Sleep and Biological Rhythms (2021) 19:163–172
https://doi.org/10.1007/s41105-020-00303-8

ORIGINAL ARTICLE

# The quality and duration of sleep are related to hedonic hunger: a cross-sectional study in university students

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Received: 19 June 2020 / Accepted: 24 December 2020 / Published online: 16 January 2021


## Abstract
There is a relationship between extreme sleep duration and increased food intake. Some studies have reported that there was no change in the homeostatic aspects of energy balance, despite the increased nutrient intake, and in this case, the hedonic aspects may be effective. The purpose of this study was to examine the associations of hedonic hunger with sleep quality and duration among university students. This cross-sectional study was carried out on university students. An online questionnaire was applied in the study, in which 1144 participants were included. The Pittsburgh Sleep Quality Index (PSQI) was used to assess sleep quality and duration, and the Power of Food Scale (PFS) and Palatable Eating Motives Scale (PEMS) for detecting hedonic hunger states. Multiple linear regression analysis was performed to evaluate the relationship between sleep quality and duration and hedonic hunger by modelling. Total PFS and PEMS scores were positively associated with PSQI scores after controlling for all possible confounding factors [$\beta$ (95%CI) = 0.04 (0.03–0.05), $p < 0.05$; 0.06 (0.05–0.07), $p < 0.05$, respectively). The relationship between the subdimensions of the PFS, PEMS and PSQI remained statistically significant, except for food availability (PFS) and social motive (PEMS).After fully adjusting, the odds of having a high PEMS score increased in individuals with short or long sleep duration, but not PFS score [OR (95%CI) = 1.40 (1.09–1.83), $p = 0.012$; 0.98 (0.70–1.21), $p = 0.878$, respectively]. While a positive relationship was found between increased hedonic hunger and poor sleep quality, an inverse relationship was observed between ideal sleep duration and hedonic hunger. The findings suggest that improving sleep quality and duration can help reduce hedonic hunger, which increases the tendency to unhealthy and delicious foods and plays a role in weight gain.

**Keywords** Sleep quality · Hedonic hunger · Sleep duration · Appetite · University students

## Introduction

Sleep is a rapidly reversible recurring state of inactivity associated with diminished responsiveness to the external environment [1]. Short and long sleep duration have been suggested to be risk factors for chronic diseases [2]. Prospective cohort studies especially point out that extremes of sleep duration (short and long) are associated with adverse health outcomes, including increased risk of obesity and non-communicable disease (i.e. diabetes and cardiovascular diseases etc.) [3, 4]. Moreover, there is much growing evidence investigating the relationship between sleep quality or time and obesity, including extensive meta-analysis reports in recent years [5–7].

Epidemiologic studies have demonstrated connections between sleep duration and diet. Sleep deprivation can modify nutritional habits [8], and adequate sleep is positively associated with health-related behaviour, such as the adoption of healthy eating habits. Recent studies observed a U-shaped association between sleep duration and eating behaviours and dietary quality among women; women with short or long sleep duration were more likely to eat during unconventional hours and replace meals with snacks than women with adequate sleep duration. Decreasing or increasing sleep duration decays the control of homeostatic, increasing food intake (especially, intake of foods rich in fat and carbohydrates) [9, 10]. The underlying mechanism is that short sleep duration is associated with decreased leptin or increased ghrelin levels [11, 12]. However, Calvin et al. [13] did not detect any change in the leptin and ghrelin levels

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of individuals with short sleep duration, and they observed an increase in the food intake of these participants. In recent systematic and meta-analysis reports, it was suggested that the hedonic system, which increases in short sleep duration, seems to play a crucial role in food intake, and increased food intake was observed in cases where the homeostatic control did not change [14]. This may be attributed to heterogeneity in the study designs, but other researchers suggest that these results are due to increased hedonic system activity that may contribute to increased food intake independent of hormonal change [13, 15]. On the other hand, it is known that there is a negative relationship between prolonged sleep time and gut hormone glucagon-like peptide 1, which provides satiety due to long sleep duration, although there are not many studies on weight gain or food intake. Moreover, it activates sedentary behaviours in individuals with long sleep duration and as a result it plays a role in appetite regulation, energy expenditure and body composition, due to the decrease in leptin, the anorexigenic adipokine [16].

Hedonic eating is satisfied by the intake of highly palatable foods, which are typically made tasty by their higher fat, sugar, and salt contents and hence also tend to be dense in calories [17]. However, it is difficult to evaluate hedonic hunger in those with eating behaviour disorders and underweight individuals. Individuals, are underweight and have eating behaviour disorders such as anorexia nervosa, have low body weight and a significant negative energy balance. Therefore, they may have higher or lower hedonic hunger scores [18]. It was demonstrated that the effects of substance abuse on the limbic system are similar to the effects of the consumption of delicious foods (especially high fat and/or sugar) on the limbic system [18]. Neuroimaging studies support the evidence that some individuals may be obese due to a disorder in their dopaminergic pathways [19, 20]. It was suggested, in experimental studies, that the activation of neurons in the limbic system of participants, responsible for the reward, increased after short-term sleep manipulation. Thus, the increase in food intake associated with sleep duration seems to be mainly driven by hedonic and nonhormonal factors [21, 22]. However, this view only is limited to short-term intervention studies. Therefore, epidemiological studies are also needed to confirm such a relationship in the large population.

To the best of our knowledge, there are no studies in the literature that examine the effect of sleep duration or quality on hedonic hunger. However, a few studies have explored the possible influence of eating behaviour constructs, as an independent and strong predictor of weight gain, short sleep duration and weight status. Chaput et al. [23] have investigated the relationship between sleep duration or quality and eating behaviour. In a 6-year longitudinal study, they observed that short sleep with a high disinhibition eating behaviour trait had a greater increase in body weight. In a recent study, Blumfield et al. [24] examined if eating behaviour mediates the relationship between sleep and body mass index (BMI) in a large sample of American adults. It was found that disinhibited eating behaviour mediated the relationship between sleep quality and weight status. Results of this research suggest that improving sleep quality may benefit weight loss by helping to reduce an individual's susceptibility to overeating. In both studies, the relationship between sleep duration or quality and three-factor eating attitude-behaviour was examined. Although eating behaviour is an independent and powerful marker of weight gain in adults, it cannot provide detailed information about the hedonic hunger status and psychological effects in various delicious food environments. Since both sleep and hedonic hunger are two important factors in weight management, it is important to explain the relationship between them. In addition, when such studies are conducted in university students, who are considered a high-risk group in terms of sleep behaviours and eating habits, more effective strategies can be developed in the struggle against obesity and adoption of healthy life habits in young people. To this end, we conducted a study to see if hedonic hunger is associated with sleep quality and to what extent hedonic hunger is related to sleep quality, depending on factors that can affect it.

## Materials and methods

### Participants

Data were obtained from a cross-sectional study that was conducted in a convenience sample of students studying at six universities in Ankara. In the research, an online questionnaire was used as a data collection tool. This online questionnaire was shared on the social media accounts of universities in Ankara province and reached the participants during October 2020. Four weeks following the students' invitations, a convenient sample of 1250 participants was reached, allowing the survey to be closed. Informed consent was obtained prior to beginning the online survey. Participants who provided exclusion criteria (i.e. the presence of any major disease, nutrition and dietetic or sports science students and underweight individuals (BMI $< 18.5$ kg/m$^2$)) were excluded ($n = 106$) to give a total sample size of 1144 adults.

Participants were full-time students, aged 18–28 years, and enrolled at six universities. Eligibility criteria for this study included the following: BMI $\geq 18.5$ kg/m$^2$; not a nutrition major or sports science major graduate or student; depression, anxiety, or other psychiatric disorders; cancer; history of obstructive sleep apnoea; free from health conditions that could interfere with diet and exercise changes; taking part in another study; and not pregnant or lactating.

### Questionnaires

An online, self-administered questionnaire was used to obtain data about demographic and personal characteristics, physical activity level, sleep time-quality and hedonic hunger. These five constructs were assessed using previously validated questionnaires, and the final questionnaire required approximately 25 min to complete.

### Demographic and personal characteristics

Participants were asked to report their gender, age, smoking status, alcohol consumption, disease status, height and weight. The BMI was calculated as weight (kg) divided by height squared ($m^2$).

### Physical activity

The International Physical Activity Questionnaire (IPAQ) was developed by Craig et al. [25] to determine the physical activity levels of participants aged 15–65 years. This questionnaire provides information about the time spent sitting, walking, and in moderate to vigorous activities. In order to evaluate all activities, it is taken as a criteria that each activity is performed for at least 10 min at a time. Data collected with the IPAQ can be reported as a continuous measure of total physical activity and reported in metabolic equivalent of task (MET) minutes. In calculating the score related to physical activity, the weekly duration (minutes) of each activity and the metabolic equivalent (MET) energy values created for the IPAQ are multiplied [25]. The Turkish validity and reliability study of the IPAQ was done by Öztürk [26].

### Sleep assessment

Sleep quality was measured with the Pittsburgh Sleep Quality Index (PSQI), which was used as a subjective measure of sleep quality and disturbances of the patient's sleep. The PSQI is a 19-item self-reported questionnaire grouped into seven score components (subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medication and daytime dysfunction). In addition, five questions of the PSQI are answered by the individual's sleep partner, if applicable. However, these questions are not included in the scoring. The PSQI questions consist of a 4-point Likert structure and are scored ranging from "0" to "3". The PSQI yields a score from 0 (good quality) to 21 (poor quality). If the total score of the PSQI is $> 5$, it indicates poor sleep quality. Those with a score $\leq 5$ were classified as good sleepers [27]. The questionnaire was validated previously for use in Turkey and achieved a Cronbach's alpha of 0.80 for 114 individuals [28].

### Hedonic Hunger

#### Power of food scale

The Power of Food Scale (PFS) assesses the psychological impact of living in food-abundant environments. It measures appetite for, rather than consumption of, palatable foods at three levels of food proximity (food available, food present, and food tasted) [29]. The questionnaire originally started with 21 items, but it was decreased to 15 items after the validity and reliability analyses in a Turkish population. The validity and reliability study of the survey carried out on 363 university students was conducted by Hayzaran et al., and a Cronbach's alpha of 0.85 for the Turkish population was observed [30]. The current PFS consists of 15 items rated on a 5-point Likert scale, with an aggregate score and three subscales: (1) food available, but not present (e.g. ''I seem to have food on my mind a lot''); (2) food present, but not tasted (e.g. ''If I see or smell a food I like, I get a powerful urge to have some''); and (3) food tasted, but not eaten (e.g. ''When I eat delicious food, I focus a lot on how good it tastes''). It means that when the individual's scale score increases, the influence of the PFS (hedonic hunger) on the individual increases [29].

#### Palatable eating motives scale

The Palatable Eating Motives Scale (PEMS) scale, developed by Burgess et al. and composed of 20 items, was reduced to 19 items after validity and reliability analyses were performed [31]. The PEMS scale was developed to identify the reasons why individuals consume delicious food and drink. The scale includes four subfactors: social, coping, reward enhancement, and conformity motives. Social motives include questions about consuming palatable foods or beverages for social reasons (e.g. consumption to enjoy a party, eating behaviour shown to socialize more with friends, etc.). Coping motive includes items related to the consumption of palatable foods or beverages to deal with negative feelings (such as anxiety, eating behaviour in a sad situation, depression, or eating behaviour related to frustration and anger). Reward enhancement motive involves questions about consuming palatable foods or drinks to enhance positive experiences, emotions or inherent satisfying traits that are not related to social situations (e.g. eating behaviour towards foods that give pleasure or make the individual happy when consumed). Conformity motive involves questions about the consumption of palatable foods in response to external pressures (e.g. conformity to social environments with friends and eating behaviour shown to avoid being excluded) [31]. Responses can range from 1 (Never/Almost Never) to 5 (Almost Always/Always) and are scored as the mean response for each motive. The validity and reliability study of the survey carried out on 363 university students was conducted by Hayzaran et al. [30]. The reliability coefficient of the PEMS (Cronbach's alpha) has been calculated as 0.88, with the four subscales of the PEMS approved in confirmatory factor analysis changes between 0.75 and 0.89 [30].

### Statistical analysis

We calculated the mean ± standard deviation values for continuous variables and the frequency (percentage) values for nominal variables. We used independent *t* tests to compare continuous variables and Pearson's Chi squared test to compare categorical data between groups by gender. After the necessary criteria were provided, linear regression analyses were performed to calculate the β-coefficient of the association between BMI and hedonic hunger status by gender. We also calculated crude values of the linear regression relationship between hedonic hunger and sleep quality. After the confounding factors "age, BMI and smoking" were included in the model, multiple linear regression was used to determine the association between hedonic hunger and sleep quality. As emphasized in the introduction, long and short sleep duration share similar physiological characteristics. Therefore, short and longed sleep duration groups (< 7 h/d or > 9 h/d, respectively) were combined and logistic regression analysis was used to determine the effect on hedonic hunger compared to ideal sleep duration (7–9 h/d). The other main reason for combining groups is that the number of individuals with long sleep duration ($n = 52$) is quite low. Then, we created multiple logistic regression analyses to assess the relationship between the PFS and PEMS scores and good/short or long sleep duration and to determine whether the odds of good/short or long sleep duration were associated with hedonic hunger by gender. Moreover, model 1 was adjusted for age and BMI. Model 2 additionally adjusted for physical activity and smoking. A $p < 0.05$ was considered statistically significant. All statistical analyses were calculated using the Statistical Package for the Social Sciences (SPSS) version 21 for Windows (SPSS Inc., Chicago, IL).

## Results

Descriptive statistics are presented in Table 1. In all, 25.3% of the 1144 participants in the study were male and 74.7% were female. The mean age of the participants was 22.0 ± 2.7 years, and the mean BMI was 24.6 ± 3.6 kg/m$^2$ (male: 25.6 ± 3.4 kg/m$^2$, female: 24.2 ± 3.6 kg/m$^2$). The majority (57.5%) of the participants were normal, 34.7% were overweight and 7.8% were obese. Females were more likely to be younger ($p = 0.003$) and have a lower BMI ($p < 0.001$), smoking ($p < 0.001$), alcohol consumption and physical activity score ($p < 0.001$) compared to males (Table 1). While the average sleep quality scores of the participants were 6.1 ± 2.6, the sleep quality was worse in females (6.3 ± 2.6) compared to males (5.8 ± 2.7) ($p < 0.001$). However, there was no significant difference between females and males in sleep duration (6.9 ± 1.4 h for females and 6.9 ± 1.4 h for males; $p = 0.748$) and time in bed ($p = 0.253$).

Table 1 also lists the mean scores for females and males on the PFS and the PEMS subscales. The scores of PFS and its subscales were found to be higher in women than men ($p < 0.001$). The coping motive (PEMS subscale) scores were significantly higher in females, while the conformity motive (PEMS subscale) scores were significantly higher in males ($p < 0.05$).

We showed the association of the PEMS and PFS aggregated and their subscales scores with BMI in the female and male groups using linear regression (Table 2). For the total group, high PFS aggregated score [$\beta$ (95%CI) = 0.07 (0.06–0.09), $p < 0.001$], "food available" [$\beta$ (95%CI) = 0.18 (0.15–0.22), $p < 0.001$), "food present" [$\beta$ (95%CI) = 0.22 (0.17–0.27), $p < 0.001$] and "food tasted" [$\beta$ (95%CI) = 0.14 (0.10–018), $p < 0.001$] scores were independently associated with high BMI, and explained 9.4% of food available, 7.2% of food present and 4.1% of food tasted. This association remained significant in both groups when classified according to gender. In the total group, PEMS scores were positively associated with BMI [$\beta$ (95%CI) = 0.05 (0.04–0.07), $p < 0.001$] and explained 4.6% of its. Moreover, there was a significant relationship between poorer sleep quality and higher "coping motive and reward motive" (PEMS subscales), but not "social motive" or "conformity motive". While positive linear trends for only "social motive" scores with BMI did not remain statistically significant in the female group and for both "social motive" and "conformity motive" in the male group.

After modelling was performed with age, BMI, smoking and physical activity, which were thought to affect the PFS and PEMS subscales, multiple linear regression analysis was conducted to determine the effect of hedonic hunger on sleep quality (Table 3). The PFS total scores were positively associated with the PSQI scores after being fully adjusted [$\beta$ (95%CI) = 0.04 (0.03–0.05), $p < 0.05$] and coefficient of determination was found to be 20.0%. Moreover, "food present" and "food tasted" scores were positively associated with the PSQI score after adjusting for age, BMI, smoking and physical activity [$\beta$ (95% CI) = 0.15 (0.10–0.17), $p < 0.05$ for food present; $\beta$ (95% CI) = 0.14 (0.10–0.16), $p < 0.05$ for food tasted]. The PEMS scores were positively associated with the PSQI scores after controlling for all possible confounding factors [$\beta$ (95%CI) = 0.06 (0.05–0.07), $p < 0.05$] and explained 25.6% of PEMS scores. "Coping", "reward"

**Table 1** General characteristics, sleep attitudes and hedonic hunger states of the university students by gender

| Characteristics | Total ($n = 1144$) | Females ($n = 778$) | Males ($n = 366$) | $p$ value |
|---|---|---|---|---|
| Age | 22.0 ± 2.7 | 21.8 ± 2.5 | 22.4 ± 3.1 | 0.003* |
| Smoking status, *n* (%) | | | | |
| Never | 833 (72.8) | 626 (80.5) | 207 (56.6) | |
| Former | 97 (8.5) | 55 (7.1) | 42 (11.4) | < 0.001** |
| Current | 214 (18.7) | 97 (12.4) | 117 (32.0) | |
| Alcohol consumption, % (*n*) | | | | |
| Non-drinker | 1020 (89.2) | 723 (92.9) | 297 (81.1) | < 0.001** |
| Yes | 124 (10.8) | 55 (7.1) | 69 (18.9) | |
| BMI (kg/m$^2$) | 24.6 ± 3.6 | 24.2 ± 3.6 | 25.6 ± 3.4 | < 0.001** |
| Normal | 658 (57.5) | 498 (64.0) | 160 (43.7) | |
| Overweight | 397 (34.7) | 223 (28.7) | 174 (47.5) | < 0.001** |
| Obese | 89 (7.8) | 57 (7.3) | 32 (8.8) | |
| Physical activity (MET-mins)[a] (Median (25-75th) | 742 (396–1386) | 693 (330–1314) | 1072 (532–2133) | < 0.001** |
| Disease status, %(*n*) | | | | |
| No | 981 (86.0) | 641 (82.7) | 340 (92.9) | |
| Respiratory diseases | 35 (3.1) | 30 (3.9) | 5 (1.4) | |
| Endocrine diseases | 27 (2.4) | 25 (3.2) | 2 (0.5) | |
| Digestive diseases | 24 (2.1) | 21 (2.7) | 3 (0.8) | |
| Sleeping behaviour | | | | |
| Sleep quality[b] | 6.1 ± 2.6 | 6.3 ± 2.6 | 5.8 ± 2.7 | 0.005* |
| Sleep quality ≤ 5 | 496 (43.4) | 317 (40.7) | 179 (48.9) | 6.751 |
| Sleep quality > 5 | 648 (56.6) | 461 (59.3) | 187 (51.1) | 0.009* |
| Time in bed (clock time, h) | 7.5 ± 1.5 | 7.5 ± 1.4 | 7.6 ± 1.6 | 0.253 |
| Total sleep duration (h) | 6.9 ± 1.4 | 6.9 ± 1.4 | 6.9 ± 1.4 | 0.748 |
| Total sleep duration < 7 h | 474 (41.4) | 313 (40.2) | 161 (44.0) | 1.448 |
| Total sleep duration ≥ 7 h | 670 (58.6) | 465 (59.8) | 205 (56.0) | 0.229 |
| Hedonic hunger | | | | |
| Total PFS | 47.9 ± 13.6 | 49.6 ± 13.3 | 44.5 ± 13.6 | < 0.001** |
| Food available | 17.5 ± 5.9 | 18.2 ± 5.9 | 16.1 ± 5.6 | < 0.001** |
| Food present | 14.0 ± 4.3 | 14.4 ± 4.2 | 12.9 ± 4.3 | < 0.001** |
| Food tasted | 17.0 ± 5.1 | 17.0 ± 4.9 | 15.4 ± 5.3 | < 0.001** |
| Total PEMS | 50.0 ± 13.7 | 50.3 ± 13.3 | 49.5 ± 14.4 | 0.362 |
| Social motive | 12.4 ± 4.3 | 12.4 ± 4.2 | 12.5 ± 4.3 | 0.954 |
| Coping motive | 13.3 ± 4.6 | 13.7 ± 4.6 | 12.5 ± 4.3 | 0.001* |
| Reward motive | 14.0 ± 4.8 | 14.0 ± 4.8 | 13.8 ± 4.9 | 0.503 |
| Conformity motive | 9.6 ± 3.0 | 9.3 ± 2.8 | 10.0 ± 3.4 | 0.002* |

*BMI* Body Mass Index; MET: Metabolic Equivalent of Task; *PEMS* Palatable Eating Motives Scale; *PFS* Power of Food Scale; *PSQI* Pittsburgh Sleep Quality Index

Numeric variables are presented as mean ± standard deviation (except for physical activity). Nominal variables are shown as percentage (frequency); *p* values were derived by independent t test and Pearson's Chi squared, respectively

[a]Data are presented as median (25 and 75th quartile) values; *p* values were derived by Mann Whitney *U* test

[b]Defined by the Pittsburgh Sleep Quality Index (PSQI). A global PSQI score > 5 indicates poor sleep quality

*$p < 0.01$; **$p < 0.001$

and "conformity" motives were positively associated with the PSQI scores in the crude and fully adjusted models. Variables with significant correlation between the PFS or PEMS subscales and the PSQI in total participants remained significant in both groups according to gender. In males, higher current PFS scores were associated with

**Table 2** Linear regression analysis of the relationship between scores of PFS or PEMS subscales and BMI by gender

| | Total | | | | Female | | | | Male | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $\beta$ | SE | 95% CI | $R^2$ | $\beta$ | SE | 95% CI | $R^2$ | $\beta$ | SE | 95% CI | $R^2$ |
| PFS | | | | | | | | | | | | |
| Food available | 0.18 | 0.01 | 0.15–0.22 | 0.094** | 0.20 | 0.02 | 0.16–0.24 | 0.113** | 0.22 | 0.03 | 0.16–0.28 | 0.136** |
| Food present | 0.22 | 0.02 | 0.17–0.27 | 0.072** | 0.24 | 0.02 | 0.19–0.30 | 0.085** | 0.27 | 0.03 | 0.19–0.34 | 0.118** |
| Food tasted | 0.14 | 0.02 | 0.10–0.18 | 0.041** | 0.15 | 0.02 | 0.10–0.20 | 0.045** | 0.17 | 0.03 | 0.11–0.24 | 0.078** |
| PFS total | 0.07 | 0.01 | 0.06–0.09 | 0.084** | 0.08 | 0.01 | 0.06–0.10 | 0.098** | 0.09 | 0.01 | 0.06–0.11 | 0.136** |
| PEMS | | | | | | | | | | | | |
| Social motive | 0.03 | 0.02 | − 0.01–0.08 | 0.002 | 0.04 | 0.03 | − 0.01–0.10 | 0.003 | 0.03 | 0.04 | -0.05–0.11 | 0.001 |
| Coping motive | 0.21 | 0.02 | 0.16–0.25 | 0.075** | 0.25 | 0.02 | 0.20–0.30 | 0.107** | 0.18 | 0.03 | 0.11–0.26 | 0.063** |
| Reward motive | 0.16 | 0.02 | 0.12–0.20 | 0.047** | 0.15 | 0.02 | 0.10–0.20 | 0.041** | 0.19 | 0.03 | 0.12–0.26 | 0.074** |
| Conformity motive | 0.11 | 0.05 | 0.01–0.21 | 0.009 | 0.13 | 0.04 | 0.04–0.22 | 0.011* | 0.07 | 0.05 | -0.02–0.17 | 0.006 |
| PEMS total | 0.05 | 0.01 | 0.04–0.07 | 0.046** | 0.06 | 0.01 | 0.04–0.08 | 0.053** | 0.05 | 0.01 | 0.02–0.07 | 0.044** |

*BMI* Body Mass Index; *PEMS* Palatable Eating Motives Scale; *PFS* Power of Food Scale; *SE* Standard Error

Beta coefficient, standard error, 95% confidence interval, R squared and $p$ value calculated from linear regression analysis

*$p<0.01$; **$p<0.001$

**Table 3** Multiple linear regression analysis of associations between scores of PFS or PEMS subscales and PSQI by gender

| | | Total | | | | Female | | | | Male | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | β | SE | 95% CI | R2 | β | SE | 95% CI | R2 | β | SE | 95% CI | R2 |
| PFS | | | | | | | | | | | | | |
| Food available | Crude | 0.04 | 0.01 | 0.01–0.08 | 0.007 | 0.02 | 0.02 | −0.13–0.05 | 0.002 | 0.03 | 0.01 | 0.01–0.13 | 0.021 |
| | Adjusted[a] | 0.06 | 0.01 | 0.03–0.14 | 0.010 | 0.04 | 0.01 | 0.01–0.10 | 0.005 | 0.05 | 0.02 | 0.02–0.17 | 0.035 |
| Food present | Crude | 0.19 | 0.01 | 0.16–0.23 | 0.101* | 0.17 | 0.02 | 0.12–0.21 | 0.075* | 0.23 | 0.03 | 0.17–0.30 | 0.143* |
| | Adjusted | 0.15 | 0.01 | 0.10–0.17 | 0.196* | 0.10 | 0.02 | 0.06–0.14 | 0.203* | 0.18 | 0.03 | 0.12–0.24 | 0.220* |
| PFS total | Crude | 0.06 | 0.01 | 0.05–0.07 | 0.112* | 0.05 | 0.01 | 0.04–0.07 | 0.085* | 0.08 | 0.01 | 0.06–0.10 | 0.156* |
| | Adjusted | 0.04 | 0.01 | 0.03–0.05 | 0.200* | 0.04 | 0.01 | 0.02–0.05 | 0.208* | 0.06 | 0.01 | 0.04–0.08 | 0.222* |
| PEMS | | | | | | | | | | | | | |
| Social motive | Crude | 0.06 | 0.02 | −0.01–0.10 | 0.006 | 0.03 | 0.02 | −0.01–0.08 | 0.003 | 0.07 | 0.02 | 0.01–0.16 | 0.012 |
| | Adjusted | 0.05 | 0.01 | 0.01–0.08 | 0.012 | 0.03 | 0.02 | −0.01–0.07 | 0.010 | 0.08 | 0.03 | 0.02–0.14 | 0.015 |
| Coping motive | Crude | 0.25 | 0.01 | 0.22–0.28 | 0.194* | 0.24 | 0.01 | 0.21–0.28 | 0.194* | 0.25 | 0.03 | 0.20–0.31 | 0.182* |
| | Adjusted | 0.21 | 0.02 | 0.18–0.24 | 0.269* | 0.19 | 0.02 | 0.16–0.22 | 0.281* | 0.22 | 0.03 | 0.16–0.27 | 0.270* |
| Reward motive | Crude | 0.19 | 0.01 | 0.16–0.22 | 0.125* | 0.17 | 0.01 | 0.14–0.21 | 0.107* | 0.22 | 0.02 | 0.17–0.28 | 0.163* |
| | Adjusted | 0.16 | 0.02 | 0.13–0.18 | 0.221* | 0.14 | 0.02 | 0.10–0.17 | 0.247* | 0.19 | 0.03 | 0.13–0.24 | 0.246* |
| Conformity motive | Crude | 0.25 | 0.02 | 0.21–0.30 | 0.087* | 0.26 | 0.03 | 0.20–0.33 | 0.082* | 0.27 | 0.03 | 0.19–0.34 | 0.115* |
| | Adjusted | 0.22 | 0.03 | 0.18–0.27 | 0.210* | 0.22 | 0.03 | 0.16–0.28 | 0.234* | 0.26 | 0.04 | 0.18–0.33 | 0.248* |
| PEMS total | Crude | 0.08 | 0.01 | 0.06–0.08 | 0.166* | 0.07 | 0.01 | 0.06–0.09 | 0.151* | 0.08 | 0.01 | 0.06–0.10 | 0.194* |
| | Adjusted | 0.06 | 0.01 | 0.05–0.07 | 0.256* | 0.06 | 0.01 | 0.05–0.07 | 0.266* | 0.07 | 0.01 | 0.06–0.09 | 0.286* |

*PEMS* Palatable Eating Motives Scale; *PFS* Power of Food Scale; *PSQI* Pittsburgh Sleep Quality Index; *SE* Standart Error

Beta coefficient, standart error, 95% confidence interval, R squared and p value calculated from a multiple linear regression analysis

[a]All models adjusted for age, BMI, physical activity and smoking

*$p<0.05$

worse sleep quality compared to females after adjustment for confounders [$\beta$ (95%CI) = 0.06, (0.04–0.08), $p<0.05$ for males; $\beta$ (95% CI) = 0.04, (0.02–0.05), $p<0.05$ for females], and coefficient of determinations were found to be 22.2% and 20.8%, respectively. When classified by gender, the PEMS and PSQI scores remained significant after being fully adjusted in both groups. In both females and males, there was a significant relationship between poorer sleep quality and higher "food present and food tasted" (PFS subscales), "coping motive, reward motive and conformity motive" (PEMS subscales), but not "food available" and "social motive".

Table 4 shows the subgroup analysis of multiple logistic regression between the hedonic hunger score and sleep duration according to gender. After adjusting for potential confounding factors (age and BMI) in model 2, the odds of having a high PEMS score increased in individuals with short or long sleep duration, but not the PFS score. According to model 2, participants who slept for less than 7 h or more than 9 h had 40% higher odds for increased PEMS scores compared to those who slept for 7–9 h (reference group). Moreover, poor sleep duration was associated with a 1.79 higher odds ratio for a high PEMS score in the male group. In the female group, inadequate sleep duration was positively associated with the PEMS score in the crude model or model 1 (adjusting for age and BMI), but the association was not significant in the fully adjusted models (model 2). While there was no relationship between the PFS and sleep duration in the female group, this association was found only in the crude model of the male group (odds ratio (OR) (95% CI) = 1.72 (1.09–2.72), $p = 0.020$).

## Discussion

With a large sample of young people, this is the first research to examine the relationship between sleep quality and duration and hedonic hunger by potential confounding. General results have shown that poor sleep quality or inadequate sleep duration may be associated with high hedonic hunger and most of its subdimensions.

As is known, the PFS and PEMS have been developed to detect the factors affecting the hedonic hunger impulse. In particular, the PFS is used to assess the psychological effects of various delicious foods, while the PEMS was developed to determine the reasons for consuming delicious foods and drinks. In this study, hedonic hunger scores were found statistically significant between women and men, especially in the PFS and its subcomponent scores. Since eating disorders are more common in women, most of the studies on hedonic hunger have been in women and sometimes in both genders. In the majority of studies, it was determined that women are more sensitive to

**Table 4** Logistic regression models for the association between sleep duration and PEMS and PFS score according to gender

| | Total | *p* | Female | *p* | Male | *p* |
|---|---|---|---|---|---|---|
| PFS | | | | | | |
| Crude | | | | | | |
| 7–9 h | 1 [Reference] | | 1 [Reference] | | 1 [Reference] | |
| < 7 h or > 9 h | 1.18 (0.90–1.56) | 0.249 | 1.16 (0.88–1.56) | 0.196 | 1.72 (1.09–2.72) | 0.020* |
| Model 1 | | | | | | |
| 7–9 h | 1 [Reference] | | 1 [Reference] | | 1 [Reference] | |
| < 7 h or > 9 h | 1.01 (0.75–1.35) | 0.931 | 1.07 (0.81–1.39) | 0.239 | 1.45 (0.90–2.36) | 0.126 |
| Model 2 | | | | | | |
| 7–9 h | 1 [Reference] | | 1 [Reference] | | 1 [Reference] | |
| < 7 h or > 9 h | 0.98 (0.70–1.21) | 0.878 | 0.94 (0.75–1.15) | 0.538 | 1.13 (0.68–1.91) | 0.630 |
| PEMS | | | | | | |
| Crude | | | | | | |
| 7–9 h | 1 [Reference] | | 1 [Reference] | | 1 [Reference] | |
| < 7 h or > 9 h | 1.61 (1.27–2.03) | < 0.001*** | 1.39 (1.05–1.84) | 0.023* | 2.21 (1.46–3.36) | < 0.001*** |
| Model 1 | | | | | | |
| 7–9 h | 1 [Reference] | | 1 [Reference] | | 1 [Reference] | |
| < 7 h or > 9 h | 1.47 (1.16–1.87) | 0.001** | 1.26 (1.02–1.68) | 0.045* | 2.03 (1.33–3.12) | 0.003** |
| Model 2 | | | | | | |
| 7–9 h | 1 [Reference] | | 1 [Reference] | | 1 [Reference] | |
| < 7 h or > 9 h | 1.40 (1.09–1.83) | 0.012* | 1.20 (0.92–1.70) | 0.148 | 1.79 (1.13–2.84) | 0.006** |

*PEMS* Palatable Eating Motives Scale; *PFS* Power of Food Scale

All OR's and 95% CI's with *p* value were given for those with short or long sleep duration compared to other with good sleep

Model 1: adjusted for age and BMI. Model 2: additionally adjusted for smoking and physical activity

Short or long sleep duration was defined by less than 7 h or over 9 h

Good sleep duration for female and male group ($n$) = 422 and 186, respectively. Short or long sleep duration for female and male group ($n$) = 356 and 180, respectively

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$

reward-related food intake than men [32, 33], but it was reported in the other study that there was no such difference by gender [34]. In a review of molecular mechanisms of hedonic hunger, it has been shown that oestrogen plays a strong role in food motivation and reward processes and affects the prefrontal cortex, which is an area known as one of the hedonic reward areas [35]. In a recently published study on Iranian adults, it was shown that the score obtained from the PFS and all its subgroups is higher in women compared to men [36]. The relationship between hedonic starvation and BMI still remains controversial. In some studies, obese individuals were more sensitive to consuming food for pleasure [37, 38]. However, in the studies in which the effect of hedonic fasting status on BMI was examined in the general population, no relationship could be established between the PFS score and BMI. When the population of referenced studies is examined, there are different countries (Canada and Japan) and target groups (adult women and university students) [39, 40]. In the study conducted by Lipsky et al. [41], food available and food present scores were higher in overweight and obese young individuals. In the study conducted on the Turkish population, a significant relationship was found between the scores of all subgroups of the PEMS and BMI [42]. A positive correlation was shown between the PFS score and BMI in both groups, but this relationship was weaker in men in another study [36]. In our study, similar findings were found in both groups. However, the effect of potential factors that could affect the relationship between BMI and hedonic hunger by gender was not included, so this situation in the study may cause bias. In future studies, there is a need to investigate the question of whether there is a gender difference between hedonic hunger and BMI and the underlying factors.

Considering the linear regression relationship between hedonic hunger status and sleep quality in our study, a strong relationship was found with other components other than food available and social motive. The results of studies investigating the relationship between sleep quality and eating behaviour strengthen our findings [23, 24]. For example, a cross-sectional study examining the effect of eating behaviour on sleep quality revealed a linear relationship between increased disinhibited eating behaviour and poor sleep quality in both men and women [24]. The relationship between eating competence and quality of sleep, which examines the positive psychosocial status of eating attitudes and behaviours, was investigated in university students, constituting the high-risk group for bad eating habits. Finally, it was determined that those who had a high eating competence score had better overall sleep quality and fewer sleep-related problems compared to the low-risk group [43]. Actually, the scales, used in studies showing the relationship between sleep quality and eating attitudes and behaviours, examine the level of hunger and nutrition in response to social, environmental, emotional and nutritional stimuli [24, 43, 44]. However, the appetizing aspects of the eating behaviour or the underlying causes were not mentioned in these specified scales. Experimental research found that neuronal activity is associated with hedonic eating and activation of the right anterior cingulate cortex, which is one of the hedonic rewarding areas, increase in short sleepers via neuroimaging [21, 22]. It is known that endocannabinoids, dopamine, and opioids are associated with hedonic rewarding by affecting the receptor system in the brain [45]. It is emphasized that the levels of these receptor systems or neurotransmitters increase due to insomnia, and thus increases motivation of the stimulant and willingness, which examines the stimulating importance of foods and aspects associated with their taste [46].

The PEMS score was found to be higher in individuals who slept a short or long time compared to the ideal sleep time, despite not as much as sleep quality. Especially after full modelling, this relationship remained in men. In the expanding reports, one of the most important views explaining increased food intake (especially unhealthy snack foods) due to impaired sleep time is hedonic rather than appetite-related hormonal factors [47]. Interestingly, the participants gained more than 1 kg in weight when the sleep restraint programme was applied for five nights in an experimental study on healthy adults. In addition, participants took an average of 550 cal between 22:00 and 03:59, and the majority of this energy was made up of carbohydrate and fat-rich foods, increasing hedonic appetite [48]. In contrast to short sleep time, studies examining the relationship between prolonged sleep time and eating behaviour and hedonic hunger are limited. In the study conducted by Almoosawi et al. [47], it was founded that individuals who slept for a long time were associated with a lower healthy dietary pattern score. In a recent meta-analysis review, it was emphasized that long sleep duration was associated with risk of obesity in adults [47]. There are several potential mechanisms linking diet to prolonged sleep and metabolic impairment. Long sleep time can initiate systemic inflammation, which reduces the level of adipokines that provide satiety in adipocytes and hunger hormones in the brain [16]. In addition, low levels of satiety hormones are observed in individuals due to decreased systemic insulin sensitivity and glucose utilization [49]. As a result, long sleep duration can trigger the development of obesity and hedonic hunger mechanisms. In our research, it has been shown that hedonic dependence is one of the most potential mechanisms that can underlie this situation. However, this should be supported by clinical and epidemiological studies. We thought that the reason for a statistically stronger result in men compared with women may be due to hormonal differences, which is the possible underlying reason for a lower relation between sleep quality and hedonic appetite in women; the duration of sleep can be affected by hormonal conditions or the menstrual cycle. Due to this interaction, women may show a weaker relationship between sleep duration and hedonic appetite. Especially in this context, future research should examine the effect of sleep duration and quality on human eating behaviour or the hedonic hunger response and include topics such as how hedonic appetite and sleep quality together mediate the increase in BMI by controlling factors affecting hedonic appetite, such as gender, age, physical activity, hormonal status and menstrual cycle. In therapeutic interventions for weight management, it will be beneficial to focus on sleep quality and duration in reducing hedonic hunger.

Although this research determined the psychological effects and causes of hedonic appetite and evaluated the relationship between hedonic hunger status and sleep quality and duration, there are some limitations in this research. The self-reported data were used to determine the sleep and hedonic hunger conditions of the participants. Moreover, the results obtained may not be generalized for all university students, as students self-determined to participate in the study, like online survey research. In the study, it was not questioned whether the students worked at night or not, and this may affect the results. While individuals who sleep 7–9 h were considered as the reference group or good sleep group, those with impaired sleep times were not categorized as short (< 7 h) or long sleep (> 9 h) durations. Regression analysis was very difficult to perform, as the number of samples per group was low if categorized as short and long sleep durations. While increased appetite, nutrient intake, eating attitude, or hedonic status are often associated with short sleep duration, this data is limited to individuals with long sleep times [50, 51]. It is important to investigate the effectiveness of nutrition in long-term sleepers, as in hedonic hunger. Lastly, causality cannot be deduced from the findings of the study due to the cross-sectional study design. Thus, the findings show that there is a need for more longitudinal and experimental research.

## Conclusions

In conclusion, findings from this study found that individuals who have lower hedonic hunger may have better overall sleep quality compared with individuals who have higher hedonic hunger. However, an inverse relationship was found between a good sleep duration and hedonic hunger scores (especially the PEMS score). The findings suggest that improving sleep quality and duration can help reduce hedonic hunger, which increases the tendency to unhealthy and delicious foods and plays a role in weight gain. In addition, it is important to reach the level of evidence by conducting both longitudinal and experimental intervention studies for health promotion and weight management in young people.

**Acknowledgments** This study was not supported by any institution or organization. We would like to express our gratitude to Ankara University students for their help in data collection. I also make a present of this article to my Hayal baby. So glad I have you, Hayal!

**Author contributions** MA and ANBS contributed in conception, search, statistical analyses and manuscript drafting. MA, ANBS and FPÇ contributed in data interpretation and design. All authors approved the final version.

## Compliance with ethical standards

**Conflict of interest** Authors declare that there is no conflict of interest.

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