Current Psychology (2026) 45:319
https://doi.org/10.1007/s12144-025-08521-4

The mediating role of hedonic pleasure in the relationship between chronotype and eating behaviors in healthy young adults: A perspective on the wanting–liking balance

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Received: 12 May 2025 / Accepted: 30 November 2025 / Published online: 26 January 2026

Abstract

Emerging evidence suggests that individual chronotypes may influence eating behavior through different dimensions of hedonic processing. This study aimed to examine the mediating role of anticipatory ("wanting") and consummatory ("liking") pleasure in the relationship between morningness chronotype and emotional eating behavior within a framework informed by the wanting-liking balance model. A cross-sectional design was used with 236 medical students aged 18–30 years. Participants completed the Morningness–Eveningness Questionnaire (MEQ) to determine chronotype, the Temporal Experience of Pleasure Scale (TEPS) with consummatory (TEPS-CPF) and anticipatory (TEPS-CAPF) subscales, and the Dutch Eating Behavior Questionnaire (DEBQ), which assesses restrained (RE), emotional (EE), and external eating (ExE). Based on MEQ scores, 236 students (66.5% female; median age = 21 years) were classified as evening (24.6%), morning (17.8%), or neither type (57.6%). Chronotype groups differed only in daily smoking, which was more common among evening types ($p = .003$). SEM showed direct effects of MEQ on DEBQ-RE ($\beta = .31$, $p < .01$) and DEBQ-ExE ($\beta = -.21$, $p < .01$), while TEPS-CAPF partially mediated these associations (DEBQ-RE: $\beta = -.05$, $p = .026$; DEBQ-ExE: $\beta = .08$, $p = .002$). These findings highlight the complex, multidimensional role of hedonic pleasure in shaping eating behaviors and suggest that chronotype-related differences in reward processing may contribute to individual variability in eating regulation. The study supports a transdiagnostic perspective of hedonic functioning and highlights the need to assess both the "wanting" and "liking" dimensions in the context of eating behavior and chronobiology.

Keywords Chronotype · Eating behaviors · Hedonic pleasure · Young adults

Introduction

Biological rhythms are endogenous patterns of molecular, physiological, and behavioral activity that recur regularly, are observed in all living organisms, and play a critical role in maintaining homeostasis and regulating adaptive functioning (Coskun et al., 2023). The regulation of biological rhythms at the molecular level is governed by the interaction between polygenic variations in core clock genes, such as CLOCK, PER, and BMAL, along with biological characteristics (e.g., age and sex) and environmental factors (e.g., light exposure and lifestyle), all of which contribute to individual differences in circadian timing and stability. (Gentry et al., 2021). Biological rhythms manifest across a broad spectrum of temporal scales and are classified into three primary categories based on their periodicity: ultradian rhythms, which occur more frequently than once every 24 h; circadian rhythms, which follow a cycle of approximately 24 h; and infradian rhythms, which extend beyond the 24 h (Kandeğer et al., 2021). The suprachiasmatic nucleus (SCN), located in the hypothalamus, is considered the central regulator of circadian rhythms in mammals, coordinating daily physiological and behavioral cycles in

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response to environmental cues (Czeisler & Gooley, 2007). As the central oscillator underlying behavioral rhythms, the SCN regulates fundamental physiological processes in the mammalian brain—such as the sleep–wake cycle and feeding behavior (Buijs et al., 2017; Kang et al., 2015; McHill & Butler, 2024) and also plays a critical role in modulating reward processing and motivational systems (Abrahamson & Moore, 2001). The hypothalamus influences the circadian regulation of food intake through direct neural connections with brain regions involved in eating behavior (Buijs et al., 2017; Byrne & Murray, 2017; Kang et al., 2015; McHill & Butler, 2024) while also rhythmically modulating reward sensitivity and motivational states via its projections to the dopaminergic mesolimbic pathway (Abrahamson & Moore, 2001; Guilding et al., 2010; Matsumoto & Hikosaka, 2007; Meye et al., 2013). The structural and functional properties of the circadian rhythms confer an evolutionarily significant adaptive advantage by synchronizing feeding behavior and hedonic processing with underlying physiological processes (Antle & Silver, 2016; Olejniczak et al., 2023).

Eating behavior is influenced by hedonic processing and the interaction of neural circuits involved in homeostatic regulation and executive functioning. Understanding how these concepts and hypothalamic circuits influence appetite and motivational processes remains an active area of research in neuropsychology (Morales & Berridge, 2020). The body's energy requirements drive homeostatic eating patterns and maintain a physiological balance between energy intake and expenditure (Blundell et al., 2020; Stover et al., 2023). Executive functions, mediated by the prefrontal cortex, play a crucial role in the self-regulation of eating behavior by engaging higher-order cognitive processes such as planning, impulse control, and decision-making. These functions are particularly important for identifying eating behaviors that conflict with personal goals, exerting control over reward-driven cues, and regulating habitual patterns of food intake (Dohle et al., 2018). Hedonic processing is commonly conceptualized as comprising two core components: "wanting," which refers to anticipatory pleasure or motivational drive, and "liking," which reflects the consummatory experience of pleasure. "Wanting" refers to a motivational process mediated by mesolimbic dopaminergic pathways that generates reward anticipation independent of physiological need, whereas "liking" reflects the consummatory experience of pleasure, primarily associated with opioidergic activity elicited by the consumption of palatable and emotionally gratifying foods (Berridge, 2009). Although "wanting" (anticipatory pleasure) and "liking" (consummatory pleasure) are moderately positively correlated, evidence suggests that these two components function independently at the neural and behavioral levels (Berridge & Robinson, 1998; Gard et al., 2006). Emerging evidence suggests that an imbalance between the "wanting" (anticipatory pleasure) and "liking" (consummatory pleasure) components of hedonic processing may contribute significantly to the development of maladaptive eating behaviors. For example, some studies have reported decreased anticipatory pleasure (decreased wanting) alongside increased consummatory pleasure (increased liking) in individuals with binge eating disorder (Berridge, 2009); however, other findings suggest the opposite pattern, with increased anticipatory pleasure (increased "wanting") and diminished consummatory pleasure (reduced "liking") (Morales & Berridge, 2020). In the context of eating disorders, the dynamic balance between the "wanting" and "liking" systems plays a pivotal role in shaping hedonic aspects of eating behavior (Berridge, 2009; Berridge & Robinson, 1998). Research suggests that hedonic processes can override homeostatic signals, leading to dysregulation of eating behavior (Erlanson-Albertsson, 2005).

Chronotype describes individual variations in circadian preference—ranging from morningness to eveningness—that influence the timing and functioning of behavioral and physiological processes by the endogenous circadian rhythm. An individual's chronotype influences eating behavior and hedonic processing over time, which is shaped by dynamic and bidirectional interactions within neurobiological networks (la Fleur et al., 2024; Olejniczak et al., 2023). A literature review reveals that the relationship between chronotype and eating behaviors has been predominantly investigated using bidirectional interaction models or unidimensional hedonic frameworks. Studies in non-clinical populations have shown that individuals with a morning chronotype are more likely to experience pleasure (Matthews, 1988). In contrast, those with an evening chronotype are associated with a reduced capacity for pleasure (Drezno et al., 2019; Jankowski, 2014). In this context, it has been suggested that the increased capacity for pleasure observed in individuals with a morning chronotype may increase the reward value of food, potentially increasing the risk for hedonic-driven eating behaviors (Hasler et al., 2010). However, emerging evidence suggests that individuals with a morning chronotype may effectively regulate impulsive eating behaviors through higher-order cognitive processes, enabling them to balance hedonic drives with more controlled and restrictive eating patterns (Beaulieu et al., 2024). On the contrary, individuals with an evening chronotype have been reported to have a reduced capacity for pleasure and a higher prevalence of unhealthy or risky eating behaviors (Arslan et al., 2022; Garaulet et al., 2023). Consistent with this, Beaulieu et al. (2020) also showed that an evening chronotype was associated with greater wanting for high-fat relative to low-fat food. However, current research suggests that the dimensions of pleasure—anticipatory and consummatory—may have distinct and multidimensional influences on eating behavior (Berridge, 2009; Morales & Berridge, 2020). Therefore, an important emerging research question is whether the differences in eating behavior observed between individuals with morning and evening chronotypes can be understood in terms of multidimensional hedonic processes.

In summary, previous research has predominantly examined the relationship between chronotype and eating behavior in terms of unidimensional hedonic models. However, recent studies suggest that this relationship is not solely linear or unidirectional but rather multidimensional, dynamic, and shaped by reciprocal interactions. In this context, hedonic processing is increasingly recognized as a transdiagnostic construct across different psychopathological conditions, comprising distinct but interrelated subdimensions—most notably anticipatory pleasure ("wanting") and consummatory pleasure ("liking")—rather than functioning as a singular, unitary process in the classical sense (Dolan et al., 2022; Treadway & Zald, 2011). Investigating whether variations in eating behavior associated with chronotype in a healthy young adult population are mediated by the functioning of hedonic systems may address a significant gap in the psychiatric literature. In addition, this approach may provide novel insights into the prevention, diagnosis, and treatment of clinical conditions such as obesity and eating disorders. In line with this theoretical framework and preliminary evidence in the literature, the present study aims to test the following hypotheses: 1.Morningness tendency is positively associated with hedonic pleasure dimensions. 2. Anticipatory ("wanting") and consummatory ("liking") pleasure dimensions would be positively correlated. 3. Anticipatory and consummatory pleasure dimensions would act as moderators and mediators in the relationship between morningness tendency and hedonic-driven eating behavior.

Method

Study design and participants

This study was designed as a cross-sectional study conducted among medical students. The study population consisted of students enrolled in the Faculty of Medicine of Usak University, where participant recruitment was facilitated through social media groups managed by official department representatives. Data collection was conducted using Google Forms, an online-based platform. In this context, a self-administered questionnaire was developed to ensure student accessibility and distributed to relevant official social media groups. The data collected through Google Forms was transferred to Excel format and processed according to the scoring procedures of the relevant scales. After this process, the final data set was structured for analysis. The inclusion criteria for the study were determined as being between the ages of 18–30 years, being an active medical school student, not being treated with any psychiatric disease diagnosis or having a psychiatric disease in remission with treatment, having a body mass index between 18.5 kg/m—24.9 kg/m^2, having given voluntary informed consent for participation, and not having any illness that would prevent completing the self-report scales applied via the online platform. All procedures were conducted according to institutional and national ethical guidelines, adhering to the World Medical Association Declaration of Helsinki principles and subsequent amendments. This study was approved by the Non-Interventional Clinical Research Ethics Committee of Usak University on December 19, 2024, with decision number 519–519-04, and written informed consent was obtained from all participants.

Study measures and data collection

Sociodemographic and clinical data form

The researchers developed a sociodemographic and clinical data form to assess participants' sociodemographic variables such as age, gender, BMI, marital status, monthly income, employment status, substance use, daily caffeine and cigarette consumption, psychiatric history, and presence of comorbid medical conditions.

Morningness-Eveningness Questionnaire (MEQ)

This 19-item Likert-type scale classifies individuals into three distinct chronotype categories: morning type (M-type), neither type (N-type), and evening type (E-type). A total score between 16 and 41 indicates E-type, scores between 42 and 58 reflect N-type, and scores between 59 and 86 correspond to M-type. Higher scores represent a stronger tendency toward morning preference, whereas lower scores represent a stronger tendency toward evening preference. The validity and reliability of the Turkish version were established in a sample of university students (Pündük et al., 2005).

Temporal Experience of Pleasure Scale (TEPS)

The 15-item Turkish version of the TEPS measures two fundamental dimensions of hedonic experience: contextual anticipatory pleasure factor (CAPF) and consummatory pleasure factor (CPF). Each item is rated on a 6-point Likert scale ranging from 1 ('strongly disagree') to 6 ('strongly agree'). While no cut-off score has been established, higher scores reflect greater hedonic capacity. The validity and reliability of the Turkish version were established in a sample of university students (Guliyev et al., 2024).

Dutch Eating Behaviour Questionnaire (DEBQ)

DEBQ is a widely used self-report instrument consisting of 33 items that evaluate eating behaviors across three subscales: external eating (DEBQ- ExE), emotional eating (DEBQ-EE), and restrained eating (DEBQ-RE). Each item is rated on a five-point Likert scale, and no standardized cut-off values have been established. Total and subscale scores are interpreted as continuous measures that reflect the frequency of the corresponding eating behaviors. The Turkish adaptation of the scale demonstrated good validity and reliability in a sample of Turkish university students (Bozan et al., 2011).

Statistical analysis

An a priori power analysis was conducted to estimate the required sample size for detecting the predictive effect of MEQ on external eating, the DEBQ subscale with the strongest previously reported association (f^2=.38). Assuming a two-tailed test with alpha=.05, power of.80, and one predictor of interest, the analysis indicated that approximately N=216 participants are required to detect an effect of this magnitude. When accounting for five additional covariates (total predictors u=6), the required sample size increases slightly to N ≈ 220. Given that the current study includes 236 participants, the sample is sufficiently powered to examine the relationship between MEQ and DEBQ (Muzni et al., 2021).

All statistical analyses were conducted using the Statistical Package for the Social Sciences (SPSS) version [26.0] and Stata version [17.0]. Descriptive statistics were used to summarize sociodemographic and clinical variables. Group differences in categorical variables (e.g., gender, smoking status) across chronotype groups (M-type, N-type, E-type) were assessed using Pearson's chi-square (χ^2) tests or Fisher-Freeman-Halton test. Bonferroni correction was applied to control for multiple comparisons, setting the adjusted alpha level at.017 for comparisons involving more than two groups. Kruskal–Wallis (KW) tests were employed to examine group differences in the TEPS, DEBQ scales and subscales for continuous variables that did not meet parametric assumptions. Where significant effects were found, pairwise comparisons were conducted and interpreted in light of the Bonferroni-adjusted significance threshold. Spearman rank-order correlation coefficients were computed to assess the relationships between the MEQ, TEPS, and DEBQ.

To evaluate the direct and indirect effects of chronotype (M-type, N-type, E-type) on anticipatory (TEPS-CAPF) and consummatory pleasure (TEPS-CPF) and eating behaviors (DEBQ-ExE, DEBQ-EE, DEBQ-RE), a path analysis was conducted using structural equation modeling (SEM) (Fig. 1). An initial hypothesized model was tested, and non-significant paths (p>.05) were removed to yield a final model that retained only statistically significant relationships. Model fit was evaluated using multiple fit indices, including the chi-square test of model fit, the Root Mean Square Error of Approximation (RMSEA) and its associated 90% confidence interval, the Comparative Fit Index (CFI), the Tucker-Lewis Index (TLI), and the Standardized Root Mean Square Residual (SRMR). Additionally, the Coefficient of Determination (CD) was used to estimate the proportion of explained variance.

Results

A total of 236 university students participated in the study. Of the sample, 58 students (24.6%) were categorized as E-type, 42 students (17.8%) as M-type, and 136 students (57.6%) as N- type.

The sociodemographic characteristics of the participants are presented in Table 1. Chronotype groups did not significantly differ in terms of age, weight, height, gender, BMI, marital status, monthly family income, employment status, psychiatric or medical disorders, substance use, history of self-harm or suicide attempts, history of suicidal ideation, family history of psychiatric disorders, or daily caffeine intake (all ps>.017, Bonferroni-adjusted threshold). When applying the Bonferroni correction for multiple comparisons (α=.017), only daily smoking habits differed significantly

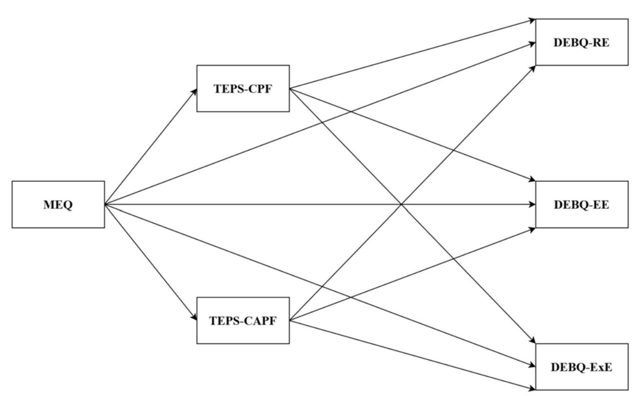

Fig. 1 Proposed Model 1.**Note.** MEQ=Morningness–Eveningness Questionnaire, TEPS=Temporal Experience of Pleasure Scale, DEBQ=Dutch Eating Behavior Questionnaire, CPF=Consummatory Pleasure Factor, CAPF=Contextual Anticipatory Pleasure Factor, RE=Restrained Eating, EE=Emotional Eating, ExE=External Eating

Table 1 Sociodemographic characteristics of the sample (N = 236, 100%)

		Evening Type (N = 58)	Neither Type (N = 136)	Morning Type (N = 42)	Statistics	
		N (%)			KW or χ2	p
Age	Years, mdn (IQR)	21.5 (2.8)	21 (2)	21 (2)	.932[1]	.627
Gender	Female	34 (58.6%)	91 (66.9%)	32 (76.2%)	3.398[2]	.183
	Male	24 (41.4%)	45 (33.1%)	10 (23.8%)		
Weight	kg, mdn (IQR)	60.3 (15.1)	60.8 (12.4)	61.0 (13.3)	.566	.754
Height	M, mdn (IQR)	169.0 (11.0)	170.0 (9.0)	171.0 (9.0)	.515	.773
BMI	kg/m^2, mdn (IQR)	21.3 (2.9)	21.4 (3.5)	21.0 (3.0)	.941[1]	.625
Marital Status	Single	54 (93.1%)	134 (98.5%)	42 (100.0%)	4.587[3]	.073
	Married	4 (6.9%)	2 (1.5%)	0 (0.0%)		
Living Arrangements	With parents	6 (10.3%)	20 (14.7%)	4 (9.5%)	12.963[2]	.044
	In a dormitory or hostel	17 (29.3%)	65 (47.8%)	19 (45.2%)		
	At home with friends	9 (15.5%)	13 (9.6%)	1 (2.4%)		
	Alone	26 (44.8%)	38 (27.9%)	18 (42.9%)		
Monthly Family Income	17,000–50000 tl	24 (41.4%)	65 (47.8%)	28 (66.7%)	10.817[2]	.094
	50,000–80000 tl	17 (29.3%)	40 (29.4%)	7 (16.7%)		
	80,000–130000 tl	15 (25.9%)	22 (16.2%)	7 (16.7%)		
	> 130,000 tl	2 (3.4%)	9 (6.6%)	0 (0.0%)		
Employment Status	Employed	3 (5.2%)	5 (3.7%)	0 (0.0%)	1.810[3]	.470
	Unemployed	55 (94.8%)	131 (96.3%)	42 (100.0%)		
History of Psychiatric Disorders	No	48 (82.8%)	118 (86.8%)	38 (90.5%)	1.267[2]	.531
	Yes	10 (17.2%)	18 (13.2%)	4 (9.5%)		
Medical Disorders	No	54 (93.1%)	117 (86.0%)	39 (92.9%)	2.858[2]	.240
	Yes	4 (6.9%)	19 (14.0%)	3 (7.1%)		
History of Substance Use	No	48 (82.8%)	126 (92.6%)	38 (90.5%)	4.375[2]	.112
	Yes	10 (17.2%)	10 (7.4%)	4 (9.5%)		
History of Self-Harm	No	49 (84.5%)	125 (91.9%)	38 (90.5%)	2.480[2]	.289
	Yes	9 (15.5%)	11 (8.1%)	4 (9.5%)		
History of Suicidal Thoughts	No	39 (67.2%)	98 (72.1%)	34 (81.0%)	2.320[2]	.313
	Yes	19 (32.8%)	38 (27.9%)	8 (19.0%)		
History of Suicide Attempts	No	55 (94.8%)	129 (94.9%)	41 (97.6%)	.469[3]	.833
	Yes	3 (5.2%)	7 (5.1%)	1 (2.4%)		
Family History of Psychiatric Disorders	No	49 (84.5%)	122 (89.7%)	41 (97.6%)	4.607[2]	.100
	Yes	9 (15.5%)	14 (10.3%)	1 (2.4%)		
Daily Caffeine Intake	None	2 (3.4%)	11 (8.1%)	4 (9.5%)	5.571[2]	.695
	2–3 cup/week	10 (17.2%)	26 (19.1%)	8 (19.0%)		
	1 cup/day	20 (34.5%)	30 (22.1%)	8 (19.0%)		
	2–3 cup/day	19 (32.8%)	46 (33.8%)	15 (35.7%)		
	> 3 cup/day	7 (12.1%)	23 (16.9%)	7 (16.7%)		
Daily Smoking	None	24 (41.4%)	96 (70.6%)	32 (76.2%)	26.808[2]	.003
	2–4 per week	4 (6.9%)	9 (6.6%)	3 (7.1%)		
	1 per day	1 (1.7%)	2 (1.5%)	2 (4.8%)		
	1–20 per day	13 (22.4%)	11 (8.1%)	2 (4.8%)		
	10–20 per day	11 (19.0%)	10 (7.4%)	3 (7.1%)		
	> 20 per day	5 (8.6%)	8 (5.9%)	0 (0.0%)		

BMI = body mass index, tl = turkish lira, kg = kilogram, m = meter. [1]Kruskal-Wallis test, [2]Pearson chi square test or [3]Fisher-Freeman-Halton test were used. A Bonferroni correction was applied to adjust for multiple comparisons across chronotype groups (α = .05/3 = .017)

across chronotype groups, $\chi^2(10, N=236)=26.81$, $p=.003$. While 76.2% of M-type and 70.6% of N-type reported not smoking, this proportion was substantially lower among E-type (41.4%). E-type also showed a higher prevalence of smoking more than 10 cigarettes per day (27.6%). Although a difference in living arrangements was observed across chronotypes, $\chi^2(6, N=236)=12.96$, $p=.044$, this did not reach the adjusted significance threshold ($p<.017$). No other sociodemographic or clinical characteristics significantly differed between chronotype groups.

Comparative analyses examined differences in TEPS and DEBQ across chronotype groups (see Table 2).

Table 2 Comparative analysis results of the TEPS and the DEBQ across chronotype groups

		Evening Type (N=58)		Neither Type (N=136)		Morning Type (N=42)		Statistics		Post Hoc Differences
		Mdn (IQR)	M (SD)	Mdn (IQR)	M (SD)	Mdn (IQR)	M (SD)	KW	p	
TEPS	Total	68 (16)	68.4 (9.8)	71 (13)	69.1 (11.5)	78 (15)	75.7 (9.9)	14.088	**.001**	**ET=NT<MT**
	CPF	38.5 (7)	38.1 (6.3)	38 (7)	37.7 (6.2)	42 (7)	40.8 (5.5)	9.159	**.010**	**ET=NT<MT**
	CAPF	31.0 (9.3)	30.3 (6.7)	32.0 (8.0)	31.3 (6.4)	36.0 (8.3)	34.9 (5.0)	14.482	**.001**	**ET=NT<MT**
DEBQ	Total	2.6 (.7)	2.7 (.6)	2.7 (1.0)	2.8 (.7)	2.7 (1.0)	2.7 (.8)	.720	.698	-
	RE	2.1 (1.5)	2.2 (.9)	2.8 (1.5)	2.7 (.9)	2.7 (1.4)	2.6 (.9)	11.173	**.004**	**ET<NT=MT**
	EE	2.4 (1.6)	2.4 (1.1)	2.4 (1.8)	2.5 (1.1)	2.1 (1.5)	2.4 (1.2)	.701	.704	-
	ExE	3.4 (.7)	3.4 (.9)	3.2 (.8)	3.2 (.6)	3.4 (1.4)	3.3 (1.0)	5.089	.079	-

MEQ=Morningness–Eveningness Questionnaire, TEPS=Temporal Experience of Pleasure Scale, DEBQ=Dutch Eating Behavior Questionnaire, CPF=Consummatory Pleasure Factor, CAPF=Contextual Anticipatory Pleasure Factor, RE=Restrained Eating, EE=Emotional Eating, ExE=External Eating. [1]Kruskal-Wallis test was used. A Bonferroni correction was applied to adjust for multiple comparisons across chronotype groups (α=.05/3=.017)

Chronotype groups significantly differed in total TEPS scores, KW=14.09, p=.001, with M-type reporting significantly higher scores than E and N- types (ET=NT<MT). This pattern held across subcomponents, including the TEPS-CPF (KW=9.16, p=.010) and the TEPS-CAPF (KW=14.48, p=.001), where M-type again reported the highest scores. No significant differences were observed in total DEBQ (KW=0.72, p=.698). However, a significant difference was noted in the DEBQ-RE (KW=11.17, p=.004), with E-type scoring lower than N and M- types (ET<NT=MT). The DEBQ-EE (KW=0.70, p=.704) and the DEBQ-ExE (KW=5.09, p=.079) did not significantly differ across chronotype groups (all p>.017, Bonferroni-adjusted threshold).

Spearman correlation analyses were conducted to examine the relationships between the MEQ, the TEPS, and the DEBQ (see Table 3). MEQ scores showed positive associations with the TEPS. Specifically, the MEQ was positively correlated with total TEPS scores (r=.235, p<.01), as well as with the TEPS-CPF (r=.158, p<.05) and the TEPS-CAPF (r=.235, p<.01). Regarding eating behaviors, no significant correlation was found between the MEQ and total DEBQ scores (r=.030, p>.05). However, a modest positive correlation was observed between the MEQ and the DEBQ-RE (r=.149, p<.05), whereas no significant relationships were found with the DEBQ- EE (r=–.022, p>.05) or the DEBQ-ExE (r=–.067, p>.05). On the other hand, total TEPS scores were positively associated with total DEBQ (r=.182, p<.01). Subscale-level associations indicated that TEPS scores correlated with the DEBQ-ExE (r=.310, p<.01) and the DEBQ- EE (r=.153, p<.05), while showing no significant association with the DEBQ-RE (r=–.101, p>.05). Furthermore, the TEPS-CAPF was positively correlated with total DEBQ (r=.214, p<.01), EE (r=.207, p<.01), and DEBQ-ExE (r=.329, p<.01), whereas the TEPS-CPF showed no significant associations with DEBQ subscales. Finally, BMI was not significantly correlated with the MEQ, TEPS, or DEBQ (all ps>.05).

Figure 2 presents the SEM results of the hypothesized model depicted in Fig. 1, in which all specified paths were tested (also see Table 4). In the final model, MEQ scores were found to significantly predict TEPS-CPF (β=.13, p=.02), and TEPS-CAPF (β=.27, p<.01). CPF scores were found to be significantly predictor DEBQ-EE (β=–.40,

Table 3 Correlation matrix between the MEQ, the TEPS, and DEBQ

		MEQ	TEPS			DEBQ				BMI
			Total	CPF	CAPF	Total	RE	EE	ExE	
MEQ		1.000								
TEPS	Total	.235**	1.000							
	CPF	.158*	.856**	1.000						
	CAPF	.235**	.912**	.596**	1.000					
DEBQ	Total	.030	.182**	.096	.214**	1.000				
	RE	.149*	-.101	-.057	-.119	.567**	1.000			
	EE	-.022	.153*	.030	.207**	.886**	.263**	1.000		
	ExE	-.067	.310**	.248**	.329**	.540**	.010	.374**	1.000	
BMI		.027	.010	-.019	.030	-.053	.021	-.067	-.068	1.000

MEQ=Morningness–Eveningness Questionnaire, TEPS=Temporal Experience of Pleasure Scale, DEBQ=Dutch Eating Behavior Questionnaire, CPF=Consummatory Pleasure Factor, CAPF=Contextual Anticipatory Pleasure Factor, RE=Restrained Eating, EE=Emotional Eating, ExE=External Eating. *p<.05, ** p<.01; Spearman Correlation Coefficients

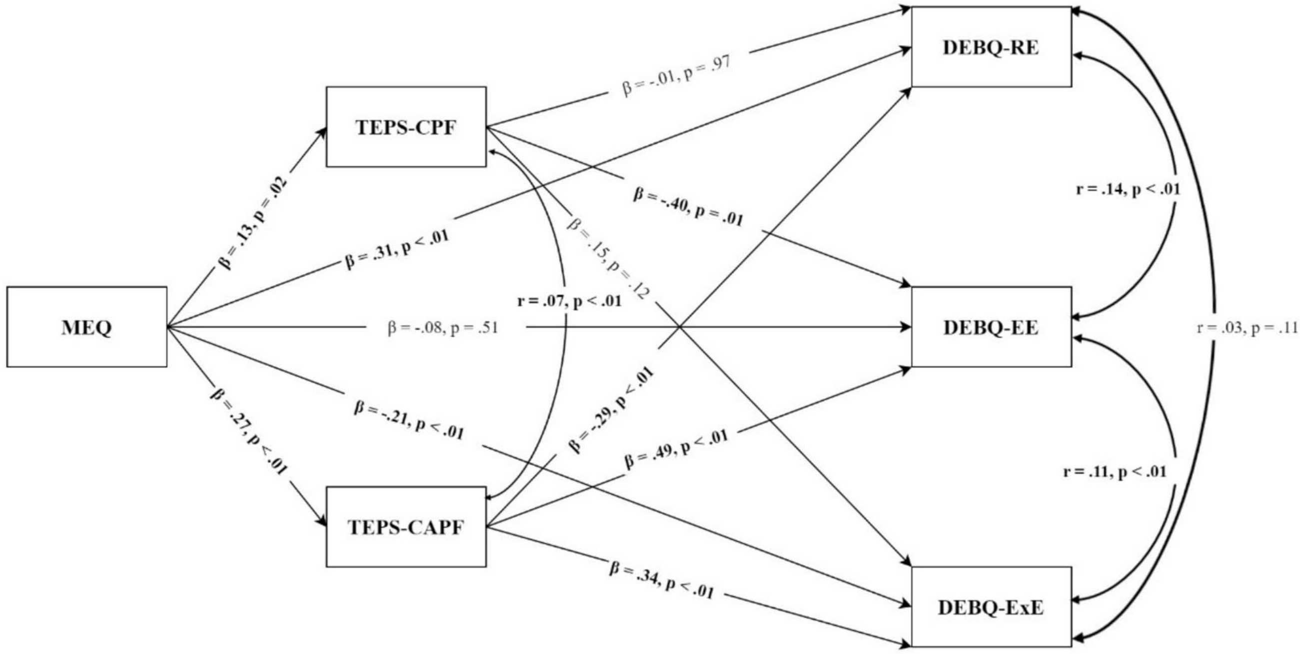

Fig. 2 Standardized path coefficients (β) and significance levels (p) resulting from the path analysis of the hypothesized model. **Note.** MEQ = Morningness–Eveningness Questionnaire, TEPS = Temporal Experience of Pleasure Scale, DEBQ = Dutch Eating Behavior Questionnaire, CPF = Consummatory Pleasure Factor, CAPF = Contextual Anticipatory Pleasure Factor, RE = Restrained Eating, EE = Emotional Eating, ExE = External Eating

Table 4 Standardized path coefficients for the structural model

Outcome Variable	Predictor	β (SE)	95% CI	p
TEPS-CPF	MEQ	.13 (.07)	[.02,.29]	.024
TEPS-CAPF	MEQ	.27 (.07)	[.13,.39]	<.001
DEBQ-RE	TEPS-CAPF	–.29 (.07)	[–.42, –.13]	.003
	MEQ	.31 (.07)	[.14,.36]	.004
DEBQ-ExE	TEPS-CAPF	.34 (.08)	[.16,.47]	<.001
	MEQ	–.21 (.06)	[–.31, –.07]	.002
DEBQ-EE	TEPS-CPF	–.40 (.07)	[–.51, –.15]	.009
	TEPS-CAPF	.49 (.08)	[.15,.63]	<.001

Standardized path coefficients (β) are shown with bootstrap standard errors (SE). 500 Bootstrap Replications, CI = bias-corrected accelerated 95% confidence intervals based on 500 bootstrap replications

p = .01) but not with DEBQ-RE (β = –.01, p = .97) or DEBQ-ExE (β = .15, p = .12). CAPF scores significantly predicted DEBQ-EE (β = .49, p < .01), DEBQ-ExE (β = .34, p < .01), and DEBQ-RE scores (β = –.29, p < .01). Direct associations were also observed between MEQ and DEBQ-RE (β = .31, p < .01) and DEBQ-ExE (β = –.21, p < .01), while no direct effect was found on DEBQ-EE (β = –.08, p = .51). Additionally, TEPS-CPF and TEPS-CAPF scores were correlated (r = .07, p < .01). Intercorrelations among DEBQ subscales revealed significant associations between DEBQ-RE and DEBQ-EE (r = .14, p < .01) and between DEBQ-EE and DEBQ-ExE (r = .11, p < .01). In contrast, no significant correlation was observed between DEBQ-RE and DEBQ-ExE (r = .03, p = .11).

Table 5 Indirect effects of MEQ on DEBQ via TEPS

Outcome Variable	Pathway	β (SE)	95% CI	p
DEBQ-RE	MEQ → TEPS-CAPF → DEBQ-RE	–0.05 (0.02)	[–0.09, –0.01]	.026
	MEQ → TEPS-CPF → DEBQ-RE	0.01 (0.02)	[–0.03, 0.05]	.512
DEBQ-ExE	MEQ → TEPS-CAPF → DEBQ-ExE	0.08 (0.03)	[0.03, 0.13]	.002
	MEQ → TEPS-CPF → DEBQ-ExE	–0.02 (0.02)	[–0.06, 0.02]	.198
DEBQ-EE	MEQ → TEPS-CAPF → DEBQ-EE	0.04 (0.03)	[–0.02, 0.09]	.156
	MEQ → TEPS-CPF → DEBQ-EE	0.03 (0.03)	[–0.02, 0.08]	.141

Standardized coefficients (β) and standard errors (SE) are reported. CI = bias-corrected accelerated 95% confidence intervals based on 500 bootstrap replications

Mediation analyses showed that TEPS-CAPF pleasure exerted distinct indirect influences on eating behaviors (see Table 5). The CAPF pathway partially mediated the associations between MEQ and DEBQ-RE (β = –.05, p = .026) and between MEQ and DEBQ-ExE (β = .08, p = .002), whereas CPF showed no significant mediation effects for these variables (all ps > .10). For DEBQ-EE, indirect effects through both CAPF and CPF were positive but nonsignificant (all ps > .10).

The fit indices indicated an excellent model fit. The chi-square test comparing the hypothesized model to the saturated model was non-significant ($\chi^2(4)=5.450$, p=.244), suggesting a good fit. The RMSEA value was.039, with a 90% CI ranging from.000 to.112 and a p close of.505, indicating a close fit of the model in the population. Other fit indices were within acceptable or excellent ranges: CFI=.993 and TLI=.975. The SRMR value of.031 was well below the recommended cutoff of.08, further supporting model adequacy. The coefficient of determination (CD) was.131, suggesting that the model accounted for a modest proportion of the variance in the observed variables. These results suggest that the proposed model provides a robust and parsimonious representation of the data.

Discussion

This study aimed to address a significant gap in the literature by taking a holistic approach to examine the influence of chronotype on eating behavior through the perspective of hedonic pleasure dimensions. Our findings show that individuals with a morning chronotype exhibit significantly higher levels of anticipatory and consummatory pleasure than those with an evening chronotype. A tendency toward a morning chronotype was positively associated with both anticipatory and consummatory pleasure levels. In addition, a statistically significant positive correlation was found between anticipatory and consummatory pleasure levels. Between-group and correlational analyses also revealed significant direct relationships between chronotype and both restrained and external eating, such that greater morningness was associated with increased restrained eating and decreased external eating, independent of mediation by hedonic dimensions. Within the SEM framework, however, the anticipatory pleasure dimension of hedonic capacity exhibited opposing mediated (indirect) effects on these direct associations. An anticipatory–pleasure–mediated pathway offset the positive direct link between morningness and restrained eating via a negative indirect effect, while in relation to external eating, it intensified the negative direct link via a positive indirect effect. SEM indicated that the two dimensions of hedonic pleasure are directly associated with emotional eating in opposing directions: anticipatory pleasure was positively associated with emotional eating, whereas consummatory pleasure was negatively associated. Anticipatory pleasure also significantly mediated the association between morningness and increased emotional eating, while no evidence of mediation was observed for consummatory pleasure. This pattern raises the possibility that chronotype-dependent and chronotype-independent hedonic processes may play distinct roles in shaping emotional eating. Taken together, these findings delineate the multilayered interaction among chronotype, hedonic experience, and eating behavior, implicating multiple mechanisms that may contribute to both adaptive and maladaptive eating phenotypes.

Consistent with our hypothesis, individuals with a morning chronotype report higher levels of pleasure (Tan et al., 2020). Moreover, the subdimensions of pleasure were positively associated, which may reflect the relatively high psychological functioning and integrated hedonic processing characteristic of university student samples (Nguyen et al., 2021). This tendency could enhance hedonic-based eating behaviors via positive reinforcement mechanisms. In line with previous evidence, morningness has been linked to reduced external eating but increased restrained eating (Beaulieu et al., 2024; Budkevich et al., 2021; Schubert & Randler, 2008), suggesting that individuals with a morning chronotype may demonstrate greater cognitive control over reward-driven eating cues, potentially supported by prefrontal self-regulatory processes (Dohle et al., 2018). Paradoxically, however, the mediated influence of anticipatory pleasure was oppositely signed: despite the direct effects of morningness favoring greater restraint and less external eating, elevations in anticipatory pleasure—via positive reinforcement—were associated with more external eating and reduced restrained eating. The findings suggest that in individuals with a morningness chronotype, increased levels of anticipatory pleasure may serve as a potential risk factor contributing to the development of unhealthy eating behavior patterns through its mediating effects (Dohle et al., 2018; Erlanson-Albertsson, 2005).

Recent literature suggests that increased levels of anticipatory 'wanting' pleasure observed in conditions such as obesity and binge eating do not necessarily correspond with heightened consummatory “liking” pleasure (Morales & Berridge, 2020). This finding suggests that in highly sensitive individuals, the drive to obtain food may be dissociated from the actual hedonic experience of consumption, reflecting a disconnect between anticipatory and consummatory aspects of reward processing (Devoto et al., 2018; Robinson et al., 2015; Stice & Yokum, 2016). Within the framework of incentive sensitization theory, this dissociation provides a robust model for understanding reward-related mechanisms underlying eating behaviors (Berridge & Robinson, 2016). By emphasizing heterogeneity in hedonic contributions to the chronotype–eating linkage, our study underscores the importance of examining specific domains, particularly anticipatory pleasure. Research grounded in this theory shows that individuals with food addiction display more frequent and intense emotional eating responses to palatable foods compared to those without such vulnerability (Bozkurt et al., 2024). A key mechanism proposed within incentive sensitization theory is that factors which sensitize the mesolimbic system—such as stress and emotional arousal—may increase the “wanting” response to food in individuals with heightened reward sensitivity (Morales & Berridge, 2020). Conversely, in our data, a stronger inclination toward the morningness chronotype was indirectly associated—via elevations in anticipatory pleasure—with reduced restrained eating and increased external eating. This constellation may denote a potential risk profile for the emergence of maladaptive eating, particularly under stress or heightened affect, when ‘wanting’ responses are amplified. This pattern further suggests that the anticipatory reward-processing component may attenuate the self-regulatory advantages typically attributed to morningness—indeed, under specific contexts, functioning as a suppressor/opponent mediator that can overshadow the direct effects.

Another notable finding was that emotional eating exhibited divergent associations with the two components of hedonic processing: irrespective of chronotype, it was positively related to anticipatory pleasure (“wanting”) and inversely related to consummatory pleasure (“liking”). When chronotype was included in the SEM, greater morningness predicted higher anticipatory pleasure, which in turn was associated with increased emotional eating—a significant indirect effect. By contrast, there was no evidence that consummatory pleasure mediated the chronotype–emotional eating association. Taken together, these results suggest that when affect-regulation processes (e.g., stress, psychopathology, negative affect) intersect with diminished consummatory hedonia and heightened incentive salience, the likelihood of maladaptive eating patterns such as emotional eating increases. This constellation may also compromise the putative buffering/regulatory role of a morning chronotype in eating phenotypes governed by self-regulation and cue reactivity (e.g., restrained and external eating) (Evers et al., 2018). Furthermore, a more substantial capacity for “liking” may attenuate reliance on eating as an emotion-regulation strategy under stress, implying that, in healthy populations, emotional eating aligns more closely with the qualitative hedonic experience than with incentive salience per se.

Limitations and future recommendations

This study has several limitations. First, the inclusion of only medical students in the sample limits the generalizability of the findings due to the limited diversity of the sample. This homogeneous sample was deliberately selected to minimize the influence of potential confounding variables such as age, sex, light exposure, and geographical location on biological rhythms. However, this approach may limit the generalizability of the findings to the broader population. Second, due to the study's cross-sectional design, only contemporaneous associations between variables could be examined, and these findings should be interpreted with caution, as causality cannot be inferred. Third, as the data were obtained solely through self-report measures and not supplemented by clinical assessments, the objectivity and precision of the responses may be limited. Fourth, the study's cross-sectional nature precludes the ability to follow intra-individual changes over time or capture potential seasonal variations. Finally, this study did not consider additional psychosocial and lifestyle factors—such as sleep duration, stress levels, and physical activity—that may influence the associations between chronotype, hedonic capacity, and eating behaviors. These methodological limitations limit the generalizability of the findings and highlight the need for cautious interpretation.

Several recommendations can be made to address these limitations in future research. First, the recruitment of larger and more diverse samples from multiple universities and academic disciplines may improve the representativeness of the study population. Second, longitudinal designs could monitor participant changes over time, allowing for a more nuanced examination of potential causal relationships between changes in chronotype and variations in hedonic capacity and eating behaviors. Finally, future research should consider developing comprehensive models that include relevant psychosocial and environmental factors—such as stress, physical activity, and dietary habits—that may influence the relationship between morningness-eveningness and hedonic capacity and eating behaviors. Accordingly, chronotype effects may emerge chiefly under contextual strain (high stress, poor sleep quality, social jetlag), and moderated-mediation models incorporating these moderators warrant evaluation (Vrabec et al., 2022; Zhou et al., 2024).

Conclusion

Taken together, our findings indicate that explanatory models of eating behaviour should integrate both chronotype and the hedonic components of reward. Among healthy young adults, a stronger morningness tendency was linked to higher anticipatory (“wanting”) and consummatory (“liking”) pleasure, greater dietary restraint, and lower external cue reactivity. Crucially, emotional eating showed divergent associations with the two hedonic components—positively with anticipatory pleasure and negatively with consummatory pleasure—independent of chronotype. Within the structural model, morningness exerted direct effects on restrained (positive) and external (negative) eating; at the same time, higher anticipatory pleasure formed an indirect pathway (emotional eating) that attenuated the restraint advantage and amplified externally cued eating. By contrast, consummatory pleasure did not mediate the links between chronotype and emotional eating. In line with incentive-sensitisation models, excessive 'wanting' in the absence of a commensurate rise in 'liking'—a disparity that may be accentuated under affective load—may bias behaviour toward reward seeking and thereby increase the likelihood of maladaptive eating. Clinically, a concurrent appraisal of chronotype and hedonic profile could refine risk stratification for hedonically driven overeating and inform personalised strategies that (i) dampen cue-dependent "wanting" (e.g., cue-exposure and attentional control techniques) and (ii) strengthen adaptive "liking" (e.g., interventions that enhance sensory pleasure and mindful savoring to reduce emotion-regulation eating). Framed in this way, chronotype may be understood not merely as a timing preference but as a component of an integrated, dynamic system in which circadian preference interacts with dissociable hedonic processes to shape the expression of eating phenotypes, suggesting that a contextualised, multidimensional perspective is likely to provide a more precise account than one-dimensional explanations.

Authors' contributions **Conceptualization:** Burak Okumus; **Data curation:** Burak Okumus; **Formal analysis:** Burak Okumus, Makbule Esen Oksuzoglu; **Investigation:** Burak Okumus, Makbule Esen Oksuzoglu; **Methodology:** Burak Okumus, Makbule Esen Oksuzoglu; **Software:** Makbule Esen Oksuzoglu; **Supervision:** Burak Okumus, Makbule Esen Oksuzoglu; **Validation:** Burak Okumus, Makbule Esen Oksuzoglu; **Visualization:** Makbule Esen Oksuzoglu; **Writing – original draft:** Burak Okumus; **Writing – review & editing:** Burak Okumus, Makbule Esen Oksuzoglu.

Funding Open access funding provided by the Scientific and Technological Research Council of Türkiye (TÜBİTAK). This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Data availability The data that support the findings of this study are available from the corresponding author upon reasonable request.

Declarations

Informed consent Informed consent was obtained from all subjects involved in the study.

Consent to publish All participants consented to the study's submission and publication.

Competing interest None.

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