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ORIGINAL ARTICLE

Determination of the relationship between body composition and nutritional habits and chronotype in healthy Turkish adults

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ABSTRACT

This cross-sectional study aims to determine the relationship between chronotype characteristics, dietary habits, and body composition in 110 adults, of which 75.5% are female, residing in Mersin, Türkiye. Data collection included a descriptive information form, the Morningness-Eveningness Scale for assessing chronotype, a detailed 24-hour dietary record for evaluating dietary intake, and Bioelectrical Impedance Analysis for accurate anthropometric measurements of body composition. The evening types had higher BMI, body weight, waist circumference, hip circumference, total fat mass, and lower body water ratio than the morning types. Positive correlations were found between sleep duration and body mass index, total fat mass, and fat percentage. The evening types tended to skip breakfast more frequently and had higher energy intake during dinners and snacks. Additionally, the evening types consumed more lipids, carbohydrates, sodium, and saturated and polyunsaturated fatty acids. These findings suggest that chronotype influences anthropometric measurements, nutritional habits, and meal energy distribution. These findings highlight the importance of considering chronotype characteristics to understand how body composition and dietary patterns interact, underscoring the need for customized interventions to promote healthier lifestyles.

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KEYWORDS
Chronotypes; circadian rhythm; nutritional habits; meal timing; dietary choices

Introduction

Circadian rhythms are cycles of basic biological events that are influenced by both individual and environmental factors that regulate metabolic activities that occur over a 24-hour period (Poggiogalle et al. 2018). These inner timing systems and daily rhythms allow individuals to adapt to environmental differences, thereby influencing food intake and dietary habits (Jagannath et al. 2017).

The term "social jetlag" is employed to define the discordance between biological and societal timing. This can be characterized as a type of circadian misalignment stemming from differences in sleep/activity schedules between days off and work/school days, leading to serious health outcomes in both children and adults (Liang et al. 2022; Roenneberg et al. 2012; Roenneberg et al. 2019). The connection between circadian misalignment and metabolic disturbance is also mediated through dietary modifications, as cardiometabolic health is strongly influenced by dietary behavior (Liang et al. 2022; Roenneberg et al. 2012).

Chronotype is defined as the circadian preferences of individuals with respect to their 24-hour activities and sleep-wake times and is an indicator of their circadian stage. These stages indicate an individual's physical condition, hormonal concentrations, thermoregulatory status, neurocognitive functions, and feeding and sleeping habits throughout the day (Levandovski et al. 2013).

Chronotypes, which are influenced by sex, age, genetic inheritance, and external factors (Roenneberg et al. 2003), classify individuals into three types: morning, intermediate, and evening (Horne and Ostberg 1977). Morning individuals are the most productive in the morning, whereas evening individuals peak in the afternoon or evening in terms of activity and performance (Randler 2016). Morning individuals sleep early in the evening and wake up early, and their physical and mental activities peak early in the morning (Horne and Ostberg 1977; Randler 2016; Urbán et al. 2011). The group between the morning and evening types was defined as the intermediate type (Horne and Ostberg 1977).

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The data for this study were derived from a master's thesis titled "Determining the Relationship Between Chronotype and Body Composition and Nutritional Habits in Adults" authored by Güler Ezgi Baldan.

Chronic circadian misalignment, observed in shift workers (Hebl et al. 2022), is linked to an increase in the consumption of caffeinated beverages and a lack of sufficient fruit and vegetable intake. This is also associated with a lower intake of fiber and protein and an increase in the consumption of high-energy substances, such as alcohols, sugars, and carbohydrates (Arab et al. 2023; van der Merwe et al. 2022).

The circadian rhythm of each cell is regulated by the central clock in the suprachiasmatic nucleus (SCN) of the hypothalamus. The SCN, receiving external light through the eyes and optic nerve, synchronizes the clocks of peripheral cells and tissues according to the world's 24-hour light/dark cycle. External light is the primary cue for the central circadian clock. However, other cues such as food intake, timing, and composition can regulate rhythms in the peripheral clock and clock-controlled genes in body tissues and organs (van der Merwe et al. 2022). Being a morning or evening chronotype not only affects sleep/wake times, but can also impact meal times. The consumption of food at inappropriate times (such as at night) may have negative effects on the biological clock (van der Merwe et al. 2022). Some studies have shown that high energy intake at night leads to increased fat storage and obesity (Fong et al. 2017; McHill et al. 2017).

Understanding the relationship between chronotype, dietary habits, and body composition is crucial for promoting healthy lifestyles and reducing metabolic health risks. Therefore, this study aimed to determine the relationship between chronotype, body composition, and eating habits in adults.

Methods

This cross-sectional study was conducted between April 15th and September 2nd, 2022. In this study, the sample was selected utilizing the quota sampling method. The study encompassed individuals who applied for dietary services. The sample comprised individuals who satisfied the predetermined inclusion criteria and consented to participate in the study.

The inclusion criteria were as follows;

- Being at least 18 years of age,
- Having a daytime work schedule,
- Not adhering to any specialized restrictive diet.

The exclusion criteria were as follows;

- Having any chronic illness,
- Regular use of medications or dietary supplements that affect sleep, wakefulness, and circadian rhythm,
- Being pregnant,
- Having a history of neurological or psychiatric illness,
- Having a diagnosis of any sleep disorder.

Data collection tools

The study utilized a "Descriptive Information Form" to collect anthropometric and demographic information, a "Morningness-Eveningness Questionnaire Self-Assessment Version (MEQ-SA)" to identify chronotype, and a "Food Consumption Record Form" to document food consumption. Data were collected by the researcher through face-to-face interviews.

The Descriptive Information Form was prepared based on the literature (Baron et al. 2013; Okada et al. 2019; Schubert and Randler 2008) and included 14 questions related to sociodemographic characteristics, eating habits, and total sleep time of individuals. This study also calculated the daily amount of caffeine consumed by individuals (Hanci et al. 2013; Haytowitz et al. 2019).

Bioelectrical Impedance Analysis, including body composition such as; body weight, fat mass, fat percentage, muscle mass, total body water, and total body water percentage, was evaluated using a Tanita BC-601 body analyzer. The waist circumference, hip circumference, and height of the participants were measured. Weight measurements were recorded with an accuracy of 0.1 kg, and height was measured with the head positioned on the Frankfort plane and the feet together using a non-flexible tape measure. Measurements were performed on an empty stomach with thin clothing and no shoes. Prior to measurement, participants were instructed to fast for at least two hours, not drink much water, remove any metal items (such as coins or jewelry), use the restroom, and avoid consuming caffeine-containing beverages (such as tea or coffee for four hours before the analysis. Participants were instructed to abstain from consuming alcohol and engaging in strenuous physical activity for a period of 24 hours before the analysis took place. The circumference of the waist was determined by measuring halfway between the lower ribs and the iliac crest using a non-stretchable tape. Meanwhile, the circumference of the hips was measured at the widest point around the buttocks with the same tape. Body Mass Index (BMI) was quantified by dividing an individual's mass, measured in kilograms, by the square of their stature in meters.

Anthropometric measurements were performed using reference values from the World Health Organization (A healthy lifestyle – WHO recommendations 2010; Waist circumference and waist-hip ratio-WHO expert consultation 2008).

The Morningness-Eveningness Questionnaire Self-Assessment Version scale was developed by Horne and Östberg (Horne and Ostberg 1976), and a Turkish validity and reliability study was conducted by Punduk et al (Pündük et al. 2005). The scale consists of 19 Likert-type questions that assess lifestyle, sleep-wake patterns, and performance. Cronbach's alpha coefficient of the scale was 0.812, indicating its suitability for use in Turkish society. In this study, Cronbach's alpha coefficient was calculated to be 0.971. If the total score from the scale falls between 16 and 41, it is considered an "evening type," between 42 and 58 as an "intermediate type," and between 59 and 86 as a "morning type."

Dietary intake was evaluated utilizing a 24-hour dietary recall method coupled with a systematic interview. This approach aimed to meticulously collect detailed data regarding all food and beverage items ingested by the participant within the preceding 24-hour period, generally spanning from midnight to midnight of the preceding day. The Food and Food Photo Catalogue was used to determine the portion sizes of foods consumed (Rakıcıoğlu et al. 2010). The macro-and micronutrient values of the food consumption records of the participants were obtained using the Nutrition Information Systems (BeBiS) version 9 program. BeBiS program uses the German, USDA (U.S. Department of Agriculture), and Turkomp nutrient databases (Ebispro for Windows, Stuttgart, Germany; Turkish Version (BeBiS 8.2), Pasifik Elektirik Elektronik Ltd. Şti. (www.bebis.com.tr); Istanbul, 2019).

Statistical evaluation of the research

Data were analysed using SPSS 23.0. Normal distribution assumptions were assessed by examining skewness and kurtosis values using the Kolmogorov-Smirnov test, histogram, and Q-Q plot. Parametric tests were employed because the normality assumptions were met.

In the analysis of sociodemographic variables, the arithmetic means and standard deviations were computed for numerical variables exhibiting a normal distribution. For the descriptive statistical evaluation of categorical variables, frequency distributions, including counts and percentages, were employed. To explore the associations between categorical and numerical variables, a one-way analysis of variance (ANOVA) was performed. Subsequent to this, the Bonferroni post-hoc analysis was utilized to ascertain the specific groups contributing to significant variances when examining three or more categorical variables. All statistical assessments adhered to a significance threshold of $p < 0.05$ and were conducted within a 95% confidence interval.

Ethics committee

This research adhered to the ethical principles delineated in the Declaration of Helsinki and received approval from the Ethics Committee of Okan University, under the approval number 13.04.2022/153. All participants provided their written informed consent prior to participation in the study.

Results

The results of this study are summarised as follows.

Descriptive characteristics and anthropometric measurements of participants

The study included 83 (75.5%) females and 27 (24.5%) males with a mean age of 33.6 ± 8.6 years. The majority of participants (67.3%) had college degrees, 61.8% worked in daytime jobs (38.2% were not employed), and 69.1% earned more than the minimum wage. The sample comprised 41%37.3) morning types (26 females and 15 males), 34%30.9) intermediate types (29 females and 5 males), and 35%31.8) evening types (28 females and 7 males). No significant differences were detected in terms of sex ($\chi2 = 5.376$, $p = 0.068$), education ($\chi2 = 6.094$, $p = 0.192$), and work ($\chi2 = 4.102$, $p = 0.129$) among chronotypes in Table 1.

Relationship between chronotypes, total sleep duration and anthropometric measurements

Table 1 presents the mean and standard deviation values for various anthropometric measurements, total sleep duration and total caffeine consumption of individuals with different chronotypes as well as the results of one-way analysis of variance (ANOVA) and Bonferroni correction for pairwise comparisons of means. The ANOVA results indicated significant differences between the groups in terms of higher BMI, body weight, waist circumference, and hip circumference. In addition, there were significant differences in total fat mass; however, no such differences were observed in lean body mass (kg) and total body water (kg). The Bonferroni correction further revealed that significance was evident

Table 1. The distribution of chronotypes was based on specific characteristics, such as sex, education, and work status, along with the mean and standard deviation values of anthropometric measurements, total sleep duration, and total caffeine consumption.

	Morning Type[a] X̄ ± SD	Intermediate Type[b] X̄ ± SD	Evening Type[c] X̄ ± SD	F*	*P* value	Bonferroni test
Total Sleep Duration (hour)	6,7 ± 00,5	7,3 ± 00,80	7,80 ± 1,40	12,625	**<0.001$^{a–c}$, 0.026$^{a–b}$**	a–c, a–b
Total Caffeine Consumption (mg)	278,2 ± 0149,00	426,9 ± 190,6	582,1 ± 0188,20	28,358	**<0.001$^{a–c}$, 0.001$^{a–b}$**	a–c, a–b
BMI (kg/m^2)	23.50 ± 3.90	25.20 ± 4.10	30.10 ± 5.80	19.86	**<0.001**	a–c
Body Mass (kg)	68.50 ± 14.70	70.50 ± 16.20	85.00 ± 21.10	9.67	**<0.001$^{a–c}$, 0.002$^{b–c}$**	a–c, b–c
Waist circumferences (cm)	80.00 ± 13.60	81.80 ± 13.20	94.00 ± 16.20	10.08	**<0.001$^{a–c}$, 0.002$^{b–c}$**	a–c, b–c
Hip circumferences (cm)	101.80 ± 8.70	105.20 ± 7.40	113.20 ± 9.20	17.30	**<0.001$^{a–c}$, 0.001$^{b–c}$**	a–c, b–c
Waist/Hip ratio	0.70 ± 0.09	0.70 ± 0.08	0.80 ± 0.09	3.159	**0.046$^{a–c}$, 0.044$^{b–c}$**	a–c, b–c
Body Fat (%)	24.40 ± 7.30	30.20 ± 6.10	35.70 ± 6.30	27.25	**<0.001$^{a–c}$, 0.003$^{b–c}$**	a–c, b–c
Total body fat mass (kg)	16.20 ± 6.40	21.10 ± 7.60	30.70 ± 10.30	29.95	**<0.001$^{a–c}$, 0.033$^{b–c}$**	a–c, b–c
Lean body mass (kg)	49.10 ± 11.70	46.40 ± 10.60	51.60 ± 13.10	1.62	0.203	
Total body water (kg)	37.30 ± 8.30	35.90 ± 7.60	39.90 ± 9.30	2.00	0.140	
Total body water (%)	54.80 ± 5.00	51.20 ± 4.10	47.30 ± 4.10	26.26	**<0.001**	a–c
	n(%)	n(%)	n(%)	χ2**	p	
Sex						
Male	15(55.6)	5(18.5)	7(25.9)	5.376^{β}	0.068	
Female	26(31.3)	29(35.0)	28(33.7)			
Education						
At least high school	6(14.6)	7(20.6)	7(20)			
Collage/undergraduate	34(82.9)	21(61.8)	24(68.6)	6.094$^{£}$	0.192	
Post graduate	1(2.4)	6(17.6)	4(11.4)			
Work						
Daytime	29(70.7)	22(64.7)	17(48.6)	4.102^{β}	0.129	
Not employed	12(29.3)	12(35.3)	18(51.4)			

*one-way ANOVA; **chi-square; n, number; SD, standart deviation; bold type, $p \le 0.05$.
^{β}0 cells (0,0%) have expected count less than 5; $^{£}$3 cells (33,3%) have expected count less than 5.
[a, b, c]adjustment for multiple comparisons: Bonferroni; [a]morning type; [b]intermediate type; [c]evening type.
a-c, morning type-evening type statistical significance for Bonferroni.
a-b, morning type-intermediate type statistical significance for Bonferroni.
b-c, intermediate type- evening type statistical significance for Bonferroni.

between evening-type individuals and those of morning and intermediate types.

Pearson's correlation analysis was used to determine the relationship between participants' total sleep duration and anthropometric measurements. However, the results of this analysis are not included in the table. Our findings showed a significant positive correlation between BMI and total sleep duration (r* = 0.191, $p = 0.045$). Furthermore, we found a significant positive relationship between total fat mass, body fat percentage, and total sleep duration (r* = 0.368, $p <$ 0.000; r* = 0.246, $p = 0.010$), and also a negative correlation between total sleep duration and body water percentage (r* = −0.324, $p = 0.001$). Our study showed that individuals with an evening chronotype had longer sleep durations and consumed more caffeine than others ($p < 0.05$) in Table 1.

Results about individuals' nutritional habits and meal preferences

Table 2 shows the distribution of meals skipped by individuals who skip meals according to chronotypes, and the mean of the daily number of main and snack meals and frequency of meal skipping in all chronotypes. The results indicated that the rate of skipping breakfast among evening-type individuals was significantly higher than that among the other groups (χ2 = 39.866, $p < 0.001$). Moreover, the mean meal count of individuals with an evening chronotype was significantly lower than that of individuals with morning and intermediate chronotypes (F = 9.118, $p < 0.001$). The consumption of daily snacks was highest among evening chronotype individuals (F = 9.84, $p < 0.001$), with these individuals ingesting more snacks than those with a morning chronotype. In contrast, morning chronotype individuals show a reduced prevalence of meal skipping compared to evening and intermediate chronotype individuals.

The relationship between individuals' chronotypes nutritional intake and meal energy distrubution

A summary of meal energy distributions based on various chronotypes is presented in Table 3. This table shows that there were significant differences between the morning-, intermediate-, and evening-type chronotypes. The data revealed that morning-type individuals had a higher energy intake at breakfast, whereas

Table 2. Distribution of meals skipped by individuals who skip meals according to chronotypes, and the mean of the daily number of main and snack meals and frequency of meal skipping in all chronotypes.

	Morning Type[a] n(%)	Intermediate Type[b] n(%)	Evening Type[c] n(%)	χ2*	F**	*P* value	Bonferroni Test
Breakfast	7 (53.8%)	7 (43.7%)	26 (89.6%)	39.866		**<0.001**	
Lunch	1 (7.6%)	6 (37.5%)	2 (6.8%)				
Dinner	1 (7.6%)	0 (0%)	0 (0%)				
Snack	4 (31.3%)	3 (18.8%)	1 (3.6%)				
	X̄ ± SD	X̄ ± SD	X̄ ± SD				
Daily Main Meals	2.7 ± 0.50	2.6 ± 0.50	2.20 ± 0.60		9.118	**<0.001[a–c], 0.008[b–c]**	a–c, b–c
Daily Snacks	2.10 ± 0.60	2.4 ± 0.60	3.0 ± 1.20		9.84	**<0.001[a–c], 0.019[b–c]**	a–c, b–c
Meal Skipping Frequency	1.2 ± 0.40	1.6 ± 0.40	1.7 ± 0.50		10.8	**<0.001[a–b], 0.001[a–c]**	a–b, a–c

*chi-square; **one-way ANOVA; SD, standard deviation; bold type, $p \leq .05$.
[a, b, c]adjustment for multiple comparisons: Bonferroni; [a]morning type; [b]intermediate type; [c]evening type.
a-c, morning type-evening type statistical significance for Bonferroni.
a-b, morning type-intermediate type statistical significance for Bonferroni.
b-c, intermediate type- evening type statistical significance for Bonferroni.

Table 3. Meal energy distribution by chronotype.

Meal-Energy	Morning Type[a] X̄ ± SD	Intermediate Type[b] X̄ ± SD	Evening Type[c] X̄ ± SD	F*	*P* value	Bonferroni test
Breakfast (kcal)	381.00 ± 216.60	371.50 ± 226.50	140.20 ± 260.10	12.175	**<0.001[a–c], <0.001[b–c]**	a–c, b–c
Breakfast (%kcal)	20.90 ± 10.90	18.80 ± 10.30	5.00 ± 8.60	26.721	**<0.001[a–c], <0.001[b–c]**	a–c, b–c
Mid-Morning Snack (kcal)	138.70 ± 113.00	170.40 ± 128.20	261.60 ± 288.90	4.119	**0.018[a–c], 0.019[b–c]**	a–c, b–c
Mid-Morning Snack (%kcal)	8.30 ± 7.10	9.00 ± 7.40	10.60 ± 11.20	0.692	0.503	
Lunch (kcal)	447.90 ± 193.70	480.80 ± 239.40	572.00 ± 318.40	2.384	0.097	
Lunch (%kcal)	24.70 ± 8.90	24.70 ± 12.00	23.6 ± 11.70	0.129	0.879	
Afternoon Snack (kcal)	220.40 ± 113.30	237.90 ± 172.90	386.70 ± 269.90	8.126	**0.001[a–c], 0.005[b–c]**	a–c, b–c
Afternoon Snack (%kcal)	12.60 ± 6.50	12.40 ± 9.00	16.20 ± 11.10	2.072	0.131	
Dinner (kcal)	486.90 ± 189.30	535.80 ± 196.30	668.00 ± 273.00	6.606	**0.002[a–c], 0.044[b–c]**	a–c, b–c
Dinner (%kcal)	27.60 ± 9.80	27.70 ± 9.50	28.90 ± 11.70	0.162	0.851	
Night Snack (kcal)	116.40 ± 146.10	155.30 ± 139.10	376.30 ± 245.30	21.604	**<0.001[a–c], <0.001[b–c]**	a–c, b–c
Night Snack (%kcal)	6.70 ± 8.30	10.40 ± 7.40	13.50 ± 10.30	5.759	**0.003[a–c], 0.004[b–c]**	a–c, b–c

*one-way ANOVA; SD, standart deviation; bold type, $p \leq .05$.
[a, b, c]adjustment for multiple comparisons: Bonferroni; [a]morning type; [b]intermediate type; [c]evening type.
a-c, morning type-evening type statistical significance for Bonferroni.
a-b, morning type-intermediate type statistical significance for Bonferroni.
b-c, intermediate type- evening type statistical significance for Bonferroni.

evening-type displayed greater energy consumption during dinner and snack times. In addition, the evening type had an elevated energy intake during the mid-morning snack times compared with other chronotypes. However, the percentage of mid-morning snacks was not significant.

Table 4 displays the mean and standard deviation values for the different dietary components in the morning, intermediate, and evening types. Energy intake is significantly higher among evening types than among the morning and intermediate types. Additionally, evening types have a significantly higher intake of lipids, carbohydrates, sodium, and saturated and polyunsaturated fatty acids, whereas morning types have a higher intake of protein, vitamin A, carotene, and water-insoluble fibre. Furthermore, significant differences were observed in the intakes of vitamins C and D, niacin, iron, zinc, and water-soluble essential amino acids. Also, Pearson correlation analysis was performed between the participants' total sleep duration and food consumption. However, the results are not shown in the Table 4. Total sleep duration was shown to have a significant negative correlation with both the percentage of protein intake and amount of biotin consumed ($r = -0.265$, $p = 0.005$, $r = -0.203$, $p = 0.034$). However, a significant positive correlation was detected between carbohydrate intake and the total sleep duration ($r = 0.210$, $p = 0.027$).

Discussion

Significant results were reported in our study, which investigated the relationship between chronotype characteristics, body composition, and dietary habits. The major findings of our research included correlations between chronotype characteristics and various measures such as anthropometric measurements, nutrients, and food preferences. Additionally, differences in total sleep duration and caffeine consumption among participants were found to be significant based on the chronotype. A discussion of these results in our study is provided in the current literature.

Table 4. The relationship between participants' daily macro-and micronutrient intake according to their 24 h recall food consumption.

	Morning Type[a] $\bar{X} \pm SD$	Intermediate Type[b] $\bar{X} \pm SD$	Evening Type[c] $\bar{X} \pm SD$	F*	*p* value	Bonferroni test
Energy (kcal)	1782,90 ± 443,70	1936,80 ± 392,40	3256,60 ± 1232,70	2,691	0,072	
Protein (g)	89,58 ± 39,27	86.06 ± 24.51	106.39 ± 46.50	2.869	0.061	
Protein (%)	20,20 ± 5,10	18,20 ± 3,80	17,60 ± 3,90	3,715	**0.028[a-b], 0,033[a-c]**	a-b, a-c
Lipid (g)	65,80 ± 24,30	72,00 ± 23,90	**105,80 ± 39,00**	19,121	**<0,001[a-c], <0,001[b-c]**	a-c, b-c
Lipid (%)	32,70 ± 8,90	32,70 ± 6,70	**38,70 ± 6,80**	7,270	**0,003[a-c], 0.005[b-c]**	a-c, b-c
Carbohydrate (g)	202,90 ± 66,30	230,20 ± 53,30	**252,10 ± 66,00**	5,922	**0,003[a-c], 0.004[b-c]**	a-c, b-c
Cholesterol (mg)	419,70 ± 346,70	304,90 ± 166,50	419,70 ± 362,40	1,625	0,202	
Vitamin A (mcg)	**1641,60 ± 771,60**	1067,00 ± 707,80	1083,30 ± 703,10	7,725	**0,003[a-b], 0.004[a-c]**	a-b, a-c
Caroten (mg)	7,50 ± 4,60	4,10 ± 3,60	3,30 ± 3,80	11,659	**<0,001[a-b], 0.001[a-c]**	a-b, a-c
Vitamin E (mg)	11,10 ± 4,20	11,70 ± 6,00	**18,40 ± 9,10**	13,300	**<0,001[a-c], <0,001[b-c]**	a-c, b-c
Vitamin B1 (mg)	1,20 ± 0,30	1,00 ± 0,30	1,20 ± 0,50	2,162	0,120	
Vitamin B2 (mg)	1,90 ± 0,60	1,70 ± 0,40	1,60 ± 0,70	1,733	0,182	
Vitamin B6 (mg)	1,80 ± 0,60	1,50 ± 0,50	1,70 ± 0,70	1,723	0,183	
Folat (µg)	382,20 ± 143,80	315,40 ± 124,10	329,30 ± 162,00	2,285	0,107	
Vitamin C (mg)	**130,10 ± 62,20**	93,70 ± 55,80	94,60 ± 62,00	4,571	**0,032[a-b], 0.036[a-c]**	a-b, a-c
Vitamin D (mcg)	3,50 ± 2,20	5,30 ± 4,30	**9,60 ± 13,80**	5,255	**0,006[a-c], 0.007[b-c]**	a-c, b-c
Vitamin K (mg)	96,30 ± 127,40	67,00 ± 36,90	73,30 ± 64,60	1,162	0,317	
Vitamin B12 (mcg)	4,90 ± 2,10	5,80 ± 2,90	5,90 ± 3,50	1,359	0,261	
Biotin (mcg)	62,70 ± 21,70	51,00 ± 14,50	57,20 ± 29,30	2,442	0,092	
Niacin (mg)	35,90 ± 16,70	32,80 ± 10,60	**43,80 ± 24,10**	3,457	**0.035[a-c], 0,038[b-c]**	a-c, b-c
Sodium (mg)	2359,80 ± 1044,10	2894,70 ± 1052,30	**3514,50 ± 1591,10**	8,102	**<0,001[a-c], <0.001[b-c]**	a-c, b-c
Potassium (mg)	3112,10 ± 880,20	2813,90 ± 728,40	3007,90 ± 1020,40	1,069	0,347	
Calsium (mg)	863,90 ± 375,90	872,40 ± 262,30	892,30 ± 363,10	068	0,934	
Magnesium (mg)	350,80 ± 110,40	325,70 ± 94,00	373,30 ± 134,80	1,495	0,229	
Phosphorus (mg)	1462,10 ± 463,80	1375,90 ± 316,80	1562,70 ± 546,10	1,465	0,236	
Iron (mg)	11,90 ± 3,90	12,20 ± 4,10	**14,50 ± 5,50**	3,466	**0,049[a-c], 0.035[b-c]**	a-c, b-c
Zinc (mg)	11,50 ± 3,70	11,50 ± 4,20	**13,70 ± 4,80**	3,239	**0,043[a-c], 0.043[b-c]**	a-c, b-c
Fiber (g)	**28,40 ± 9,20**	22,70 ± 8,30	24,50 ± 11,10	3,388	**<0,001[a-b], <0.001[a-c]**	a-b, a-c
Water-insoluble fiber (g)	**19,60 ± 6,30**	15,00 ± 5,30	15,60 ± 7,40	5,920	**0,007[a-b], 0.023[a-c]**	a-b, a-c
Water-soluble fiber (g)	8,20 ± 3,50	6,90 ± 2,90	7,50 ± 3,90	1,279	0,283	
Monounsaturated FA (g)	21,90 ± 8,50	26,00 ± 9,50	**36,20 ± 13,90**	17,296	**<0,001[a-c], <0.001[b-c]**	a-c, b-c
Polyunsaturated FA (g)	13,00 ± 6,40	14,00 ± 6,90	**24,20 ± 13,50**	15,422	**<0,001[a-c], <0.001[b-c]**	a-c, b-c
Saturated FA (g)	24,30 ± 8,40	26,50 ± 9,10	**37,60 ± 12,90**	17,615	**<0,001[a-c], <0.001[b-c]**	a-c, b-c
Omega 3 (g)	1,80 ± 1,40	2,20 ± 2,70	**2,70 ± 2,10**	1,462	0,236	
Omega 6 (g)	10,60 ± 5,20	11,10 ± 5,70	**19,30 ± 10,90**	14,630	**<0,001[a-c], <0.001[b-c]**	a-c, b-c
Essential amino acid (mg)	45,70 ± 20,90	42,60 ± 13,00	52,40 ± 25,40	2,060	0,132	
Non-essential amino acid (mg)	44,40 ± 18,70	43,00 ± 11,80	52,20 ± 23,00	2,519	0,085	

*one-way ANOVA; SD, standard deviation; bold type, $p \leq .05$; FA: Fatty Acid.
[a, b, c]adjustment for multiple comparisons: Bonferroni; [a]morning type; [b]intermediate type; [c]evening type.
a-c, morning type-evening type statistical significance for Bonferroni.
a-b, morning type-intermediate type statistical significance for Bonferroni.
b-c, intermediate type- evening type statistical significance for Bonferroni.

Chronotypes, antropometric measurements and sleep duration

Sleep deprivation or circadian desynchronization can lead to autonomic and metabolic dysregulation. It has been reported that in healthy adults, several days of sleep deprivation or circadian misalignment leads to an increase in appetite and energy intake, along with a range of metabolic disturbances (McEwen and Karatsoreos 2015). Our findings indicate that the average sleep duration varies between 6 and 8 hours across all chronotypes. However, it has been observed that individuals with an evening chronotype have a significantly longer average sleep duration than others in our study ($p < 0.05$). There is no evidence to suggest that regularly sleeping between 6 to 8 hours has harmful effects or leads to long-term health consequences. However, it has been reported that sleeping durations of 9 hours or more, as well as those of 5 hours or less, should be concerning in terms of cardiovascular disease risks (Cappuccio et al. 2011). The longer sleep duration in evening-type individuals may indicate circadian misalignment, potentially leading to adverse anthropometric characteristics, such as higher body mass index, increased body fat percentage, and enlarged waist and hip circumferences. Researches indicate that insufficient or excessive sleep duration increases the risk of hepatic steatosis associated with insulin resistance (Cao et al. 2023) and is associated with increased obesity risk (Keramat et al. 2023) and cardiovascular risk factors (Khanji et al. 2023). We believe that these findings could be indicative of an increased risk of obesity and cardiovascular disease in evening-type individuals. Also, individuals with an evening chronotype, despite sleeping for longer durations, experience lower quality of sleep (Abdollahi et al. 2023; Günal 2023). It is important to note that our study did not assess the sleep quality of individuals, which is a limitation of our study. Our results provide valuable insights into the implications of the relationship between lifestyle and sleep patterns for health. These findings may offer significant clues for future research in this field.

Chronotypes, meal energy distribution and antropometric measurements

Studies have shown that diets with high energy density are associated with an increased BMI, adiposity, and an increased risk of obesity (Lucassen et al. 2013; Rouhani et al. 2016; Wang 2014). Similarly, a study focusing on adolescents showed that individuals who are evening-type have higher BMI and rates of obesity compared to those who are morning-type, which is attributed to unhealthy eating habits that are rich in fats and sugars (Arora and Taheri 2015). Our study's findings indicate that individuals with an evening chronotype, characterized by a high BMI and wider waist-to-hip ratios, are at an increased risk of obesity, particularly due to their heavy evening meals. The imbalance in daily energy intake and the distribution of energy across meals, coupled with the consumption of energy-dense snacks at night and the circadian misalignment experienced by these individuals, is thought to lead to altered anthropometric indicators. These results comprehensively demonstrated the effects of chronotype on dietary habits and body composition, highlighting the complex interplay between circadian rhythms and lifestyle factors.

Additional studies are needed to support these findings. A Korean study by Yu et al. (2015) found that evening-types have larger waistlines compared to morning or intermediate chronotypes. De Amicis et al. (2020) reported that evening chronotypes have a higher prevalence of abdominal obesity and visceral fat accumulation. Similarly, in a study of obese individuals, those with an evening chronotype had a higher average waist circumference (Vera et al. 2018). Consistent with these studies, our research revealed that evening chronotypes tend to have wider waist and hip circumferences and a higher waist-to-hip ratio ($p < 0.05$). This could be due to a mismatch between social and biological rhythms, characterized by late-night consumption of energy-dense foods and lower physical activity levels. This could have an impact on body measurements and result in increased waist and hip sizes. Therefore, the interaction between circadian rhythm and lifestyle has a significant effect on body composition.

A study investigating the relationship between chronotype characteristics and cardiometabolic outcomes in young adults revealed that evening chronotypes possess higher body fat percentages and cardiometabolic risks than morning chronotypes (De Punder et al. 2019). Another study found that evening-type individuals have higher body fat mass than morning-type individuals (Sumner et al. 2012). Consistent with these findings, our study suggests that evening-type individuals with higher body fat mass and waist circumference are at increased risk of cardiometabolic outcomes. Furthermore, a deeper understanding of the effects of chronotypes on chronic diseases and the disease burden is important. The findings of our study provide a fundamental source of information for understanding the impact of chronotypes on health.

Chronotypes and food consumption

Toktaş et al. (2018) found that individuals with an evening chronotype had a higher intake of energy, fat, and carbohydrates, and a lower percentage of energy derived from protein, compared to morning chronotype individuals. This finding aligns with those of other studies (Arora and Taheri 2015; Çakır et al. 2018), which reported that evening-type individuals tend to consume diets high in carbohydrates and fats yet consume fewer fruits, vegetables, fish, and whole grains (Vera et al. 2018). Conversely, a large-scale study with 3,072 participants indicated that morning chronotypes consumed higher amounts of energy, protein, and fat but had lower carbohydrate intake (Günal 2023). Our findings corroborate these observations, showing that evening individuals have higher fat consumption, especially saturated fats ($p < 0.05$). The increased energy intake during dinner and night-time snacks seems to contribute to this dietary pattern.

Additionally, in a study by Çakır et al. (2018), morning chronotype participants were found to have a higher intake of vitamins A and folate. In contrast, evening chronotypes had decreased dietary folate intake (Kanerva et al. 2012), and a pattern of low vitamin-mineral intake associated with evening eating was noted (Sato-Mito, Sasaki, et al. 2011; Sato-Mito, Shibata, et al. 2011).

In our study, morning individuals had higher total and soluble fiber intake, along with greater consumption of vitamin A, carotene, and vitamin C, which are abundant in fruits and vegetables ($p < 0.05$). On the other hand, evening chronotype individuals consumed more vitamin E and omega-6 fatty acids, which are typically found in vegetable oils, and had higher sodium intake. Notably, despite morning individuals having a higher percentage of energy from protein, evening individuals had a greater intake of iron and zinc, which are abundant in protein-rich food ($p < 0.05$). This may be due to the predominance of plant-based protein sources among morning types, as indicated by their higher fibre intake.

The timing of meals, which is out of sync with circadian rhythms, is a risk factor for obesity-related chronic diseases (Nas et al. 2017). Richter et al. (2020) showed that diet-induced thermogenesis is higher in the morning than in the evening, indicating the metabolic impact of meal timing. Skipping breakfast, which leads to higher postprandial insulin concentrations and increased fat oxidation, may disrupt metabolic flexibility in response to prolonged fasting, potentially leading to impaired glucose homeostasis and low-grade inflammation in the long-term (Nas et al. 2017). Teixeira et al. (2018) discovered that evening chronotypes tended to skip breakfast more often than intermediate and morning chronotypes. They also had breakfast and lunch times later. Those who skipped breakfast consumed more daily energy, carbohydrates, and fats. In our study, it was shown that evening people most often skip breakfast. Among the reasons for evening individuals skipping breakfast meals most frequently, one can consider desynchronisation with the biological clock and the lack of a sense of hunger upon waking, possibly attributed to substantial energy intake during the afternoon meals of the day.

Circadian rhythm disorders can negatively affect food choices, appetite, and energy balance, leading to weight gain (Broussard and Cauter 2016; Mota et al. 2016). Our study found that evening individuals skipped meals more frequently and that their breakfast had a notably lower energy density ($p < 0.001$). This suggests a tendency to compensate for missing morning meals later in the day. Evening individuals also had a lower average number of main meals per day and snacked more frequently, often choosing high-energy, high-fat, and low-nutritional value snacks ($p < 0.001$). This altered meal pattern, with meal times shifted to later hours, may have a negative impact on metabolic health. Baron et al. (2013) discovered that excess energy consumption primarily occurs during dinner and after 8:00 PM. The amount and percentage of protein and carbohydrates consumed before sleep as well as carbohydrates and fats consumed after 8:00 PM were associated with a higher total caloric intake.

Chronotype, sleep quality and caffeine intake

In our study, it was found that the average caffeine consumption among intermediate- and evening-type participants exceeded the recommended daily maximum dose of 400 mg for adults (Safety of Caffeine | EFSA 2015). Notably, the highest caffeine intake was observed in the evening-type individuals. The preference of evening-type individuals for evening activities is associated with higher consumption of caffeinated beverages (Mazri et al. 2019; Zhang et al. 2018). Furthermore, excessive caffeine consumption has the potential to negatively affect sleep quality (Yildirim and DÖ 2023). Research conducted on university students has demonstrated that the consumption of caffeinated beverages adversely affects sleep quality (Aysan et al. 2014). Our study observed that evening-type individuals had longer total sleep duration than morning-type individuals ($p < 0.05$). This phenomenon can be interpreted as a result of the circadian misalignment between day and night in intermediate and evening types, combined with high caffeine intake, potentially degrading sleep quality, and thus necessitating longer sleep durations. These findings highlight the complex relationship between circadian rhythm, caffeine consumption, and sleep patterns, emphasising their collective impact on overall health and well-being.

Strengths and limitations

The strengths of this study are manifold, including the provision of detailed sociodemographic information on the participants and comprehensive data encompassing anthropometric measurements, caffeine consumption, eating habits, detailed dietary intake, and sleep duration, all correlated with their chronotypes. An in-depth evaluation of participants' body composition is a noteworthy aspect of this research. However, this study has certain limitations. The cross-sectional nature of the study precludes drawing causal inferences from the findings. The sample size may have affected the statistical significance of these results. It is also important to note that the study collected only a single day's dietary intake data and lacked data on sleep quality. Furthermore, the research was conducted exclusively with individuals adhering to daytime work schedules, thereby not providing insight into the experiences of shift workers.

Conclusions

In conclusion, this study expands our understanding of how chronotype characteristics can influence dietary habits and body composition. This opens new avenues for targeted nutritional and lifestyle interventions based on individual chronotype profiles. These findings are crucial for the development of personalized approaches for nutritional counselling and lifestyle modifications, potentially contributing to improved health outcomes.

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Author contributions statement

GEB; To construct the hypothesis or idea of the research and/or article, To design and plan the methodology that will lead to obtaining results, To organize and oversee the implementation of the study and take responsibility for its progress, To provide the necessary personnel, space, financial resources, and equipment for the study, To take responsibility for case follow-up, data collection, organization, and reporting, conducting experiments, etc., To take responsibility for the evaluation and conclusion of the findings, To take responsibility for literature review, To take responsibility for writing the entire study or its main sections, Before submitting the study, independently evaluate the scientific aspect of the work, separate from language and stylistic revisions.

DÖE; To construct the hypothesis or idea of the research and/or article, To design and plan the methodology that will lead to obtaining results, To organize and oversee the implementation of the study and take responsibility for its progress, To take responsibility for the evaluation and conclusion of the findings, To take responsibility for literature review, To take responsibility for writing the entire study or its main sections, Before submitting the study, independently evaluate the scientific aspect of the work, separate from language and stylistic revisions.

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