Received: 17 October 2022 | Revised: 19 January 2023 | Accepted: 24 January 2023

DOI: 10.1002/oby.23749

Obesity A Research Journal | THE OBESITY SOCIETY | WILEY

ORIGINAL ARTICLE

Sleep and Metabolic Health

Evening types as determined by subjective and objective measures are more emotional eaters

Marta Garaulet[1,2,3] | Barbara Vizmanos[4,5,6,7] | Teresa Muela[1] | Alejandra Betancourt-Núñez[4,5,6] | María-Ángeles Bonmatí-Carrión[8] | Céline Vetter[9] | Hassan S. Dashti[10,11,12,13] | Richa Saxena[10,11,12] | Frank A. J. L. Scheer[3,10,13]

[1]Department of Physiology, Regional Campus of International Excellence, University of Murcia, Murcia, Spain

[2]Biomedical Research Institute of Murcia, IMIB-Arrixaca-UMU, University Clinical Hospital, Murcia, Spain

[3]Medical Chronobiology Program, Division of Sleep and Circadian Disorders, Departments of Medicine and Neurology, Brigham and Women's Hospital, Boston, Massachusetts, USA

[4]Institute of Nutrigenetics and Nutrigenomics, University Center for Health Sciences, University of Guadalajara, Guadalajara, Mexico

[5]Department of Philosophical, Methodological and Instrumental Disciplines, University Center for Health Sciences, University of Guadalajara, Guadalajara, Mexico

[6]Nutritional Status Assessment Laboratory, Department of Human Reproduction, Child Growth and Development Clinics, University Center for Health Sciences, University of Guadalajara, Guadalajara, Mexico

[7]Department of Public Health, University Center for Health Sciences, University of Guadalajara, Guadalajara, Mexico

[8]Ciber Fragilidad y Envejecimiento Saludable (CIBERFES), Madrid, Spain

[9]Department of Integrative Physiology, University of Colorado Boulder, Boulder, Colorado, USA

[10]Broad Institute, Cambridge, Massachusetts, USA

[11]Center for Genomic Medicine, Massachusetts General Hospital and Harvard Medical School, Boston, Massachusetts, USA

[12]Department of Anesthesia, Critical Care and Pain Medicine, Massachusetts General Hospital and Harvard Medical School, Boston, Massachusetts, USA

[13]Division of Sleep Medicine, Harvard Medical School, Boston, Massachusetts, USA

Correspondence
Marta Garaulet, Department of Physiology, Faculty of Medicine, Espinardo Campus, University of Murcia, Murcia, Spain.
Email: garaulet@um.es

Funding information
MCIN (Ministerio de Ciencias e Innovación)/AEI (Agencia Estatal de Investigación)/10.13039/501100011033, Grant/Award Number: PID2020-112768RB-I00; Spanish Government of Investigation, Development and Innovation Innovation including FEDER (Fondo Europeo de Desarrollo Regional) co-funding, Grant/Award Number: SAF2017-84135-R; Autonomous Community of the Region of Murcia through the Seneca Foundation, Grant/Award Number: 20795/PI/18;

Abstract

Objective: This study aimed to determine the association between being an evening type (ET; defined subjectively by the Morning-Evening Questionnaire or objectively by the dim-light melatonin onset [DLMO] timing) and reporting emotional eating (EE) behaviors.

Methods: Cross-sectional analyses were conducted in 3964 participants (four international cohorts: ONTIME and ONTIME-MT [both Spain], SHIFT [the US], and DICA-CEM [Mexico]), in which chronotype (Morning-Evening Questionnaire), EE behaviors (Emotional Eating Questionnaire), and dietary habits (dietary records or food-frequency questionnaire) were assessed. Among 162 participants (ONTIME-MT subsample), additional measures of DLMO (physiological gold standard of circadian phase) were available.

Marta Garaulet and Barbara Vizmanos contributed equally to this work.

National Institutes of Health, Grant/Award Numbers: R01DK099512, R01DK102696, R01DK107859, R01HL118601, R01HL140574, R01HL153969, R01DK105072; Secretaría de Educación Pública, *Programa para el Desarrollo Profesional Docente*, Grant/Award Number: UDG-PTC-1511; University of Guadalajara, Programa de Fortalecimiento de la Investigacion; Consejo Nacional de Ciencia y Tecnología, Grant/Award Numbers: SNI-CVU-22064, SNI-CVU-484393

Results: In three populations, ETs presented with a higher EE score than morning types ($p < 0.02$); and they made up a higher proportion of emotional eaters ($p < 0.01$). ETs presented with higher scores on disinhibition/overeating as well as food craving factors and experienced these behaviors more frequently than morning types ($p < 0.05$). Furthermore, a meta-analysis showed that being an ET was associated with a higher EE score by 1.52 points of a total of 30 points (95% CI: 0.89–2.14). The timing of DLMO in the early, intermediate, and late objective chronotypes occurred at 21:02 h, 22:12 h, and 23:37 h, with late types showing a higher EE score ($p = 0.043$).

Conclusions: Eveningness associated with EE in populations with different cultural, environmental, and genetic backgrounds. Individuals with late DLMO also showed more EE.

INTRODUCTION

Chronotype refers to the preferred or typical timing of behaviors throughout the day of an individual. Evening types (ETs) prefer a later bedtime and wake time, whereas morning types (MTs) adopt an earlier bedtime and wake time [1, 2]. Preferences for the timing of behaviors, including sleep and physical activity, have been frequently assessed by the Morningness-Eveningness Questionnaire (MEQ), considered an international gold standard measure of chronotype [3]. Chronotype shows a relationship with the timing of the central circadian clock [4]. The timing of the central clock can be reliably assessed by the dim-light melatonin onset (DLMO), as melatonin release by the pineal gland is regulated by the central clock [5]. ETs and MTs tend to have later and earlier DLMO, respectively [6]. However, chronotype is also influenced by factors other than circadian timing (environmental, social, psychological, and homeostatic sleep factors). All these elements may cause individuals to adopt an earlier or later sleep schedule than that expected if it were based exclusively on their DLMO [7]. For these reasons, the MEQ and DLMO—although correlated—do not assess the same processes [6]. However, both have been used to categorize chronotype, either subjectively or objectively [8]. Despite the usefulness of DLMO, studies involving its determination are generally small because it requires a high number of biological samples and the collection is lengthy, laborious, and costly, requiring specialized expertise in data collection and interpretation [6].

Evening chronotypes had higher metabolic risk than MTs across different age groups [9–12], even when the degree of obesity is considered [13]. In addition, being an ET has been associated with emotional dysregulation [14] and psychological disturbances, in particular increased risk of depression and anxiety [15]. Furthermore, eveningness correlates with other personality dimensions [16]. ETs compared with MTs are more impulsive, perceive more problems related to themselves, and are less able to inhibit and adapt their behaviors [16].

Being an emotional eater has been related to obesity, especially abdominal obesity [17], the riskiest form of obesity [18]. We previously developed and validated the Emotional Eating (EE) Questionnaire (EEQ) [19] to assess EE in different populations [20, 21]. This questionnaire includes three factors: disinhibition (tendency to overeat in response to different emotional stimuli), food

Study Importance

What is already known?

- Late chronotype is associated with increased risk for obesity.
- Emotional eating (EE) is a primary risk factor for obesity.

What does this study add?

- We found that eveningness associated with emotional eating in populations with different cultural, environmental, and genetic backgrounds.
- This is the first study to evaluate the association between individual chronotype and EE using the dim-light melatonin onset, the gold standard measure to assess the timing of the central clock, used to objectively characterize chronotype.

How might these results change the direction of research or the focus of clinical practice?

- Evening types are a vulnerable population at increased obesity and metabolic risk; therefore, chronotype must be considered in metabolic disturbances, and it may inform behavioral approaches aimed at emotional eating.
- Future studies may be warranted to test personalized behavioral therapy, targeting aspects of emotional eating in individuals with an evening chronotype to improve their eating behaviors and health.

craving (intense desire to consume a specific food), and sense of guilt (feeling of responsibility for having done something self-perceived as wrong).

Based on these factors, we hypothesized that ETs tend to be emotional eaters. In this study, we analyzed a large population in Spain (Obesity, Nutrigenetics, TIming, and MEditerranean study [ONTIME]) and replicated findings in cohorts from Europe (Spain: ONTIME-MelaTonin study [ONTIME-MT]) and North America (the US: Shift work, Heredity, Insulin, and Food Timing study [SHIFT]; and Mexico: DIeta, CAlidad, Cronotipo y EMociones study [DICACEM]). We studied the potential association between eveningness (as determined by MEQ and DLMO) and EE and components of EE. In secondary analyses, we studied energy intake and dietary habits in those populations in which chronotype is associated with disinhibition or food craving to better understand the connection between individual chronotype and obesity in those individuals with EE.

METHODS

Study populations and ethical considerations

This cross-sectional analysis includes data from four populations (ONTIME, ONTIME-MT, SHIFT, and DICACEM). Participants included in this study were adult volunteers (18 to 65 years old) who had completed the EEQ and MEQ. In ONTIME, ONTIME-MT, and SHIFT populations, individuals were excluded if they had a bulimia diagnosis; if they were prone to binge eating; and if they were undergoing treatment with antidepressants or were taking medications for sleep, opioids, amphetamines, or tranquilizers.

The ethics committees of each country and institution approved each study protocol. All volunteers approved their participation (informed consent form). Good clinical practice principles were followed.

ONTIME (ClinicalTrials.gov identifier NCT02829619; University Ethical Committee, ID-632/2017; University of Murcia, Spain) includes information on individuals with overweight or obesity who attended clinical centers for nutritional counseling and weight loss (Mediterranean diet) from 2008 on ($n = 2266$).

ONTIME-MT (ClinicalTrials.gov identifier NCT03036592; University Ethical Committee, ID-1188/2015; University of Murcia, Spain) included data from healthy adults not taking medication and specifically invited in 2017 to evaluate the role of melatonin receptor 1B (*MTNR1B*) single-nucleotide polymorphism and food timing interaction in glucose control ($n = 642$). A subsample, called the DLMO (ONTIME-MT) subsample, was invited to perform a DLMO assessment ($n = 162$).

SHIFT (ClinicalTrials.gov identifier NCT02997319; Mass General Brigham Institutional Review Board, #2016P000651) was aimed at determining the effect of food intake and melatonin on glucose tolerance, particularly in carriers of the *MTNR1B* risk gene variant [22] ($n = 388$).

DICACEM (University Ethical Committee CI-02719; University of Guadalajara, Mexico) is based on a general health assessment of volunteer university administrative workers ($n = 668$) at the end of 2019.

In the ONTIME and ONTIME-MT studies, the family and work status of participants were quite diverse (e.g., mothers working or not; men working or not; young people interested in eating healthier; older individuals who may have fewer social obligations and who wanted to improve their dietary intake to achieve better health and well-being). SHIFT included predominantly day-working adults but also night-shift workers. DICACEM subjects were all daytime university workers.

Variables

For all the populations, two questionnaires (MEQ and EEQ) were completed. Sociodemographic, anthropometric, and nutritional variables were also included. DLMO was assessed exclusively in the DLMO subsample.

Assessment of subjective chronotype

To categorize the subjective chronotype in each population, we used the validated MEQ [3, 23], which includes 19 questions about preferred bedtime, wake time, or time for performing physical activities during the day (the higher the score, the higher the morning preference). MEQ score was categorized into morning preference (≥59 points), intermediate (42–58 points), and evening preference (≤41 points). Both morning and evening preferences included participants in the moderate and extreme categories (from original classification) [3, 23].

Objective chronotype (DLMO measurements)

Melatonin concentrations were determined from saliva samples collected under dim-light conditions (to obtain DLMO) for a total of 5 hours (from 4 hours before and up to 1 hour after each participant's usual bedtime). The individual's usual bedtime was determined using 1 week of data (derived from a study-specific smartphone app). Saliva samples were collected every 30 minutes (11 measurements) using the Salivette device (Sarstedt) in a dark room at the Hospital Virgen de la Arrixaca (Murcia, Spain).

During the DLMO protocol, participants were instructed to remain seated in dim light (<10 lux) and not to eat or drink any food or use cell phones from 30 minutes before starting and during the 5-hour determinations in order to limit any possible influence on salivary melatonin assessments. The objective criterion for establishing DLMO was the time point at which the interpolated melatonin concentration crossed the threshold of the mean plus two standard deviations (SDs) of three baseline reference samples [24]. Subsequently, participants

were classified according to their DLMO into objectively determined chronotypes based on tertiles, with the following cutoff points: early (DLMO ≤ 21:40 h), intermediate (DLMO 21:40–22:40 h), and late individuals (DLMO ≥ 22:40 h).

EE behavior

In all cohorts, EE behavior was assessed with the 10-item EEQ, a validated self-administered test involving three factors [19]. The first factor, disinhibition (six items), includes questions such as "Do you feel less control over your diet when you are tired after work at night?" The food craving factor (two items) asks the participant, "Do you have cravings for specific foods?" The third factor, feeling guilty (two items), explores questions related to participant emotions and the relationship to body weight scales, as well as the sense of guilt that eating "forbidden" foods produces [19]. The more frequently each behavior was reported, the higher the total EE score. We classified participants into nonemotional eaters (0–10 points, including low emotional eaters [6–10 points]) and emotional eaters (11–30 points, including very emotional eaters [≥21–30 points]) [25]. For the factors-based score, the values of all questions involved within each factor were summed separately [19].

Anthropometric and body composition assessments

All four studies assessed anthropometric measurements with similar techniques: height of participant when standing without shoes and head in the Frankfurt plane, using a centimeter scale. Weight was assessed in light clothing and without shoes. Body composition data were obtained by bioimpedance: Tanita TBF-300 (ONTIME and ONTIME-MT); Tanita BC-568 (DICACEM). For SHIFT, each participant also underwent dual-energy x-ray absorptiometry (Hologic Horizon A model).

Waist circumference was measured at the midpoint between the edge of the lower costal and the iliac crest. Hip circumference was measured around the widest part of the hips, and the waist-hip ratio was calculated as waist/hip circumferences.

Dietary intake assessments

The studies used different methods to assess dietary intake. In ONTIME, a 24-hour recall was used (from Sunday, Tuesday, and Thursday). In ONTIME-MT and DLMO, a 7-day dietary record was used, and a 14-day dietary record was used in SHIFT. During the study period, participants were asked to fill out a paper record (SHIFT) or use a smartphone app (ONTIME-MT) noting the type of food/drink and the portion size or amount for each eating/drinking occasion; each entry was time-stamped on the smartphone app. A trained dietitian provided participants with instructions for completing food records, a portion size estimation information sheet, and an example of a completed food record. In ONTIME and SHIFT, food record data were entered by a trained dietitian. In ONTIME-MT and DLMO, participants completed the information directly in the app. Food data were analyzed with Grunumur 2.0 in the ONTIME, ONTIME-MT, and DLMO studies. The Nutrition Data System for Research (NDSR) software (Nutrition Coordinating Center, University of Minnesota, Minneapolis, Minnesota) was used in SHIFT. In DICACEM, a semiquantitative food-frequency questionnaire validated with a validated photograph album of Mexican foods was applied and captured by experienced nutritionists (software: Nutricloud) [25].

In the ONTIME and ONTIME-MT studies, we calculated the Mediterranean diet score [26]. This score varied from 0 to 9 (low- to high-quality). Eating beneficial components of the diet in an amount equal to or greater than the sex-specific median value (fresh/dried fruits, vegetables, legumes, fish, cereals/potatoes) each added 1 point, and for each component presumed to be deleterious (meat/eggs and dairy products), 1 point was added if participants ate less than the sex-specific median. Alcohol and fat intake was also evaluated [26].

Statistical analysis

Quantitative variables were expressed as mean ± SD and qualitative variables as frequency (percentage); comparisons of these variables among the four studies were performed with ANOVA and χ^2, respectively. We performed a simple correlation between subjective (MEQ) and objective (DLMO) chronotype. Comparisons of EEQ score (as continuous variable) and each derived factor among the three groups of chronotypes (according to MEQ or DLMO) were performed with ANCOVA adjusted for age, sex, and body mass index (BMI) (because it may affect EE). We also used the ANCOVA's post hoc test (Fisher least significant difference) when we found overall differences. Among the three chronotypes, the proportions between emotional and nonemotional eaters and between presence and absence of each EE factor were analyzed with χ^2. Some simple Pearson correlation analyses were performed between quantitative variables (i.e., EEQ score with energy or macronutrient intake). All analyses were performed with SPSS Statistics version 28 (IBM Corp.). A p value of <0.05 was considered significant.

For the meta-analyses, a linear regression analysis was performed for EEQ score (continuous variable) as the dependent variable and individual chronotype (three categories: MTs, intermediate, and ETs) as the independent variable, recoding as two dummy variables and considering MTs as reference. The categorization of chronotypes was subjective by the MEQ in ONTIME, ONTIME-MT, SHIFT, and DICACEM, whereas for the DLMO subpopulation we used the objective categorized chronotypes obtained by DLMO measurements. This linear regression model was performed for each study, and we recorded each beta (95% confidence interval [CI]). Fixed-effect, inverse variance-weighted meta-analyses were conducted using the R package "metafor" for the central associations of morning and evening preference on EEQ score (for the two analysis models; Model 1, adjusted for age and sex, and Model 2, adjusted for age, sex, and BMI). We also analyzed the same two models for EEQ

TABLE 1 General characteristics of the adults enrolled in the four cohorts with subjective measures of chronotype (by Morning Evening Questionnaire [MEQ]) and in the subsample with objective measures of chronotype (by DLMO)

	Subjectively (MEQ)				Objectively (DLMO)
	Spain		US,	Mexico,	Spain,
Variable	ONTIME ($n = 2266$)	ONTIME-MT ($n = 642$)	SHIFT ($n = 388$)	DICACEM ($n = 668$)	DLMO (ONTIME-MT) subsample ($n = 162$)
Age (y)	40 ± 12[a]	42 ± 12[b]	30 ± 10[c]	37 ± 10[d]	35 ± 13
Sex, *n* (%)					
Men	435 (19.2)	169 (26.3)	92 (23.7)	209 (31.3)	52 (32.1)
Women	1831 (80.8)	473 (73.7)	296 (76.3)	459 (68.7)	110 (67.9)
Weight (kg)	84.53 ± 17.98[a]	73.8 ± 14.29[b]	68.10 ± 14.67[c]	74.79 ± 16.75[b]	73.29 ± 15.58
Height (m)	1.65 ± 0.08[a]	1.67 ± 0.08[b]	1.67 ± 0.09[b]	1.65 ± 0.09[a]	1.69 ± 0.09
BMI (kg/m^2)	31.0 ± 5.5[a]	26.5 ± 4.7[b]	24.4 ± 4.5[c]	27.3 ± 5.2[d]	25.6 ± 5.0
Body fat (%)	36.7 ± 6.6[a]	31.0 ± 9.4[b]	29.7 ± 9.1[c]	32.6 ± 8.2[d]	27.7 ± 10.4
Waist circumference (cm)	101.2 ± 14.9[a]	87.7 ± 12.9[b]	83.4 ± 12.0[c]	88.0 ± 13.6[b]	85.3 ± 12.9
Hip circumference (cm)	113.4 ± 10.0[a]	103.4 ± 10.3[b]	99.8 ± 9.0[c]	104.4 ± 10.4[b]	101.6 ± 10.1
Waist-hip ratio	0.89 ± 0.09[a]	0.84 ± 0.08[b]	0.83 ± 0.07[b]	0.84 ± 0.08[b]	0.83 ± 0.07
Total energy (kcal)	1989 ± 751[a]	1500 ± 577[b]	1936 ± 439[a]	2359 ± 933[c]	1722 ± 662
Carbohydrate (g)	202 ± 90[a]	178 ± 73[b]	217 ± 56[c]	276 ± 115[d]	198 ± 74
Carbohydrate (%)	41 ± 11[a]	48 ± 8[b]	36 ± 6[c]	47 ± 7[d]	47 ± 8
Protein (g)	84 ± 34[a]	67 ± 26[b]	80 ± 27[c]	89 ± 36[d]	73 ± 27
Protein (%)	17 ± 5[a]	18 ± 4[b]	17 ± 4[c]	15 ± 3[d]	17 ± 4
Fat (g)	93 ± 49[a]	58 ± 29[b]	81 ± 24[c]	99 ± 44[d]	69 ± 35
Fat (%)	43 ± 10[a]	34 ± 8[b]	36 ± 6[c]	38 ± 6[d]	35 ± 7
MEQ score	52.84 ± 9.51[a]	53.03 ± 8.98[a]	52.82 ± 10.77[a]	56.82 ± 7.77[b]	50.41 ± 9.56
EEQ score	12.25 ± 6.03[a]	11.02 ± 6.33[b]	10.45 ± 6.02[b]	8.37 ± 5.19[c]	10.50 ± 5.69

Note: Values are mean ± SD for continuous variables and *n* (%) for sex, as a categorical variable. All *p* values are highly significant across all cohorts as derived from one-way ANOVA ($p < 0.0001$). Different superscript letters indicate significant differences among cohorts with the post hoc least significant difference value.

Abbreviations: DLMO, dim-light melatonin onset; EEQ, Emotional Eating Questionnaire; MEQ, Morningness-Eveningness Questionnaire.

TABLE 2 Total emotional eating score (Emotional Eating Questionnaire [EEQ]) comparison among the three groups of different chronotypes (according to DLMO in DLMO subsample or according to Morningness-Eveningness Questionnaire [MEQ] classification in all other studies)

Cohort	*N*	Morningness	Intermediate	Eveningness	*p* value†	*p* value‡
ONTIME	2266	11.85 (6.30)[a]	12.16 (5.86)[a]	13.55 (6.01)[b]	**0.011**	**0.019**
ONTIME-MT	642	10.02 (6.14)[a]	11.10 (6.23)[a]	13.33 (6.95)[b]	**0.003**	**0.004**
SHIFT study	388	9.39 (5.64)	10.97 (6.03)	10.66 (6.49)	0.196	0.150
DICACEM	688	7.67 (4.83)[a]	8.86 (5.27)[b]	10.03 (6.60)[b]	**0.029**	**0.015**
	N	T1 (Early)	T2 (Intermediate)	T3 (Late)	*p* value†	*p* value‡
DLMO (ONTIME-MT) subsample	162	9.48 (5.62)[a]	9.93 (5.55)[a,b]	12.04 (5.66)[b]	**0.031**	0.132

Note: Data are presented as mean (SD); *p* values were derived from one-way ANOVA among groups of different chronotypes; $p < 0.05$ is indicated by bold. In DLMO subsample, we categorize the participants according to DLMO tertiles (T1: early, T2: intermediate, T3: late). In all the other studies, we include in the same group extreme morningness and morning participants and in another group extreme eveningness and those who are evening participants. Different superscript letters indicate significant differences among chronotypes with the post hoc least significant difference value of ANCOVA (adjusted for sex and age).

Abbreviation: DLMO, dim-light melatonin onset.

†ANCOVA after data adjusted for age and sex.

‡ANCOVA after data adjusted for age, sex, and BMI.

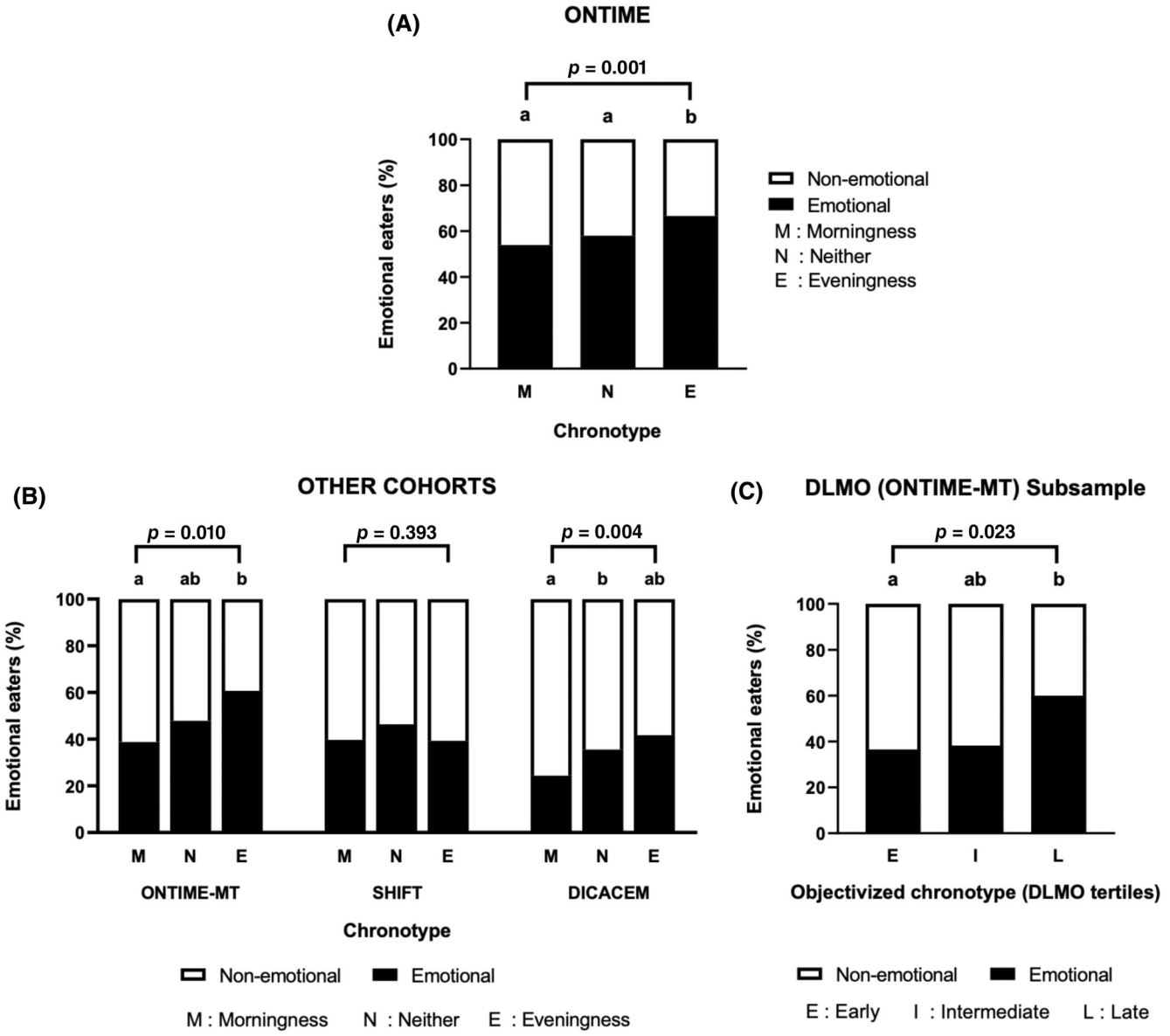

FIGURE 1 Distribution of subjects with different classifications of emotional eating (categorized into two: nonemotional/low emotional and emotional/very emotional eaters) among the three groups of different chronotypes in each study (subjectively for cohorts in panels A and B and objectively in panel C, according to dim-light melatonin onset [DLMO] in DLMO [ONTIME-MT] subsample). (A) Percentage of emotional eaters according to the chronotype evaluated by Morningness-Eveningness Questionnaire (MEQ) in ONTIME. M refers to "morningness" or morning preference, N refers to "neither type," and E to "eveningness" or evening preference. (B) Replication of the same analysis in ONTIME-MT, SHIFT, and DICACEM cohorts. (C) Percentage of emotional eaters according to the objective chronotype evaluated by DLMO in DLMO (ONTIME-MT) subsample. E refers to "early chronotype," I to "intermediate," and L to "late chronotype." *P* values above the horizontal lines indicate significant differences with χ^2. Different letters indicate significant differences among chronotypes with the post hoc Bonferroni value of χ^2.

score without question 8 ("Do you feel less control over your diet when you are tired after work at night?" because of its possible relation with evening preference for those who responded positively to this question).

We used the R package mediation for "mediation analyses." We calculated estimates for the total effect, average direct effect, and average causal mediation effect using the quasi-Bayesian Monte Carlo method based on a normal approximation with 5000 simulations. When significant, mediated fraction expresses the percentage of the possible effect mediated by the hypothesized mediator.

RESULTS

General characteristics of the four study cohorts

A total of 3964 adults were enrolled in the four studies: the smallest cohort was SHIFT ($n = 388$) and the largest ONTIME ($n = 2266$). Table 1 presents the mean values or frequencies of sociodemographic, anthropometric, dietary intake, MEQ, and EEQ information in the four cohorts and the DLMO subsample. Our results show significant differences in age among the four cohorts (the youngest being SHIFT). In all

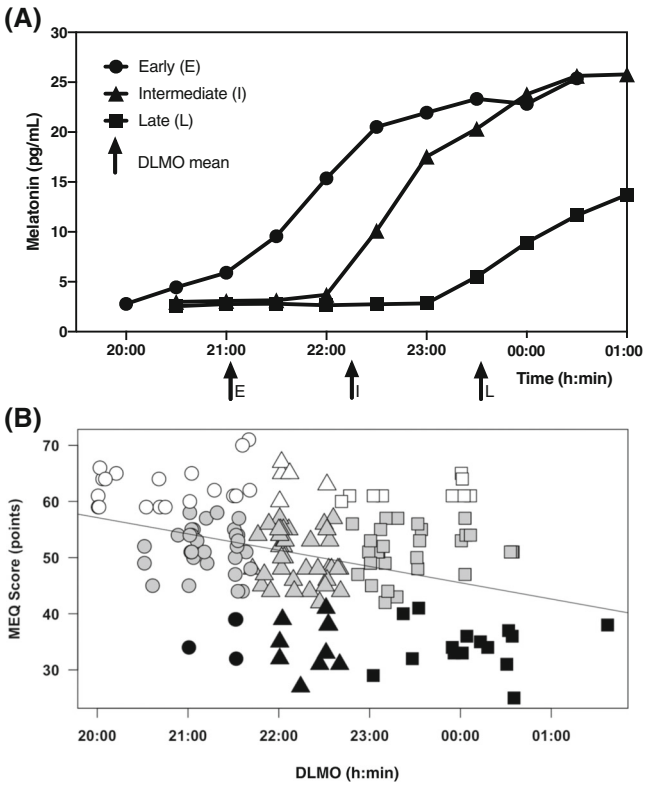

FIGURE 2 Melatonin concentration mean curves according to DLMO-chronotype tertiles and correlation between dim-light melatonin onset (DLMO) and Morningness-Eveningness Questionnaire (MEQ) ($n = 162$). (A) Salivary melatonin concentration according to time in each tertile of DLMO (circles for early, triangles for intermediate, and squares for late subjects). The arrows represent the average timing of DLMO in each group of objective chronotype participants. (B) Plot distribution and significant correlation ($r = -0.356$, $p < 0.0001$) between DLMO and MEQ score. The symbol shapes represent DLMO categorization: circles for early, triangles for intermediate, and squares for late subjects. Symbol colors represent MEQ categorization: open symbols for morning chronotypes with a higher score; gray symbols for "neither" chronotype, and black symbols for evening chronotype with the lowest MEQ scores).

five (sub)samples, women were present in higher proportions than men. ONTIME was the population with the highest obesity indicators of BMI, waist circumference, and fat percentage; the SHIFT cohort had the lowest. Significant differences in dietary intake were also observed among cohorts. The DICACEM population had the highest energy intake and ONTIME-MT the lowest. The DICACEM population had the highest average MEQ score (the most morning people) and the lowest EEQ score (the least emotional eaters) of the groups.

ETs have a greater tendency to be emotional eaters in ONTIME and replication is seen in ONTIME-MT and DICACEM

In Table 2, we compare EEQ score in each cohort according to chronotype classification. Statistical differences were found between the three chronotypes in all cohorts studied toward a higher EEQ score in more ETs ($p < 0.05$), except for SHIFT. Further sensitivity analyses showed that, after adjusting for age, sex and BMI, significance was maintained for the three previously identified cohorts (ONTIME, ONTIME-MT, and DICACEM).

In ONTIME (Figure 1A), the proportion of emotional eaters among ETs was 66.6%, whereas in MTs, it was 53.9% ($p = 0.001$). These results were replicated in ONTIME-MT and DICACEM but not in SHIFT (Figure 1B).

Objective chronotype by DLMO associates with EE in ONTIME-MT DLMO subsample

The mean timing of DLMO was observed at 22:19 ± 1:10 h. Figure 2A depicts the different timing of DLMO in the three tertiles of this subsample (early, intermediate, and late participants). For the early participants, the onset of the melatonin rise under dim-light conditions (DLMO) was at 21:02 h; for intermediate participants, DLMO was observed at 22:12 h; and for late participants, DLMO was observed at 23:37 h. As expected, DLMO was significantly and negatively associated with MEQ score, that is, the later the DLMO time, the greater the preference for evening time (lower MEQ score) ($r = -0.356$, $p < 0.0001$). However, several participants were classified differently according to MEQ score or DLMO, as shown in Figure 2B. In the DLMO subsample, using objective characterization of chronotype, the proportion of emotional eaters among late participants was almost twice as high as in early participants (60.0% vs. 36.5%, respectively, $p = 0.023$) (Figure 1C), results that replicate those from ONTIME, ONTIME-MT, and DICACEM, using subjective characterization of chronotype by the MEQ.

Meta-analyses of the international cohorts

Finally, we analyzed all data from the four cohorts and the DLMO subsample in the forest plot in Figure 3. Adjusting for possible confounders (sex, age, and BMI), EEQ score was 1.44 points higher in evening/late participants versus morning/early (Model 2). Consistently, being an ET increased the risk of being an emotional eater ($p < 0.0001$ Model 1, $p < 0.0001$ Model 2). Furthermore, running sensitivity analyses, by excluding DLMO-based chronotype and including only the MEQ-based chronotype, we observed similar results (Figure 3). We verified our results by excluding question 8 (mentioned in *Methods*) from EEQ score because of its potential implication for evening behavior (Supporting Information Figure S1).

ETs had a higher rate of disinhibition and experienced food cravings more frequently than MTs

Table 3 represents the three factors involved in the EEQ: disinhibition, food craving, and sense of guilt. These factors are shown in the three

Obesity A Research Journal THE OBESITY SOCIETY WILEY

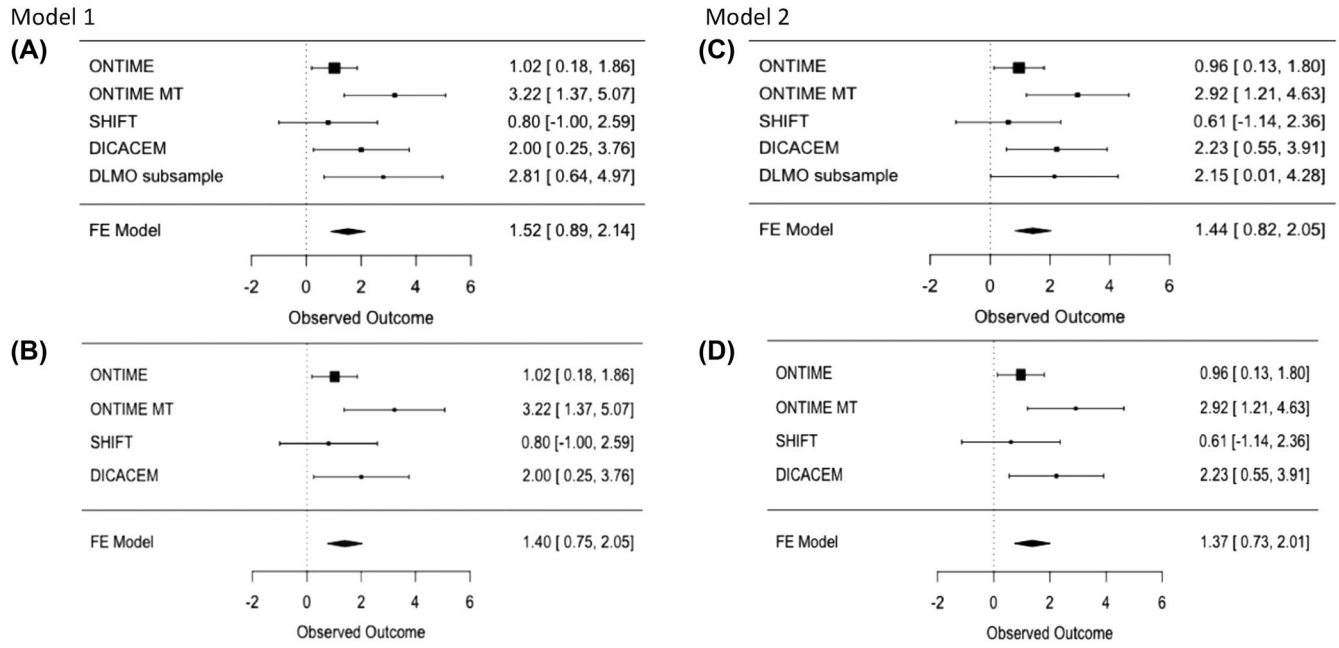

FIGURE 3 Forest plot of main association between evening preference and emotional eating score in four cohorts and dim-light melatonin onset (DLMO) (ONTIME-MT) subsample with adjustment for potential confounders: beta (95% CI). (A,B) Model 1: adjusted for age and sex. (C,D) Model 2: adjusted for age, sex, and BMI. Panels A and C include DLMO subsample and panels B and D do not. *P* values for Model 1: (A) $p = 0.0000019371$, (B) $p = 0.0000261921$ and *p* values for Model 2: (C) $p = 0.0000042245$, (D) $p = 0.0000254468$

TABLE 3 Comparisons of the means scores of the three factors of the Emotional Eating Questionnaire (EEQ) (disinhibition, food craving factor, and sense of guilt) among the three groups of different chronotypes (according to Morningness-Eveningness Questionnaire [MEQ] and according to DLMO in subsample of ONTIME-MT)

	Morningness	Intermediate	Eveningness	*p* value†	*p* value‡
ONTIME					
Disinhibition	6.72 ± 4.22[a]	6.90 ± 3.97[a]	7.97 ± 3.92[b]	**0.002**	**0.004**
Food craving	2.28 ± 1.66	2.40 ± 1.62	2.61 ± 1.77	0.207	0.222
Sense of guilt	2.85 ± 1.86	2.86 ± 1.73	2.97 ± 1.72	0.351	0.415
ONTIME-MT					
Disinhibition	5.68 ± 4.10[a]	6.22 ± 4.08[a]	7.74 ± 4.57[b]	**0.007**	**0.008**
Food craving	2.18 ± 1.49[a]	2.51 ± 1.51[b]	2.92 ± 1.55[b]	**0.013**	**0.021**
Sense of guilt	2.17 ± 1.53	2.37 ± 1.69	2.67 ± 1.93	0.052	0.083
SHIFT study					
Disinhibition	5.01 ± 3.58	6.10 ± 3.85	5.87 ± 4.34	0.116	0.085
Food craving	2.25 ± 1.32	2.57 ± 1.43	2.61 ± 1.51	0.332	0.331
Sense of guilt	2.13 ± 1.54	2.29 ± 1.59	2.18 ± 1.55	0.784	0.663
DICACEM					
Disinhibition	4.15 ± 3.19	4.79 ± 3.49	5.39 ± 4.35	0.094	0.568
Food craving	2.05 ± 1.30[a]	2.39 ± 1.38[b]	3.19 ± 1.43[c]	**<0.001**	**<0.001**
Sense of guilt	1.47 ± 1.43	1.68 ± 1.62	1.44 ± 1.75	0.568	0.666
DLMO (ONTIME-MT) subsample					
Disinhibition	5.48 ± 3.82	5.73 ± 3.72	6.64 ± 3.57	0.159	0.381
Food craving	1.92 ± 1.15[a]	2.31 ± 1.37[a,b]	2.76 ± 1.57[b]	**0.014**	**0.032**
Sense of guilt	2.08 ± 1.53[a,b]	1.91 ± 1.58[a]	2.64 ± 1.78[b]	**0.047**	0.201

Note: *p* values were derived from ANCOVA among groups of different chronotypes; $p < 0.05$ is indicated by bold. Different letters indicate significant differences among chronotypes with the least significant difference post hoc values (adjusted for sex and age).
Abbreviation: DLMO, dim-light melatonin onset.
†ANCOVA after data adjusted for age and sex.
‡ANCOVA after data adjusted for age, sex, and BMI.

chronotype groups of the five groups studied, after sensitivity analyses adjusted for age, sex, and BMI. We found significant differences among chronotypes in disinhibition average (in ONTIME and ONTIME-MT). Likewise, the food craving factor values were significantly higher in ETs in ONTIME-MT, DICACEM, and the DLMO subsample (Table 3).

Consistently, in the ONTIME and ONTIME-MT studies, the proportion of participants with disinhibition was higher among ETs. Similarly, ETs in ONTIME-MT, DICACEM, and the DLMO subsample included a higher proportion of participants who experienced food cravings more frequently (Supporting Information Table S1).

Dietary habits among ETs

Only in ONTIME, disinhibition related to total energy intake (excessive consumption) ($r = 0.051$, $p = 0.029$). Similarly, the higher the emotional food craving factor score, the higher the energy intake, both in ONTIME ($r = 0.047$, $p = 0.043$) and DICACEM ($r = 0.094$, $p = 0.015$). The ETs in the DLMO subsample showed a lower adherence to the Mediterranean diet (mean ± SD of Mediterranean diet scores: 4.9 ± 1.3, 4.5 ± 1.5, and 4.1 ± 1.3, in early, intermediate, and late types, respectively, $p = 0.020$), but after adjustment for age and sex, these significant differences disappeared ($p = 0.428$). These results were in accordance with a higher intake of fruits among the early types (239 ± 163 g vs. 211 ± 311 g and 204 ± 138 g in early, intermediate, and late types, respectively, $p = 0.009$ after adjustment). In ONTIME-MT, ETs showed a similar trend toward a lower adherence to the Mediterranean diet (4.3 ± 1.2) than intermediates (4.6 ± 1.4) and MTs (4.7 ± 1.4) ($p = 0.056$).

EE mediates the association between evening chronotype and obesity

In order to achieve a better understanding of the particular role of EE (EEQ) and the individual chronotype (MEQ) in obesity, we further explored whether EE or MEQ mediated the association in those populations in which eveningness and EE were independently associated with obesity, that is, the DLMO study subsample, ONTIME and ONTIME-MT, and SHIFT. The results of the mediation analyses are shown in Supporting Information Figure S2. EE (EEQ score) mediated the association between chronotype and obesity in 22% and in 11%, both in DLMO (using the objective chronotype by DLMO) and in ONTIME (using MEQ), respectively.

DISCUSSION

Our data show that EE is more prevalent in ETs than in MTs in populations with different cultural, environmental, and genetic backgrounds, and this happened when chronotype was determined subjectively (through a questionnaire), as well as when assessed objectively, by DLMO, in a large subsample of participants ($n = 162$).

Evening/late chronotype related to EE

We explored the association between eveningness and EE in a Spanish population (ONTIME) and attempted to replicate findings in three international cohorts. The higher prevalence of emotional eaters in ETs also occurred in the other Spanish study (ONTIME-MT) and in the Mexican cohort (DICACEM). However, this relationship was not replicated in the smaller US cohort (SHIFT). While the analytical approach was identical to what was used in the other cohorts, the smaller sample size, differences in culture, and the younger age may have contributed to the null finding in this latter cohort.

The association between EE and eveningness has not been extensively studied [27, 28], and the present contribution is the first to investigate the association between eveningness and EE in different populations. Furthermore, this is the first demonstration that the timing of the central clock, as assessed objectively by DLMO, may also relate with EE, suggesting a role for the endogenous clock mechanism, either in concert with or independently of other variables that contribute to subjective chronotype, in EE behavior.

As expected, DLMO was significantly and negatively associated with MEQ score [6, 8], indicating that DLMO was later in individuals with later chronotypes (lower MEQ) [29]. In our study with a large sample ($n = 162$), the slope of the regression model was lower than in the study by Kantermann and colleagues [30], and the categorization of chronotype based on one metric (subjective vs. objective) did not always coincide with the other, probably because they do not assess the same trait, as shown in Figure 2B. Similar results have been previously reported [8, 31].

The meta-analysis of the data from the four cohorts and the DLMO subsample revealed a higher risk of being a more emotional eater by 1.52 points in ETs than in MTs, and these results remained robust in sensitivity analyses.

Evening/late chronotype related to disinhibition

We also found that a higher mean value of the EEQ factor, called disinhibition, was more related to eveningness in the adjusted ONTIME and ONTIME-MT data. Disinhibition is one of the recognized constructs of eating behavior that refers to the tendency to overeat [32]. It also measures the breaking of dietary restraints [33]. Food-related disinhibition is implicated in binge eating, weight gain, and obesity and is also associated with impulsivity (related to weight gain), or maladaptive eating. In ONTIME, disinhibition was significantly associated with overeating (not present in the other cohorts). The fact that the ONTIME population came from weight loss clinics, where participants are subject to dietary restrictions for weight loss, may explain these differences.

In addition, among the two cohorts located in the Mediterranean area of Spain (ONTIME and ONTIME-MT), ETs showed a trend toward lower adherence to the Mediterranean diet than MTs. In a previous study conducted in DICACEM [25], we showed that being an emotional/very emotional eater was negatively associated with a "Healthy" dietary pattern and was also positively associated with the "Snacks and fast food" dietary pattern. The positive association between ETs and disinhibition has been previously demonstrated in smaller populations with other scales [34]. This association could be related to the observation that, in general, ETs have a less healthy lifestyle than MTs [35] and tend to have more unstructured days [36] that could influence their food intake [37].

Evening/late chronotype related to food craving

Emotional eaters often consume highly palatable energetic foods to calm their anxiety. The craving for these energetic foods and the subsequent satisfaction of their craving release endocannabinoids and dopamine in these individuals, clearly implicating the reward system in their food intake behaviors [38]. Other studies have shown that emotional eaters frequently consume unhealthy foods [39]. Within the EEQ, the food craving factor included two questions on difficulty with stopping eating sweet foods, especially chocolate, and on craving for specific foods [19]. Food craving has been defined as an intense desire for a specific type of food.

In the current study, ETs experienced food cravings more frequently than MTs in ONTIME-MT and DICACEM, and the same phenomenon was observed when using DLMO as categorization of chronotype. In a previous study [40], individuals who manifested food craving identified three different components: (1) a loss/lack of control as a need or obsession to eat this food, (2) immediate regret with a desire to regain and gain control for personal health/perception, and (3) a social context that triggers the overeating behavior.

We showed a positive correlation between food craving and total energy intake, as previously reported [40, 41]. Other indicators of EE described are starting to eat when anxious, overeating when sad or depressed, and comfort eating when lonely [27]. Some of these emotion-related eating behaviors are more common at night [42], and they may also be more common in ETs in the evening hours, long before they go to sleep. Indeed, our mediation analyses showed that EE mediated the association between evening chronotype and obesity.

Strengths and limitations

The primary strength of the present study is that we included subjective and objective measures of chronotype. Moreover, the results were replicated in different cohorts in Europe and America (Mexico, but not the US), including a large total sample size. Limitations related to self-reported variables such as those assessed by the MEQ [3, 23] and the EEQ [19]. However, both questionnaires have been validated [3, 19]. Our population samples also do not represent the general population of each country. However, they are large enough to suggest that the observed relationships, replicated in various populations, reflect those in developed countries. Finally, the cross-sectional design of these analyses does not allow determination of causality.

CONCLUSION

In the present study, we demonstrated that eveningness was associated with EE in three diverse international cohorts. The association was significant when considering the preferred timing in performing certain behaviors that characterizes ETs (i.e., the subjective chronotype assessed by the MEQ). In addition, we also found an association when using the timing of the central clock, determined by DLMO, to objectively characterize chronotype. It would be of interest, in a clinical setting, to personalize the therapies and identify the individual chronotype to inform the patient about possible actions to undertake attending to the chronotype in the timing of behaviors (eating, sleeping, physical activity, or light exposure). For those ETs who are emotional eaters (63% in the nutritional centers in ONTIME), it could be advisable to use individualized behavioral and cognitive therapies to decrease EE. These could be based on making specific changes in the environment and behaviors (e.g., avoiding specific foods to prevent food cravings), avoiding too restricted diets to prevent disinhibition, and applying cognitive therapies designed to prevent the sense of guilt, among other behavioral techniques [28].

AUTHOR CONTRIBUTIONS

All authors listed fully meet the criteria for authorship. The authors' responsibilities were as follows: conceptualization, Marta Garaulet, Richa Saxena, and Frank A. J. L. Scheer; methodology, Marta Garaulet, Barbara Vizmanos, Richa Saxena, and Frank A. J. L. Scheer; formal analysis, Teresa Muela, Alejandra Betancourt-Núñez, and María-Ángeles Bonmatí-Carrión; resources, Marta Garaulet, Richa Saxena, Alejandra Betancourt-Núñez, Barbara Vizmanos, and Frank A. J. L. Scheer; data curation, Marta Garaulet, Barbara Vizmanos, Teresa Muela, Alejandra Betancourt-Núñez, María-Ángeles Bonmatí-Carrión, Céline Vetter, Hassan S. Dashti, Richa Saxena, and Frank A. J. L. Scheer; writing—original draft preparation, Marta Garaulet, Barbara Vizmanos, Richa Saxena, and Frank A. J. L. Scheer; writing—review and editing, Marta Garaulet, Barbara Vizmanos, Teresa Muela, Alejandra Betancourt-Núñez, María-Ángeles Bonmatí-Carrión, Céline Vetter, Hassan S. Dashti, Richa Saxena, and Frank A. J. L. Scheer; visualization, Teresa Muela and Alejandra Betancourt-Núñez; supervision, Marta Garaulet and Frank A. J. L. Scheer. All authors have read and agreed to the final version of the manuscript.

ACKNOWLEDGMENTS

The authors would like to thank all the volunteers and collaborators for their kind interaction and care to ensure the understanding, commitment, and participation of so many volunteers. Collaborators transmit the study results' usefulness to society through their work and the individual results provided to participants. The authors thank Alberto

Sánchez-Soto for constructing Figure 2, Alberto Jiménez-Alcaraz for preliminary analyses, and Francisco Trujillo-Sánchez for the references' management.

FUNDING INFORMATION

This research received external funding for each study. ONTIME: grant PID2020-112768RB-I00 funded by MCIN (Ministerio de Ciencias e Innovación)/AEI (Agencia Estatal de Investigación)/10.13039/501100011033, The Spanish Government of Investigation, Development and Innovation (SAF2017-84135-R), including FEDER (Fondo Europeo de Desarrollo Regional) co-funding, The Autonomous Community of the Region of Murcia through the Seneca Foundation (20795/PI/18), and grant NIDDK R01DK105072 to Marta Garaulet. ONTIME-MT was funded by NIH grant R01DK105072. SHIFT: Richa Saxena was supported by NIH R01DK107859 and Massaschusetts General Hospital Research Scholars. Richa Saxena and Frank A. J. L. Scheer were supported by NIH R01DK102696 and R01DK105072. Céline Vetter is supported by R01DK105072. Frank A. J. L. Scheer was further supported by R01DK099512, R01HL118601, R01HL140574, and R01HL153969. DICACEM study: Secretaría de Educación Pública de México (Programa para el Desarrollo Profesional Docente, PRODEP) grant awarded to Alejandra Betancourt-Núñez: UDG-PTC-1511 and the Universidad de Guadalajara Programa de Fortalecimiento de la Investigación to the Instituto de Nutrigenética y Nutrigenómica Traslacional; Alejandra Betancourt-Núñez and Barbara Vizmanos also received a monthly grant by the National System of Researchers (Consejo Nacional de Ciencia y Tecnología de México), grant numbers 484393 and 22064, respectively.

CONFLICT OF INTEREST STATEMENT

Frank A. J. L. Scheer served on the Board of Directors for the Sleep Research Society and has received consulting fees from the University of Alabama at Birmingham. Frank A. J. L. Scheer's interests were reviewed and managed by Brigham and Women's Hospital and Partners HealthCare in accordance with their conflict of interest policies. Frank A. J. L. Scheer's consultancies are not related to the current work. The other authors declared no conflict of interest.

ORCID

Marta Garaulet https://orcid.org/0000-0002-4066-3509
Barbara Vizmanos https://orcid.org/0000-0003-0680-0802
Teresa Muela https://orcid.org/0000-0002-2710-3793
Alejandra Betancourt-Núñez https://orcid.org/0000-0001-6592-3031
María-Ángeles Bonmatí-Carrión https://orcid.org/0000-0002-9050-6448
Céline Vetter https://orcid.org/0000-0002-3752-1067
Hassan S. Dashti https://orcid.org/0000-0002-1650-679X
Richa Saxena https://orcid.org/0000-0003-2233-1065
Frank A. J. L. Scheer https://orcid.org/0000-0002-2014-7582

REFERENCES

1. Adan A, Archer SN, Hidalgo MP, Di Milia L, Natale V, Randler C. Circadian typology: a comprehensive review. *Chronobiol Int*. 2012;29:1153-1175.
2. Minz S, Pati AK. Morningness–eveningness preference, sleep quality and behavioral sleep patterns in humans–a mini review. *Biol Rhythm Res*. 2021;52:549-584.
3. Horne JA, Ostberg O. A self-assessment questionnaire to determine morningness-eveningness in human circadian rhythms. *Int J Chronobiol*. 1976;4:97-110.
4. Duffy JF, Dijk DJ, Hall EF, Czeisler CA. Relationship of endogenous circadian melatonin and temperature rhythms to self-reported preference for morning or evening activity in young and older people. *J Investig Med*. 1999;47:141-150.
5. Lewy AJ, Cutler NL, Sack RL. The endogenous melatonin profile as a marker for circadian phase position. *J Biol Rhythms*. 1999;14:227-236.
6. Kantermann T, Sung H, Burgess HJ. Comparing the Morningness-Eveningness Questionnaire and Munich ChronoType Questionnaire to the dim light melatonin onset. *J Biol Rhythms*. 2015;30:449-453.
7. Mongrain V, Carrier J, Dumont M. Circadian and homeostatic sleep regulation in morningness-eveningness. *J Sleep Res*. 2006;15:162-166.
8. Reiter AM, Sargent C, Roach GD. Concordance of chronotype categorisations based on dim light melatonin onset, the Morningness-Eveningness Questionnaire, and the Munich Chronotype Questionnaire. *Clocks Sleep*. 2021;3:342-350.
9. Aguilar-Galarza A, García-Gasca T, Mejía C, et al. Evening chronotype associates with increased triglyceride levels in young adults in two independent populations. *Clin Nutr*. 2021;40:2373-2380.
10. Martínez-Lozano N, Barraco GM, Rios R, et al. Author correction: evening types have social jet lag and metabolic alterations in school-age children. *Sci Rep*. 2021;11:5413. doi:10.1038/s41598-021-84775-9
11. Martínez-Lozano N, Barraco GM, Rios R, et al. Evening types have social jet lag and metabolic alterations in school-age children. *Sci Rep*. 2020;10:16747. doi:10.1038/s41598-020-73297-5
12. Knutson KL, von Schantz M. Associations between chronotype, morbidity and mortality in the UK Biobank cohort. *Chronobiol Int*. 2018;35:1045-1053.
13. Torres-Castillo N, Martinez-Lopez E, Vizmanos-Lamotte B, Garaulet M. Healthy obese subjects differ in chronotype, sleep habits, and adipose tissue fatty acid composition from their non-healthy counterparts. *Nutrients*. 2021;13:119. doi:10.3390/nu13010119
14. Antúnez JM. Circadian typology is related to emotion regulation, metacognitive beliefs and assertiveness in healthy adults. *PLOS ONE*. 2020;15(3):e0230169. doi:10.1371/journal.pone.0230169
15. Zou H, Zhou H, Yan R, Yao Z, Lu Q. Chronotype, circadian rhythm, and psychiatric disorders: recent evidence and potential mechanisms. *Front Neurosci*. 2022;16. doi:10.3389/fnins.2022.811771
16. Antúnez JM, Navarro JF, Adan A. Morningness–eveningness and personality characteristics of young healthy adults. *Pers Individ Diff*. 2014;68:136-142. doi:10.1016/j.paid.2014.04.015
17. Konttinen H, van Strien T, Männistö S, Jousilahti P, Haukkala A. Depression, emotional eating and long-term weight changes: a population-based prospective study. *Int J Behav Nutr Phys Act*. 2019;16:28. doi:10.1186/s12966-019-0791-8
18. Després JP, Lemieux I, Bergeron J, et al. Abdominal obesity and the metabolic syndrome: contribution to global cardiometabolic risk. *Arterioscler Thromb Vasc Biol*. 2008;28:1039-1049.
19. Garaulet M, Canteras M, Morales E, Lopez-Guimera G, Sanchez-Carracedo D, Corbalan-Tutau MD. Validation of a questionnaire on emotional eating for use in cases of obesity: the Emotional Eater Questionnaire (EEQ). *Nutr Hosp*. 2012;27:645-651.
20. Skolmowska D, Głąbska D, Guzek D. Body mass and emotional eating: Emotional Eater Questionnaire (EEQ) in the Polish Adolescents' COVID-19 Experience (PLACE-19) Study. *Nutrients*. 2022;14(4):828-843.

21. Ghafouri S, Abdollahi A, Suksatan W, Chupradit S, Asmundson AJN, Thangavelu L. Psychometric comparison of the Persian Salzburg Emotional Eating Scale and Emotional Eater Questionnaire among Iranian adults. *J Eat Disord*. 2022;10:17. doi:10.1186/s40337-022-00541-w
22. Gioia SC, Guirette M, Chen A, et al. How accurately can we recall the timing of food intake? A comparison of food times from recall-based survey questions and daily food records. *Curr Dev Nutr*. 2022;6:nzac002. doi:10.1093/cdn/nzac002
23. Shahid A, Wilkinson K, Marcu S, Shapiro CM. Morningness-Eveningness Questionnaire. In: Shahid A, Wilkinson K, Marcu S, Shapiro CM, eds. *STOP, THAT and One Hundred Other Sleep Scales*. Springer New York; 2012:231-234.
24. Voultsios A, Kennaway DJ, Dawson D. Salivary melatonin as a circadian phase marker: validation and comparison to plasma melatonin. *J Biol Rhythms*. 1997;12:457-466.
25. Betancourt-Núñez A, Torres-Castillo N, Martínez-López E, et al. Emotional eating and dietary patterns: reflecting food choices in people with and without abdominal obesity. *Nutrients*. 2022;14(7):1371-1389.
26. Trichopoulou A, Costacou T, Bamia C, Trichopoulos D. Adherence to a Mediterranean diet and survival in a Greek population. *N Engl J Med*. 2003;348:2599-2608.
27. Konttinen H, Kronholm E, Partonen T, Kanerva N, Männistö S, Haukkala A. Morningness-eveningness, depressive symptoms, and emotional eating: a population-based study. *Chronobiol Int*. 2014;31:554-563.
28. Budkevich RO, Putilov AA, Tinkova EL, Budkevich EV. Chronobiological traits predict the restrained, uncontrolled, and emotional eating behaviors of female university students. *Chronobiol Int*. 2021;38:1032-1041.
29. McHill AW, Sano A, Hilditch CJ, et al. Robust stability of melatonin circadian phase, sleep metrics, and chronotype across months in young adults living in real-world settings. *J Pineal Res*. 2021;70:e12720. doi:10.1111/jpi.12720
30. Vera B, Dashti HS, Gomez-Abellan P, et al. Modifiable lifestyle behaviors, but not a genetic risk score, associate with metabolic syndrome in evening chronotypes. *Sci Rep*. 2018;8:945. doi:10.1038/s41598-017-18268-z
31. Ruiz FS, Beijamini F, Beale AD, et al. Early chronotype with advanced activity rhythms and dim light melatonin onset in a rural population. *J Pineal Res*. 2020;69:e12675. doi:10.1111/jpi.12675
32. Williamson DA, Lawson OJ, Brooks ER, et al. Association of body mass with dietary restraint and disinhibition. *Appetite*. 1995;25:31-41.
33. Stunkard AJ, Messick S. The three-factor eating questionnaire to measure dietary restraint, disinhibition and hunger. *J Psychosom Res*. 1985;29:71-83.
34. Shearin EN, Russ MJ, Hull JW, Clarkin JF, Smith GP. Construct validity of the three-factor eating questionnaire: flexible and rigid control subscales. *Int J Eat Disord*. 1994;16:187-198.
35. Romero-Cabrera JL, Garaulet M, Jimenez-Torres J, et al. Chronodisruption and diet associated with increased cardiometabolic risk in coronary heart disease patients: the CORDIOPREV study. *Transl Res*. 2022;242:79-92.
36. Schubert E, Randler C. Association between chronotype and the constructs of the three-factor-eating-questionnaire. *Appetite*. 2008;51:501-505.
37. Waterhouse J, Bailey L, Tomlinson F, Edwards B, Atkinson G, Reilly T. Food intake in healthy young adults: effects of time pressure and social factors. *Chronobiol Int*. 2005;22:1069-1092.
38. Volkow ND, Wang G-J, Baler RD. Reward, dopamine and the control of food intake: implications for obesity. *Trends Cogn Sci*. 2011;15:37-46.
39. Bui C, Lin L-Y, Wu C-Y, Chiu Y-W, Chiou H-Y. Association between emotional eating and frequency of unhealthy food consumption among Taiwanese adolescents. *Nutrients*. 2021;13:2739. doi:10.3390/nu13082739
40. Collins R, Haracz K, Leary M, Rollo M, Burrows T. No control and overwhelming cravings: Australian adults' perspectives on the experience of food addiction. *Appetite*. 2021;159:105054. doi:10.1016/j.appet.2020.105054
41. Buckland NJ, Kemps E. Low craving control predicts increased high energy density food intake during the COVID-19 lockdown: result replicated in an Australian sample. *Appetite*. 2021;166:105317. doi:10.1016/j.appet.2021.105317
42. Guentcheva I, Dugas EN, Hanusaik N, Drapeau V, Sylvestre MP, O'Loughlin J. Depression symptoms and night eating in young adulthood. *Eat Weight Disord*. 2020;25:1593-1600.

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

How to cite this article: Garaulet M, Vizmanos B, Muela T, et al. Evening types as determined by subjective and objective measures are more emotional eaters. *Obesity (Silver Spring)*. 2023;31(5):1192-1203. doi:10.1002/oby.23749