (6.54±0.28) (p=0.002). A negative correlation was found between Mediterranean diet scores and evening (R=-0.184, p=0.000) and screen-based appetite (R=-0.104, p=0.048). However, no significant differences were found between chronotypes regarding appetite status (p>0.05). This study revealed that individuals in the morning chronotype showed higher adherence to the Mediterranean diet and that individuals in the evening chronotype are a group that needs more attention in terms of nutrition. These findings may contribute to the development of nutrition and health policies.

Keywords: *Appetite; chronotype; Mediterranean diet; nutrition; young adult*

1. Introduction

Living organisms exhibit rhythmic cycles in various processes such as physiological, hormonal, and behavioural processes (Selvi et al., 2017). In humans, many physiological and metabolic variations, such as sleep-wakefulness and nutritional behaviours, which have a 24-hour cycle, show time-dependent changes during the day. These rhythms that determine and/or affect human physiology are governed by a biological internal clock (Haspel et al., 2020). This circadian clock, specialised for biological determinants, ensures the maintenance of appropriate rhythms in endocrine pathways for body homeostasis (Asher and Sassone-Corsi, 2015; Julius et al., 2019). Chronotype, which reflects the circadian phases of individuals, is a concept that first emerged in 1974 and is defined as the preference for individuals' sleep and waking times (Roenneberg et al., 2019). Chronotype is also defined as an expression of individual circadian rhythm related to nutrition patterns (Takahashi et al., 2018). In addition to the timing of physiological changes such as cortisol and melatonin secretion,

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attention and work efficiency also differ between chronotypes (Salehinejad et al., 2021). Circadian rhythms are divided into three categories: morning, intermediate, and evening. Morning chronotypes tend to start their day early and prefer to engage in physical activities in the early hours. Conversely, evening chronotypes tend to wake up later and perform their daily tasks and activities in the evening. The intermediate type encompasses both categories (Muscogiuri et al., 2020). It is thought that there is a relationship between individuals' chronotypes and their eating habits, and that evening chronotypes associated with poor eating patterns. These patterns include skipping breakfast, consuming fewer vegetables and fruits, and consuming more foods high in sugar (Mazri et al., 2020; Romo-Nava et al., 2020; Teixeira et al., 2023; Martins et al., 2024). In addition, it is thought that evening chronotypes may be associated with an increase in body mass index (BMI) parallel to an increase in energy intake late at night (Beaulieu et al., 2020; Beaulieu et al., 2024). Interestingly, there is evidence that the relationship between meal timing and obesity is influenced by chronotype (Xiao et al., 2019; Teixeira et al., 2024). These findings suggest a potential interaction between meal timing, chronotype type, appetite, and eating behaviour. To our knowledge, there is a limited studies on the effect of chronotype characteristics of young adults, who are reported to have significantly more irregular sleep with increased use of technological devices (Richardson et al., 2017), on adherence to the Mediterranean diet (MD), which has proven positive health effects (Papadaki et al., 2020), and on appetite status. Our study aimed to determine the association of chronotype characteristics of young adults with adherence to MD and appetite status.

2. Materials and methods

2.1. Design of the study

This research was planned to be cross-sectional; an e-survey was created using Google Forms, and data were collected between May and July 2022 following ethical approval. Using the G*Power 3.1.9.2 programme (Faul et al., 2007), considering the type 1 error rate α=0.05, type 2 error rate β=0.20, and test power 1- β=0.80, it was determined that at least 159 people should be included in our study. The inclusion criteria for the study were accepting the informed consent form and being between 18 and 35 years of age. The exclusion criteria included having a diagnosis or history of sleep apnea, insomnia, narcolepsy, restless legs syndrome, or psychiatric disorders, being pregnant or lactating, and working in shifts. The study sample consisted of 362 healthy young adults aged 18-35 years living in Istanbul, Türkiye, who volunteered to participate in the study. A questionnaire form questioning the sociodemographic information, anthropometric measurements, and dietary habits of the individuals was filled out via an online platform. Ethical approval has been obtained from the Bahcesehir University Ethics Committee (no: E-20021704-604.01.02-33312).

2.2. Determination of appetite status

A visual analogue scale (VAS) was used to assess participants' appetite status. The VAS is frequently used in clinical and scientific research. This measurement provides important information about emotions that are difficult to assess using other methods (Gibbons et al., 2019). To ensure continuity with the VAS, extreme emotions are recorded at both ends of a 100-millimetre horizontal line. The individual can easily express the intensity of the emotion he/she feel on the line, which makes the emotion measurable afterwards. The visual analogue scale used in the study shows the evaluation of the subjective appetite status of the individual from 1 to 10 on the line. In this context, the participants' feelings of hunger, appetite status, appetite status in the evening hours, and appetite status in front of the screen (television, computer, telephone) were evaluated with VAS.

2.3. Determination of chronotypes

To determine the chronotypes of the individuals, the Morningness-Eveningness Questionnaire (MEQ) was applied (Horne and Östberg, 1976). The Turkish validity and reliability study of the MEQ was conducted by Punduk et al. (2005). The questionnaire consists of 19 questions. The scoring of the questions varies for each question. Questions 3-9 and 13-16 are scored between 1 and 4 points, questions 1, 2, 10, 17, and 18 are scored between 1 and 5 points, questions 11 and 19 are scored between 0 and 6 points, and question 12 is scored between 0 and 5 points. According to the obtained scores, chronotypes were classified as morning (59-86 points), intermediate (42-58 points), and evening (16-41 points).

2.4. Determination of adherence to the Mediterranean diet

Participants' adherence to the MD was determined using the Mediterranean Diet Adherence Scale (MEDAS). In the study of Pehlivanoglu et al. (2020), the adapted version of the scale into Turkish was found to be reliable. The scale consists of a total of 14 items. For each question asked according to the amount of consumption, 1 or 0 points are obtained, and the total score is calculated. The total score varies between 0-14, with a low score indicating low adherence with the MD and a high score indicating high adherence with the MD. MEDAS score $\leq$6 is classified as low adherence to the MD, 7-9 as acceptable adherence, and $\geq$9 as high adherence (Schroder et al., 2011).

2.5. Statistical analysis

The data obtained were statistically evaluated using the SPSS 28.0 package programme. Statistical significance was accepted as $p<0.05$ in all analyses. The normal distribution of the data was analysed by the Kolmogorov-Smirnov test. Descriptive statistics included number and percentage, mean, standard deviation, standard error, and confidence interval values. The general characteristics according to chronotype categories were determined by chi-square or one-way analysis of variance (ANOVA) test. Adjusted means of MD adherence scores and appetite status (age, gender, smoking, alcohol consumption, regular sleep status, education level, BMI, presence of chronic diseases) were compared between chronotype categories using Bonferroni-corrected analysis of covariance (ANCOVA). The relationships between MD adherence and appetite status were analysed by Pearson correlation analysis.

3. Results

The sample of our study consisted of 362 young adults with a mean age of 25.74±5.83 years, 78.5% of whom were female. When the chronotypes of the participants were analysed, it was

Table 1
General characteristics of participants according to chronotype categories.

	Morning (n=55)	Intermediate (n=236)	Evening (n=71)	Total (n=362)	P value
Gender					0.095 Cramér's V=0.114
Female	45 (15.8)	190 (66.9)	49 (17.3)	284 (78.5)	
Male	10 (12.8)	46 (59.0)	22 (28.2)	78 (21.5)	
Age (years)	25.9±6.22	25.89±6.12	25.07±4.37	25.74±5.83	0.553 η^2=0.003
Weight (kg)	64.63±13.10	65.09±15.68	65.35±15.02	65.07±15.15	0.966 η^2=0.001
BMI (kg/m²)	22.57±3.79	22.80±4.25	22.47±3.73	22.70±4.08	0.812 η^2=0.001
Education status					0.737 Cramér's V=0.041
Bachelor degree	44 (15.6)	185 (65.6)	53 (18.8)	282 (77.9)	
Master's degree	11 (13.8)	51 (63.7)	18 (22.5)	80 (22.1)	
Smoking status					**0.009** Cramér's V=0.162
Yes	8 (7.8)	66 (64.7)	28 (27.5)	102 (28.2)	
No	47 (18.1)	170 (65.4)	43 (16.5)	260 (71.8)	
Alcohol consumption status					**0.027** Cramér's V=0.142
Yes	21 (13.3)	96 (60.8)	41 (25.9)	158 (43.6)	
No	34 (16.7)	140 (68.6)	30 (14.7)	204 (56.4)	
Presence of chronic disease					0.601 Cramér's V=0.053
Yes	12 (15.6)	53 (68.8)	12 (15.6)	77 (21.3)	
No	43 (15.1)	183 (64.2)	59 (20.7)	285 (78.7)	
The most skipped meal					**0.004** Cramér's V=0.153
Breakfast	12 (8.2)	95 (64.6)	40 (27.2)	147 (40.6)	
Lunch	32 (18.5)	115 (66.5)	26 (15.0)	173 (47.8)	
Dinner	3 (25.0)	9 (75.0)	0 (0.0)	12 (3.3)	
Regular sleep pattern					**<0.001** Cramér's V=0.361
Yes	44 (21.7)	143 (70.4)	16 (7.9)	203 (56.1)	
No	11 (6.9)	93 (58.5)	55 (34.6)	159 (43.9)	

*BMI: Body Mass Index, Statistical significance: $p<0.05$; Cramér's V=effect size for chi-square test; η^2=effect size for ANOVA test.

found that 65.2% were intermediate type, followed by evening type with 19.6% and morning type with 15.2%. Gender, age, BMI, body weight, education level, and presence of chronic diseases did not show significant differences according to chronotype categories ($p>0.05$). Significant differences were found in smoking status ($p=0.009$), alcohol consumption ($p=0.027$), most frequently skipped meal ($p=0.004$), and regular sleep ($p<0.001$). While 21.7% of the participants with regular sleep were morning people, this rate was found to be 6.9% in participants with irregular sleep ($p<0.001$). The most frequently skipped meal of the participants was lunch, with 47.8%, followed by breakfast with 40.6%. While 27.2% of the participants who skipped breakfast were in the evening chronotype, this rate decreased to 15.0% for lunch ($p=0.004$) (Table 1).

The effect of the chronotype categories of the participants on the MD adherence scores is analysed in Fig. 1. It was found that the MD adherence score decreased from morning to evening [7.69±0.31 (CI: 7.09-8.28) to 6.54±0.28 (CI: 6.03-7.12), $p=0.002$]. When the effects of chronotype categories on the appetite status of individuals were analysed, it was found that although there was a lower tendency in the morning chronotype to feel hungry, recent appetite status, appetite status in the evening hours and appetite status in front of the screen (television, computer, telephone) compared to other categories, these trends were not significant ($p>0.05$) (Table 2).

The relationships between the MD adherence scores and the appetite status of the participants are evaluated in Fig. 2.

Table 2
Evaluation of appetite status according to chronotype categories.

	Morning (n=55)		Intermediate (n=236)		Evening (n=71)		P value	η^2 partial
	Mean±SE	CI Lower -Upper Bound	Mean±SE	CI Lower -Upper Bound	Mean±SE	CI Lower -Upper Bound		
Feeling hungry	5.55±0.25	5.06-6.07	5.50±0.12	5.26-5.74	5.86±0.23	5.44-6.37	0.433	0.01
Appetite status	5.99±0.29	5.56-6.64	6.04±0.14	5.76-6.32	6.11±0.28	5.56-6.64	0.896	0.01
Appetite in the evening	6.07±0.30	5.48-6.68	6.37±0.14	6.08-6.64	6.91±0.28	6.34-7.44	0.105	0.01
Appetite in front of the screen	4.46±0.36	3.75-5.18	5.01±0.17	4.67-5.34	4.81±0.33	4.17-5.48	0.446	0.01

*CI: Confidence Interval, SE: Standard Error, Statistical significance: $p<0.05$; η^2 partial=effect size for ANCOVA test.

There were weakly significant negative correlations between MD adherence scores and appetite status in the evening (R= -0.184, *p*= 0.000) and appetite status in front of screens (television, computer, telephone) (R= -0.104, *p*= 0.048). No significant correlations were found between feeling hungry and appetite status and MD adherence scores (*p*>0.05) (Fig. 2).

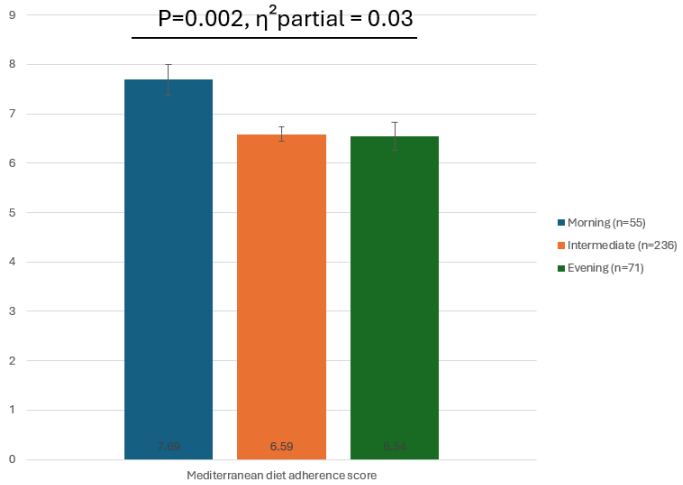


Fig. 1. Evaluation of adherence to Mediterranean diet according to chronotype categories. *Statistical significance: *p*<0.05; η² partial=effect size for ANCOVA test.

4. Discussion

This study aimed to examine how young adults' adherence to MD and appetite are affected by chronotype categories. Significant differences in MD adherence scores between chronotypes are the primary finding of our study. However, appetite scores did not show significant differences between chronotype categories. In addition, we found negative correlations between MD adherence and individuals' self-reported appetite in the evening and appetite in front of the screen.

In our study, it was found that the MD adherence score decreased from morning to evening (*p*=0.002). Our findings are in parallel with studies in the literature (Muscogiuri et al., 2020; Naja et al., 2022; Godos et al., 2023; Memic-Inan et al., 2024). In a review of observational studies on a total of 1936 adults, individuals who reported having an intermediate (n = 614) and evening (n = 173) chronotype were less likely to show a high level of adherence to the MD compared to the morning chronotype (OR = 0.28, 95% CI: 0.18, 0.42 and OR = 0.08, 95% CI: 0.03, 0.27, respectively) (Godos et al., 2023). In a cross-sectional study of 172 middle-aged adults, the chronotype score was positively correlated with the Mediterranean Diet Quality Index (PREDIMED) score (r = 0.656; p < 0.001) (Muscogiuri et al., 2020). In another study of 503 university students, good adherence to the MD was shown to have a significant association with better subjective sleep quality, fewer sleep delays, sleep disturbances, and daytime dysfunction, even after adjusting for age and gender (Naja et al., 2022). Several molecular mechanisms underlying the positive health effects of MD have been identified. These mechanisms include gut microbiota balance, reduction of low-density lipoprotein cholesterol levels, reduction of oxidative stress and inflammation in the body, improvement of insulin resistance, and enhancement of immune function. Greater adherence to the MD has been associated with lower levels of inflammatory cytokines, including C-reactive protein (CRP), interleukin-1 (IL-1), tumour necrosis factor (TNF)-α, and IL-6, which are also linked to poor sleep quality (Naja et al., 2022). As adherence to MD improves sleep patterns (Fallah et al., 2024; Patel and Cheung, 2025), it also facilitates the determination of chronotype (Muscogiuri et al., 2020). In our current study, 21.7% of the participants with regular sleep were morning chronotypes, while this rate was found to be 6.9% in participants with irregular sleep, which supports this finding in the literature.

In our study, high adherence to the MD was negatively associated with appetite status in the evening (R=-0.184, *p*=0.000) and appetite status in front of the screen (R=-0.104, *p*= 0.048). In a study conducted on type 2 diabetic patients, although

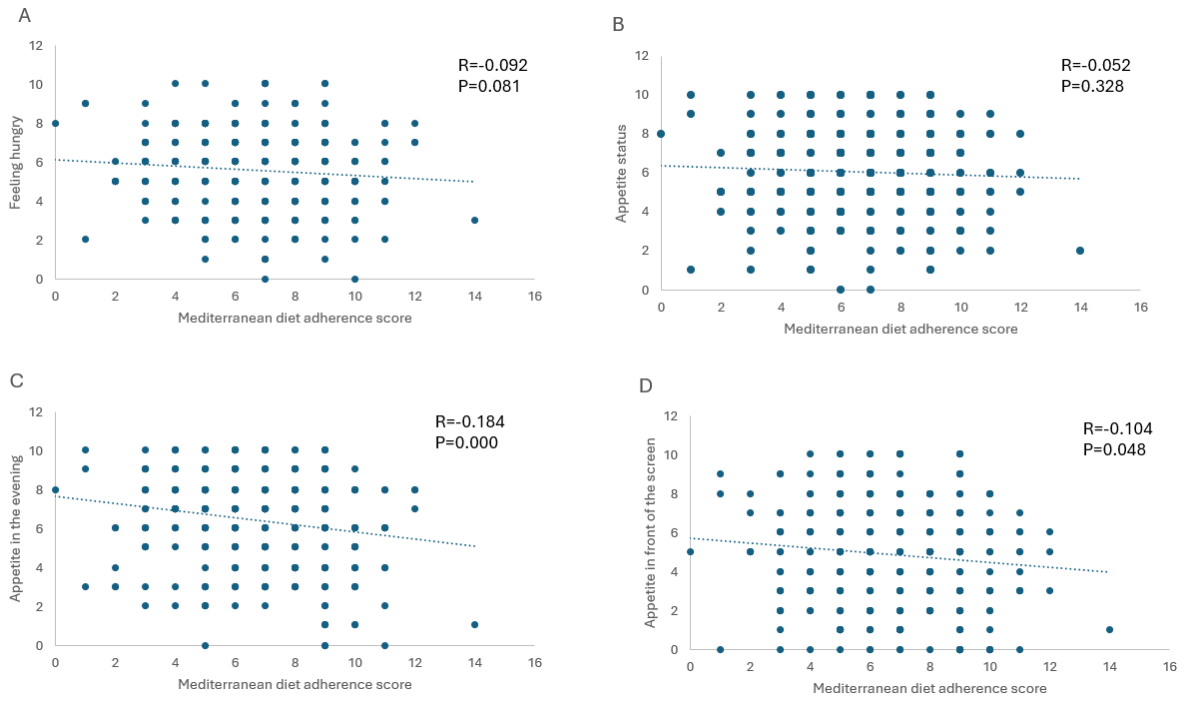


Fig. 2. Correlations between Mediterranean diet adherence scores and appetite status.

the release of appetite-related glucagon-like peptide 1 (GLP-1) and oxyntomodulin hormones increased after an MD meal, these results were not reflected in VAS results as self-assessment of individuals (Di Mauro et al., 2021). In a study of 82 overweight and obese individuals with a Western diet and a sedentary lifestyle, it was shown that the endocannabinoid system was affected following the MD intervention and increased the abundance of *Akkermansia muciniphila* in the intestine regardless of body weight changes (Tagliamonte et al., 2021). Data in the literature suggest that *Akkermansia muciniphila* increases thermogenesis through systemic GLP-1 secretion (Yoon et al., 2021; Cani and Knauf, 2021). Furthermore, the endocannabinoid system plays a tight role in the regulation of energy homeostasis and appetite (Tagliamonte et al., 2021). In the present study, the appetite scores of individuals were determined according to self-assessments. In the literature, there are studies on scales based on the individual's assessment. In a study of 306 young women, no significant relationships were found between MD scores and eating attitudes and emotional eating (Macit-Celebi et al., 2023). In another study of 300 university students, higher night eating habits predicted lower diet quality (β=-0.117, p=0.038) (Tayhan and Helvaci, 2024). There are also studies showing that higher adherence to the MD is associated with more restrained eating behaviour (Ferreira-Pêgo et al., 2020) and lower binge eating episodes (Bertoli et al., 2015). Although both the correlations between MD adherence and appetite in the evening (R=-0.184, p=0.000) and appetite in front of a screen (R=-0.104, p=0.048) were statistically significant, their strengths were weak, indicating limited practical or clinical relevance in our study. These weak associations may be attributed to multiple uncontrolled variables affecting appetite, such as the type of content viewed, duration of screen time, concurrent snacking habits, or emotional state. Therefore, while these findings suggest a potential trend between healthier dietary patterns and reduced appetite in certain contexts, further research is needed to establish clinical implications or causality.

Research suggests that neglecting eating late at night or minimising the eating interval may have positive effects on appetite perception (Jamshed et al., 2022; Malin et al., 2024; Malin, 2025). It has been reported that the evening chronotype often has overeating habits (Farkova et al., 2021; Martins-de-Passos et al., 2024; Riccobono et al., 2025). In our study, there were no significant differences in appetite scores between morning, intermediate, and evening chronotypes (p>0.05). In line with this finding of our study, Rabiei and colleagues (2021) found no significant differences in serum neuropeptide Y (NPY) and leptin levels between chronotype categories. However, there are also studies in the literature showing that individuals with a morning chronotype have lower emotional appetite levels and, consequently, lower energy intake (Malin et al., 2024; Adiguzel, 2024).

Our study has several strengths. In addition to the sample size being sufficient for statistical analysis, the balanced distribution of chronotypes among the participants facilitates the interpretation of the findings. The use of validated and reliable scales and the control of various variables with advanced statistical tests are other strengths of our study. Despite the important findings of our study, its cross-sectional nature presents a significant limitation. Another limitation is that the participants' appetite status, chronotype categories, and adherence to the Mediterranean diet were assessed using self-reported measures, which may be subject to memory errors.

5. Conclusion

The findings of our study show that as MD adherence increases, individuals tend to have a more morning-type phenotype and experience reduced appetite in the evening and while in front of screens. However, appetite scores did not show significant differences across chronotype categories. Considering all these results, dietary tendencies are closely related to chronotype categories. It will be important to closely monitor evening-type individuals who are at risk of irregular eating habits and to develop nutrition and health policies targeting this situation. Additionally, future large-scale, randomised controlled studies carefully incorporating biochemical parameters are needed to better understand the complex relationships between appetite, chronotype, and nutrition.

Conflict of interest: The authors declare that they have no conflict of interests.

Informed consent: The ethical approval for the study was obtained from the Ethics Committee of Bahçeşehir University (No: E-20021704-604.01.02-33312). Informed consent was obtained from all participants.

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