Sleep quality and perceived stress as related to hedonic hunger among university students: A cross-sectional study

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Abstract

Objective

The study aims to examine the relationship between sleep quality and stress levels in relation to hedonic hunger (HH) among university students in the United Arab Emirates (UAE) and the Kingdom of Bahrain (BH). Design: A cross-sectional study design was applied using a self-administered standardized and validated online questionnaire. Setting/Participants: A total of 565 students from both countries were recruited. Measurements: Palatable Eating Motives Scale (PEMS) and Power of Food Scale (PFS) were used to detect HH states, Pittsburgh Sleep Quality Index (PSQI) scale to assess sleep quality and sleep components, Perceived Stress Scale (PSS) to assess the stress levels, and International Physical Activity Questionnaire (IPAQ) to estimate physical activity levels among university students. Descriptive and analytical (simple, multiple linear, and logistic regressions) statistics were conducted to assess the relationships between sleep quality and perceived stress with hedonic hunger.

Results

A positive association was found between total PEMS and PFS scores with total PSQI score [β (95%CI) = 0.14 (0.06 – 0.25), p=0.001; β (95%CI) = 0.21 (0.45 – 1.04), p<0.001, respectively]. An increased likelihood of having poor sleep quality by 8% (OR= 1.08, p=0.02) and 43% (OR=1.43, p<0.001) for each one-unit increase of PEMS and PFS scores, respectively. A positive association was found between total PEMS and PFS scores with PSS score [β (95%CI) =0.19 (0.26 – 0.63), p<0.001; β (95%CI) =0.23 (1.04 – 2.22), p<0.001, respectively].

Conclusion

Reduction in HH and low-stress levels may help in improving sleep quality among university students.

Introduction

Human beings are asleep one-third of their lifetime. Sleep is defined as a state of reversible unconsciousness where the brain goes into an unresponsive state for a period of time [1]. During that time the sleep duration cycle must be met for adequate sleep quality. The sleep cycle is characterized by 5 stages, with non-rapid eye movement (non-REM), and rapid eye movement (REM). Being deprived of any stage has an adverse effect on the brain and body restoration [2]. Average adults need 6-8 hours of sleep during the night, any less than that, the bodily functions will be affected, like impaired attention span, memory loss, decreased immunity, raised risk of heart disease, as well as causing obesity [2]. Studies conclude that short sleep duration alters appetite-regulating hormones, lowers leptin, and increases ghrelin, resulting in increased appetite and body weight [3–5]. In another study, short sleep time has been related to a higher BMI, and short sleepers are more likely to be obese [6]. It was revealed that getting inadequate sleep may raise the risk of being overweight [7] as people who spend more time awake have more opportunities to eat [8]. Cross-sectional data suggest that energy consumption later in the day and during the night is associated with weight gain [9]. A study has implied that increased food intake after a short sleep duration is a physiological adaptation to provide the energy required to sustain additional wakefulness; however, when food is readily available, consumption exceeds the requirement. Nevertheless, transitioning to adequate sleep duration resulted in a decrease in energy consumption and promoted weight loss [10].

Hedonic hunger (HH) is referred to the persistent desire for consuming highly palatable foods (i.e., foods high in sugar, salt, and fat) in the absence of physiological hunger (imbalance of food regulating hormones occur), which vary greatly among individuals who score the highest on HH potentially have problematic behavioral and physiological characteristics [11]. True homeostatic hunger can only occur a few times a day as its primarily concerned with energy balance regulation of peripheral hormones (leptin and ghrelin) [12]. There may be a correlation between HH and body mass index (BMI) [13]. Studies have found that obese people may have higher HH. It has also been shown that people who have higher HH tend to lose control when eating, causing them to develop a binge eating disorder (BED). In long term, if left untreated, BED will lead to obesity [14].

Stress and obesity are two of the most prominent health issues in today's culture, with many interrelated paths. Chronic stress is linked to the etiology of obesity by interfering with both energy intake and expenditure mechanisms, resulting in a rise in appetite, caloric intake and reduction in physical activity [15]. The effect of stress on food intake appears to be highly individualized [16]. Stress impairs cognitive functions such as executive control and self-regulation by increasing intake of high-calorie, fat, and sugar foods [15]. In overweight and obese individuals, associations are observed between psychosocial stress and increased consumption of palatable foods (high in fat, sodium, and refined carbohydrates), and weight gain [16].

Few studies intended to examine the relationship between sleep and HH, however not all three measures. A recent study was conducted on sleep quality and HH among university students in Turkey using the tools Pittsburgh Sleep Quality Index (PSQI), Palatable Eating Motive Scale (PEMS), and Power of Food Scale (PFS). It was reported that poor sleep quality and duration may influence high HH, which rises the tendency to overeat unhealthy food and plays a role in weight gain [13]. Recent study conducted on food consumption frequency and perceived stress scale (PSS) among female university students in UAE; has moderate stress and high consumption of fast foods and soft drinks [17]. Hence, to further add to the existing literature, our study aimed to examine the relationships between sleep quality and perceived stress levels on HH among university students in the Gulf Cooperation Council (GCC) region. To our knowledge, this has not been studied before as we are particularly focusing on United Arab Emirates (UAE) and Kingdom of Bahrain (BH) university students. The significance of this work will help in tailoring suitable intervention programs among this critical age population.

Materials And Methods

Study Population

A cross-sectional study design was applied to university students in UAE and BH using the convenience sampling technique. In this research, an online questionnaire was prepared as the data collecting measure. The students had to be studying in universities in either BH or UAE. The questionnaire was shared through social media sites, and through the University of Sharjah's email. Data collection started in (4/March) and was carried on to (12/April) 2021 (1 month and 9 days). The Research Ethics Committee (REC) of the University of Sharjah (REC-21-03-03-08-S) approved the study. The participants had to click "Agree" on the consent form before starting the questionnaire. The inclusion criteria were university students, females, and males, from any nationality and aged 18 years old and above. A pilot study was done prior on 10 students to assess the questionnaire's fluidity, comprehension, and to fix any errors that might have occurred during the preparation of the questionnaire. The participants from the pilot test were not included in the final sample.

Data collection tools

Sociodemographic data

The self-administered electronic questionnaire was available in both Arabic and English. The English questionnaires were translated to Arabic by a qualified bilingual translator whose native language was Arabic, then back-translated to English by another qualified translator. Sociodemographic data included sex, age, nationality, marital status, financial status, disease status, smoking status, university name, colleges, academic year, CGPA, and registered semester credit hours.

Anthropometric assessment

Anthropometric data such as height and weight were obtained from participants' self-reporting. From these data, the BMI of participants was calculated.

Sleep quality assessment (PSQI)

The Pittsburg Sleep Quality Index (PSQI) was used to assess sleep quality. PSQI is a self-reported questionnaire focused on sleep-related habits and experiences over the previous month [18]. Participants were able to answer the questionnaire in English and the Arabic version of PSQI. The Arabic version's validity and reliability had previously been identified by Suleiman and colleagues [19]. The PSQI is a 19-item questionnaire that consists of 7 subjective sleep quality components; sleep latency (the time it takes to fall asleep), sleep period (actual time spent sleeping), sleep efficiency (percentage of time spent sleeping in bed), sleep disturbances, use of sleep drugs, and daytime dysfunction are all factors that affect sleep quality [18, 20]. Participants were asked to rate each object on a scale of 0 to 3, with 0 connoting the best and 3 connoting the worst [18]. The PSQI global scores range from 0 to 21, with a score of >5 (6 and above) suggesting clinically relevant poor sleep quality, and ≤5 indicating a good sleep quality [18].

Hedonic hunger assessment scales

The Power of Food Scale (PFS) is a brief and effective scale for assessing the psychological effects of living in a food-abundant climate [21, 22]. It consists of 15 statements about the availability, presence, and taste of food; it tests appetite, rather than intake of palatable foods [21]. *Food available*, when food is available but not physically present; *food present*, when food is physically present but has not been tasted; and *food tasted* when food has been tasted but not yet consumed [22]. The responses are classified on a 5-point Likert scale that ranges from 1 (I don't agree) to 5 (I strongly agree). Three domain scores and an aggregate score make up the calculation [22]. Domain scores were calculated as the mean of the question items representing the corresponding domain and the aggregate score was calculated as the mean of the three domains [23]. The PFS was found to have sufficient internal consistency, test-retest reliability, and a recent study assessed the Power of Food Scale's real-world predictive validity [21, 24].

The Palatable Eating Motive Scale (PEMS) revised is a 20-item self-reported questionnaire that is created by Burgess and was co-developed with Boggiano [25, 26]. Its purpose is to assess the frequency and reason behind individuals eating motives of consuming tasty foods and drinks during the past year. The PEMS questions are categorized into four motive domains: coping motive (e.g., "To forget my worries"), reward enhancement motive (e.g., "Because I like the feeling"), social motive (e.g., "Because it helps me to enjoy a party") and conformity motive (e.g., "To fit in with a group I like") [27]. Participants were given examples of such tasty foods and drinks (sweets, fast foods, snacks, non-alcoholic sugary drinks) and were asked to choose the best response from a 5-choice Likert-like scale, from 1 being (Never/Almost never) through 5 (Almost always/Always). Their responses were determined by how frequently these motives triggered the consumption of such foods. Either to deal with negative feelings (coping motive), to enhance positive emotions unrelated to social situations (reward enhancement motive), social reasons (social motives), and external sources (conformity motive). Furthermore, each motive domain was scored by calculating the mean of the response values for each of the question items. Then, the sum of these mean scores of all the motive domains yields a total PEMS score, which reflects the general intake of tasty foods for non-metabolic reasons [25]. The PEMS motives have a high level of internal consistency and test-retest reliability [27]. The validity of the scale has been previously identified [26, 27]. Due to poor loading on the coping or any other motive, question number 15 was changed from the original version wording "because you feel more self-confident and sure of yourself." to "because it helps to lower my stress" in the latest PEMS version questionnaire [25], which was used in this study.

Stress level assessment

Perceived Stress Scale (PSS) was developed by Cohen, Kamarck, and Mermelstein, is a self-report measure that assesses "the degree to which stressful conditions in one's life are appraised in the previous month" [28]. It consists of 10 questions that are rated on a 5-point scale (0=Never, 1=Almost never, 2=Sometimes, 3=Fairly often, 4=Very often) [29]. PSS scores were calculated by reversing responses of four specified items (4, 5, 7, and 8) and then summing through all scale items (e.g., 0 = 4, 1 = 3, 2 = 2, 3 = 1 & 4 = 0) [30]. Total PSS can range from 0 to 40, with higher scores indicating higher perceived stress. The total stress scores in results were further categorized into three groups; scores ranging from 0-13 are low stress; from 14-26 are moderate stress, and 27-40 are high perceived stress [29]. The reliability and validity of the Arabic version of the PSS were evaluated elsewhere [31] as well as PSS-10 [32].

Physical activity assessment

The International Physical Activity Questionnaires - short form (IPAQ-SF) was used to assess participants' physical activity level [33]. The questionnaire was available in Arabic version [34] along with English [33]. A study has evaluated the questionnaire's validity and reliability [35]. IPAQ-SF evaluates participants' activity levels for the last 7 days, involved in either vigorous, moderate, walking, or sitting activities [33]. The inclusion criteria are that participants should undergo these physical activities for at least 10 minutes [35]. Metabolic Equivalent Task (MET) was reported as a continuous variable. For scoring, the MET value for a given activity was multiplied by the minutes and number of days per week the activity was carried out [35]. It was further reported as a categorical variable, classified as either low, moderate, or high physical activity, according to the category criteria [35].

Statistical analysis

All variables were either analyzed as continuous (presented as mean ± standard deviation (SD)), categorical variables (frequency and percentages), or both. An independent t-test was used to analyze continuous variables and crosstabs were used to analyze categorical variables to compare data between groups by sex and between UAE and BH university students. Hence, the P-value was obtained from the independent t-test (sig. 2-tailed) and Pearson's Chi-square (sig. 2-sided). Analyses of the results were done on both countries' data combined. Total PSQI global score (0-21) and seven sleep components scores (0-3) were used to express sleeping behavior as continuous variables. Additionally, HH scales were analyzed as continuous variables; subscales scores (1-5) and total PEMS score (4-20). The PSS was analyzed as a continuous variable (0-40) and as a categorical variable; low stress (0-13), moderate stress (14-26), and high perceived stress (27-40) to classify the stress level of the students. Multiple linear regression was used to calculate the standardized Beta coefficient, standard error, 95% confidence interval, and P-value. First, the correlation between HH and sleep quality by sex. Then, the correlation between HH and PSS by sex. All variables were analyzed as continuous variables. In addition, values that expressed these correlations were calculated as crude and adjusted. All models were adjusted for confounding factors (age, BMI, physical activity, and smoking status). Multiple logistic regression was used to calculate the odds ratio (OR), 95% confidence interval, and P-value to measure the risk of having poor sleep quality. Model 1 was adjusted for age and BMI, while model 2 was adjusted further for physical activity and smoking status. The HH scales and PSS were analyzed as continuous variables, while overall sleep quality and sleep components were analyzed as categorical variables. Missing data were excluded from all these analyses either list or pairwise. A *P*-value of <0.05 was considered statistically significant. Statistical analyses were performed using SPSS software version 23 Mac OS (IBM, 2015).

Results

HH, sleep quality, and stress variables were analyzed using both countries' data combined. Data combination is justified as an independent t-test and cross-tab analyses highlighted a non-significant difference between the main components in UAE and BH university students, shown in supplementary table 1. Supplementary tables 2 and 3, shows the relationships between HH with sleep and stress according to sex. Supplementary table 4 displays the correlation matrix between all major variables.

Table 1 describes the sociodemographic characteristics of the participants according to the sex of university students. A total of 565 participants, 80.2% were females and 18.8% were males. The mean age of the total number of participants was 21.19 ± 3.8 years. Most participants were from the GCC (31.0%) and Arab non-GCC (29.0%) nationality. A significant difference was shown for smoking status between females (non-smoker: 93.6%, smoker: 6.4%) and males (non-smoker: 69.6%, smoker: 30.4%; *P*<0.001). The mean BMI was 24.5 ± 6.0 kg/m^2, where males had significantly (*P*<0.001) greater BMI than females (27.14 ± 6.45 vs 23.93 ± 5.75; respectively). The majority of participants did moderate physical activity (35.4%).

Descriptive statistics of HH, sleep quality, and stress level states of the total number of university students are presented in Table 2. Participants had a total PEMS score of 10.95 ± 3.00; 2.88 ± 1.15 for coping; 3.14 ± 1.02 for reward enhancement; 3.15 ± 1.01 for social; 1.77 ± 0.86 for conformity motive. PFS scores for food available was (2.99 ± 1.69); food present (3.40 ± 1.14); food tasted (3.30 ± 0.97); and aggregated factor of (3.21 ± 0.96). The PSQI global mean score was 7.78 ± 3.38, and 71.0% of university students reported poor sleep quality. The mean PSS-10 score was 23.09 ± 6.98; the majority of university students experienced moderate stress (60.5%) and high stress (31.5%).

The relationship between HH and PSQI using multiple linear regression analysis is shown in Table 3. PEMS scores showed a significantly positive association with PSQI after being fully adjusted [β (95%CI) = 0.14 (0.06 – 0.25), *P* <0.001], and the coefficient of the determinant was found to be 2.7%. In both crude and adjusted models "*reward*"," *coping*" and "*conformity*" revealed a positive association with PSQI. Total PFS scores were positively correlated with PSQI after controlling all cofounding factors [β (95%CI) = 0.21 (0.45 – 1.04), *P*<0.001], and the coefficient of determination was perceived to be 0.50%. Additionally, "*Food Available*", "*Food Present*" and "*Food Tasted*" has shown a positive association with total PSQI score after being adjusted for confounding factors; [β (95%CI) = 0.16 (0.16 – 0.50), *P* **<**0.001] for food available, [β (95%CI) = 0.17 (0.27 – 0.75), *P* <0.001] for food present and [β (95%CI) = 0.12 (0.13 – 0.71), *P***<**0.001] for food tasted.

Table 4 shows a multiple logistic regression that was performed to determine the ability of HH to predict the outcome of overall poor sleep quality (PSQI) and poor sleep components among university students. Model 1 was adjusted for age and BMI, while Model 2 was additionally adjusted for physical activity and smoking. According to Model 2, poor sleep quality was positively associated with the PEMS score, as the estimated odd ratio (OR) favored an increase of (8%) (OR= 1.08, 95%CI= 1.01-1.15, *P* = 0.02) for poor sleep quality for each one-unit increase of HH. An association with an increased OR of 7% (OR=1.07, *P*=0.03) for having a short sleep period (<5 hours or 5-6 hours a day) among students with high PEMS score than those who slept for 6-7 hours or >7 hours (reference group). Students with increased HH have higher odds of having medium/high sleep disturbances by 12% (OR=1.12, *P*<0.001) than having none/low sleep disturbances (reference group). There was an increased likelihood by 14% (*P*= 0.02) of students who have high PEMS scores to use medications to sleep than the reference group. Students with high PEMS scores had higher odds of 8% (OR=1.08, *P*=0.01) for increased medium/high daytime dysfunction.

According to Model 2, poor sleep quality was positively associated with PFS score, as the OR favored an increase of 43% (OR=1.43, *P*<0.001) of having poor sleep quality as HH increases. Participants with a high PFS score tended in the likelihood of having increased medium/high sleep disturbances by 60% (OR=1.60, *P*<0.001) than the reference group. An OR estimated an increased risk of 51% (OR=1.15, *P*<0.001) of having medium/high daytime dysfunction among students who have high HH.

Table 5 shows a multiple linear regression analysis of the relationship between HH and PSS.

A positive association between total PEMS score and PSS is shown [β (95%CI) = 0.19 (0.26– 0.63), *P*<0.001), among university students, with high PSS scores are more prone to consume palatable foods for coping motives [β (95%CI) = 0.26 (1.07 – 2.07), *P*<0.001). The relationship between PFS aggregated factor and PSS presented a positive relationship [β (95%CI) = 0.23 (1.04-2.22), *P*<0.001). Students with high PSS scores are more likely to consume palatable foods when food is present as shown with a coefficient determinant of (β = 0.22).

Table 1
Sociodemographic characteristics of total university students from both UAE and BH by sex

Variables	Total University Students			
	Female (n=453)	Male (n=112)	Total (n=565)	P-value
Age (years)	21.03 ± 3.63	21.84 ± 4.30	21.19 ± 3.78	**0.04**
Nationality, n (%)				
UAE Local	129 (28.5)	26 (23.3)	155 (27.4)	0.65
GCC	136 (30.0)	39 (34.8)	175 (31.0)	
Arab non-GCC	132 (29.1)	32 (28.6)	164 (29.0)	
Non-Arab	56 (12.4)	15 (13.4)	71 (12.6)	
Marital Status, n (%)				
Single	431 (95.1)	100 (89.3)	531 (94.0)	**0.04**
Married	21 (4.6)	12 (10.7)	33 (5.8)	
Divorced	1 (0.2)	0 (0.0)	1 (0.2)	
Smoking Status, n (%)				
Non-Smoker	424 (93.6)	78 (69.6)	502 (88.8)	**<0.001**
Smoker	29 (6.4)	34 (30.4)	63 (11.2)	
Disease Status, n (%)				
No	373 (82.3)	93 (83.0)	466 (82.5)	0.85
Respiratory diseases	15 (3.3)	6 (5.4)	21 (3.7)	
Cardiovascular diseases	10 (2.2)	3 (2.7)	13 (2.3)	
Digestive diseases	15 (3.3)	3 (2.7)	18 (3.2)	
Endocrine diseases	13 (2.9)	2 (1.8)	15 (2.7)	
Other	27 (6.0)	5 (4.5)	32 (5.7)	
Financial Status, n (%)				
Low	389 (85.9)	92 (82.1)	481 (85.1)	0.45
Medium	44 (9.7)	12 (10.7)	56 (9.9)	
High	20 (4.4)	8 (7.1)	28 (5.0)	
College, n (%)				
Medicine and Health Sciences	197 (43.6)	20 (17.9)	217 (38.5)	**<0.001**
Humanities	105 (23.2)	41 (36.6)	146 (25.9)	
Applied Sciences	138 (30.5)	49 (43.8)	187 (33.2)	
Graduate Studies	11 (2.4)	1 (0.9)	12 (2.1)	
Dual program	1 (0.2)	1 (0.9)	2 (0.4)	
Education Level, n (%)				
Foundation Year	24 (5.3)	6 (5.4)	30 (5.3)	0.08
Year 1	120 (26.5)	21 (18.8)	141 (25.0)	

BMI: Body Mass Index. Continuous (numeric) variables are presented as mean ± standard deviation obtained from an independent t-test. Categorical (nominal and ordinal) variables are shown as frequency (percentage) obtained from a Crosstabs test; P-value was obtained from independent t-test (sig. 2-tailed) and Pearson's Chi-square (sig. 2-sided).

BMI classification values were underweight (<18.5 kg/), normal (18.5 – 24.9 kg/), overweight (25.0-29.9 kg/), obese (³30.0 kg/ [36]. Physical activity was categorized using IPAQ scoring guidelines and its physical activity category criteria [35]. Financial status currency was in Bahraini Dinar (BD) and United Arab Emirates Dirham (AED), and values were categorized as Low: <500 BD / <5,000 AED (<1,361 USD), Medium: 500 - 1,000 BD / 5,000 – 10,000 AED (1,361 – 2,722 USD), High: >1,000 BD / >10,000 AED (>2,722 USD).

Variables	Total University Students			
	Female (n=453)	Male (n=112)	Total (n=565)	P-value
Year 2	75 (16.6)	25 (22.3)	100 (17.7)	
Year 3	57 (12.6)	24 (21.4)	81 (14.3)	
Year 4	124 (27.4)	22 (19.6)	146 (25.8)	
Year 5	18 (4.0)	6 (5.4)	24 (4.2)	
Year 6	1 (0.2)	1 (0.9)	2 (0.4)	
Post-graduate	34 (7.5)	7 (6.3)	41 (7.3)	
CGPA, n (%)				
<2.0	22 (4.9)	1 (0.9)	23 (4.1)	**0.001**
2.0 - 2.4	31 (6.8)	15 (13.4)	46 (8.1)	
2.5 - 2.9	85 (18.8)	35 (31.3)	120 (21.2)	
3.0 - 3.5	161 (35.5)	35 (31.3)	196 (34.7)	
3.6 - 4.0	154 (34.0)	26 (23.2)	180 (31.9)	
Semester Registered Credit Hours	(n =412)	(n =99)	(n = 511)	**0.04**
	21.05 ± 28.15	28.04 ± 41.88	22.41 ± 31.36	
BMI (kg/m^2)	23.93 ± 5.75	27.14 ± 6.45	24.57 ± 6.00	**<0.001**
BMI Classification, n (%)	(n= 447)	(n=111)	(n=558)	**<0.001**
Underweight	60 (13.4)	4 (3.6)	64 (11.5)	
Normal	231 (51.7)	47 (42.3)	278 (49.8)	
Overweight	101 (22.6)	29 (26.1)	130 (23.3)	
Obese	55 (12.3)	31 (27.9)	86 (15.4)	
Physical activity, n (%)				
No physical activity	134 (29.6)	32 (28.6)	166 (29.4)	0.18
Low physical activity	99 (21.9)	16 (14.3)	115 (20.4)	
Moderate physical activity	158 (34.9)	42 (37.5)	200 (35.4)	
High physical activity	62 (13.7)	22 (19.6)	84 (14.9)	

BMI: Body Mass Index. Continuous (numeric) variables are presented as mean ± standard deviation obtained from an independent t-test. Categorical (nominal and ordinal) variables are shown as frequency (percentage) obtained from a Crosstabs test; P-value was obtained from independent t-test (sig. 2-tailed) and Pearson's Chi-square (sig. 2-sided).

BMI classification values were underweight (<18.5 kg/), normal (18.5 – 24.9 kg/), overweight (25.0-29.9 kg/), obese (³30.0 kg/ [36]. Physical activity was categorized using IPAQ scoring guidelines and its physical activity category criteria [35]. Financial status currency was in Bahraini Dinar (BD) and United Arab Emirates Dirham (AED), and values were categorized as Low: <500 BD / <5,000 AED (<1,361 USD), Medium: 500 - 1,000 BD / 5,000 – 10,000 AED (1,361 – 2,722 USD), High: >1,000 BD / >10,000 AED (>2,722 USD).

Table 2
Hedonic hunger, sleep quality, and stress level scores state of total university students

Characteristics	Total University Students
	Total (n=565)
Hedonic Hunger (Mean ± SD)	
PEMS (Mean ± SD)	
Coping Motive	2.88 ± 1.15
Reward Enhancement Motive	3.14 ± 1.02
Social Motive	3.15 ± 1.01
Conformity Motive	1.77 ± 0.86
Total PEMS score	10.95 ± 3.00
PFS (Mean ± SD)	
Food Available	2.99 ± 1.69
Food Present	3.40 ± 1.14
Food Tasted	3.30 ± 0.97
Aggregated Factor score	3.21 ± 0.96
Sleep Components (PSQI)	
Subjective sleep quality score (Mean ± SD)	1.44 ± 0.91
Adequate subjective sleep quality, n (%) [1]	345 (61.1)
Inadequate subjective sleep quality, n (%)[1]	220 (38.9)
Sleep latency score (Mean ± SD)	1.62 ± 1.03
Adequate sleep latency, n (%) [1]	257 (45.5)
Inadequate sleep latency, n (%)[1]	308 (54.5)
Sleep duration score (Mean ± SD)	1.03 ± 0.98
Adequate sleep duration, n (%) [1]	422 (74.7)
Inadequate sleep duration, n (%)[1]	143 (25.3)
Sleep efficiency score (Mean ± SD)	0.66 ± 1.01
Adequate sleep efficiency, n (%) [1]	464 (82.1)
Inadequate sleep efficiency, n (%)[1]	101 (17.9)
Sleep disturbance score (Mean ± SD)	1.32 ± 0.57
Adequate sleep disturbance, n (%) [1]	379 (67.1)
Inadequate sleep disturbance, n (%)[1]	186 (32.9)
Use of sleep medication score (Mean ± SD)	0.23 ± 0.64
Adequate need for sleep medication, n (%)[1]	529 (93.6)
Inadequate need for sleep medication, n (%)[1]	36 (6.4)
Daytime dysfunction score (Mean ± SD)	1.48 ± 0.91
Less daytime dysfunction, n (%)[1]	295 (52.2)
More daytime dysfunction, n (%)[1]	270 (47.8)
Global PSQI score (Mean ± SD)	7.78 ± 3.38
Sleep quality ≤ 5, n (%)[1]	164 (29.0)
Sleep quality >5, n (%)[1]	401 (71.0)

Characteristics	Total University Students
	Total (n=565)
Perceived Stress Scale (PSS)	
Total Stress Level score (Mean ± SD)	23.09 ± 6.98
Low stress, n (%)	45 (8.0)
Moderate stress, n (%)	342 (60.5)
High perceived stress, n (%)	178 (31.5)

PEMS: Palatable Eating Motive Scale; **PFS**: Power of Food Scale; **PSQI**: Pittsburgh Sleep Quality Index; **SD**: Standard Deviation

Continuous (numeric) variables are presented as mean ± standard deviation obtained from independent t-test. Categorical (nominal and ordinal) variables are shown as frequency (percentage) obtained from the Crosstabs test; *P*-value was obtained from independent t-test (sig. 2-tailed) and Pearson's Chi-square (sig. 2-sided).

[1] Total PSQI score and sleep behavior components were analyzed as categorical variables, total PSQI global score (0 to 21) and seven sleep components scores (0 to 3) were used to express sleeping behavior as continuous variables. In addition, total PSQI score and sleep behavior components were analyzed as categorical variables. They were categorized into two outcomes: total sleep quality categorized as good sleep quality (≤5) and poor sleep quality (>5). Sleep components were categorized as either adequate or inadequate; subjective sleep quality as adequate: high and medium sleep quality (score of 0 or 1) and inadequate: low and very low sleep quality (score of 2 or 3). Sleep latency was categorized as adequate: very short and short sleep latency (score of 0 or 1) and inadequate: medium and long sleep latency (score of 2 or 3). Sleep duration was categorized as adequate: >6-7 hours and >7 hours (score of 0 or 1) and inadequate: 5-6 hours and <5 hours (score of 2 or 3). Sleep efficiency was categorized as adequate: high and medium sleep efficiency (score of 0 or 1) and inadequate: low and very low sleep efficiency (score of 2 or 3). Sleep disturbance was categorized as adequate: none or low sleep disturbances (score of 0 or 1) and inadequate: medium and high sleep disturbances (score of 2 or 3). Need for medication was categorized as adequate: none and low usage (score of 0 or 1) and inadequate: medium and high usage (score of 2 or 3). Day dysfunction was categorized as adequate: none and low day dysfunction (score of 0 or 1) and inadequate: medium and high day dysfunction (score of 2 or 3).

Table 3

Multiple linear regression analysis of the relationship between hedonic hunger scores (PEMS and PFS subscales) with total PSQI

Hedonic Hunger Scales		Total (n=565)			
		β	SE	95%CI	P-value
PEMS					
Coping Motive	Crude	0.17	0.12	0.25 – 0.73	**<0.001**
	Adjusted[1]	0.17	0.13	0.24 – 0.74	**<0.001**
Reward Enhancement Motive	Crude	0.10	0.14	0.06 – 0.61	**0.02**
	Adjusted	0.10	0.14	0.04 – 0.60	**0.02**
Social Motive	Crude	0.06	0.11	-0.09 – 0.46	0.18
	Adjusted	0.06	0.14	-0.09 – 0.46	0.19
Conformity Motive	Crude	0.10	0.17	0.06 – 0.71	**0.02**
	Adjusted	0.10	0.17	0.06 – 0.72	**0.02**
Total PEMS	Crude	0.14	0.05	0.07 – 0.25	**<0.001**
	Adjusted	0.14	0.05	0.06 – 0.25	**<0.001**
PFS					
Food Available	Crude	0.17	0.08	0.17 – 0.50	**<0.001**
	Adjusted	0.16	0.09	0.16 – 0.50	**<0.001**
Food Present	Crude	0.17	0.12	0.27 – 0.76	**<0.001**
	Adjusted	0.17	0.13	0.27 – 0.75	**<0.001**
Food Tasted	Crude	0.12	0.15	0.14 – 0.72	**<0.001**
	Adjusted	0.12	0.15	0.13 – 0.71	**<0.001**
Aggregated Factor	Crude	0.21	0.15	0.45 – 1.02	**<0.001**
	Adjusted	0.21	0.15	0.45 – 1.04	**<0.001**

PEMS: Palatable Eating Motive Scale; **PFS**: Power of Food Scale; **PSQI**: Pittsburgh Sleep Quality Index; **β**: Standardized Beta coefficient;

SE: Standard Error; **95% CI**: 95% Confidence interval

Standardized Beta coefficient, standard error, 95% confidence interval, and p-value were obtained from a multiple linear regression analysis.

[1] All models were adjusted for age, BMI, physical activity, and smoking.

Table 4

Multiple logistic regression models for the associations between total PSQI and PSQI components with total hedonic hunger scales (PFS and PE

PSQI and Sleep Components		Total Sleep Quality		Subjective Sleep Quality		Sleep Latency		Sleep Duration		Sleep Efficiency		Sleep Disturban	
		OR (95% CI)	**P-value**	**OR (95% CI)**	**P-value**	**OR (95% CI)**	**P-value**	**OR (95% CI)**	**P-value**	**OR (95% CI)**	**P-value**	**OR (95% CI)**	**P va**
Hedonic Hunger	**Total PEMS**												
	Crude												
	Good Quality	1 [Reference]	**0.01**	1 [Reference]	0.26	1 [Reference]	0.42	1 [Reference]	**0.04**	1 [Reference]	0.47	1 [Reference]	**<**
	Poor Quality	1.08 (1.02 – 1.15)		1.03 (0.98 – 1.09)		1.02 (0.97 – 1.08)		1.07 (1.00 – 1.14)		0.97 (0.91 – 1.05)		1.13 (1.06 – 1.20)	
	Model												
	Good Quality	1 [Reference]	**0.02**	1 [Reference]	0.37	1 [Reference]	0.45	1 [Reference]	**0.03**	1 [Reference]	0.763	1 [Reference]	**<**
	Poor Quality	1.08 (1.01 – 1.15)		1.03 (0.97 – 1.09)		1.02 (0.97 – 1.08)		1.07 (1.01 – 1.15)		0.99 (0.92 – 1.06)		1.13 (1.06 – 1.20)	
	Model 2												
	Good Quality	1 [Reference]	**0.02**	1 [Reference]	0.39	1 [Reference]	0.46	1 [Reference]	**0.03**	1 [Reference]	0.76	1 [Reference]	**<**
	Poor Quality	1.08 (1.01 – 1.15)		1.03 (0.97 – 1.09)		1.02 (0.96 – 1.08)		1.07 (1.00 1.15)		0.99 (0.92 – 1.06)		1.12 (1.06 – 1.20)	
	Total PFS – Aggregated Factor												
	Crude												
	Good Quality	1 [Reference]	**<0.001**	1 [Reference]	**0.03**	1 [Reference]	0.22	1 [Reference]	0.09	1 [Reference]	0.87	1 [Reference]	**<**
	Poor Quality	1.44 (1.19 – 1.75)		1.22 (1.02 – 1.47)		1.12 (0.94 – 1.33)		1.19 (0.97 – 1.46)		1.02 (0.81 – 1.28)		1.62 (1.33 – 1.98)	
	Model 1												
	Good Quality	1 [Reference]	**<0.001**	1 [Reference]	**0.05**	1 [Reference]	0.23	1 [Reference]	0.07	1 [Reference]	0.43	1 [Reference]	**<**
	Poor Quality	1.43 (1.17 – 1.75)		1.20 (1.00 – 1.45)		1.12 (0.93 – 1.33)		1.21 (0.98 – 1.49)		1.10 (0.87 – 1.39)		1.60 (1.31 – 1.95)	
	Model 2												
	Good Quality	1 [Reference]	**<0.001**	1 [Reference]	0.06	1 [Reference]	0.23	1 [Reference]	0.08	1 [Reference]	0.45	1 [Reference]	**<**
	Poor Quality	1.43 (1.17 – 1.74)		1.20 (0.99 – 1.44)		1.12 (0.93 – 1.34)		1.21 (0.98 – 1.49)		1.10 (0.87 – 1.38)		1.60 (1.31 – 1.95)	

PSQI: Pittsburgh Sleep Quality Index; **PEMS**: Palatable Eating Motive Scale; **PFS**: Power of Food Scale; **OR**: Odd Ratio; **95% CI**: 95% Confidence interval

OR, 95% CI, and P-value were obtained from multiple logistic regression.

Total PSQI score and sleep behavior components were analyzed as categorical variables, Total PSQI global score (0 to 21) and seven sleep components scores (0 to 3) were used to express sleeping behavior as continuous variables. In addition, total PSQI score and sleep behavior components were analyzed as categorical variables. They were categorized into two outcomes: total sleep quality categorized as good sleep quality (≤5) and poor sleep quality (>5). Sleep components were categorized as either adequate or inadequate; subjective sleep quality as adequate: high and medium sleep quality (score of 0 or 1) and inadequate: low and very low sleep quality (score of 2 or 3). Sleep latency was categorized as adequate: very short and short sleep latency (score of 0 or 1) and inadequate: medium and long sleep latency (score of 2 or 3). Sleep duration was categorized as adequate: >6-7 hours and >7 hours (score of 0 or 1) and inadequate: 5-6 hours and <5 hours (score of 2 or 3). Sleep efficiency was categorized as adequate: high and medium sleep efficiency (score of 0 or 1) and inadequate: low and very low sleep efficiency (score of 2 or 3). Sleep disturbance was categorized as adequate: none or low sleep disturbances (score of 0 or 1) and inadequate: medium and high sleep disturbances (score of 2 or 3). Need for medication was categorized as adequate: none and low usage (score of 0 or 1) and inadequate: medium and high usage (score of 2 or 3). Day dysfunction was categorized as adequate: none and low day dysfunction (score of 0 or 1) and inadequate: medium and high day dysfunction (score of 2 or 3).

Model 1: adjusted for age and BMI.

Model 2: was additionally adjusted for physical activity and smoking status.

Table 5
Multiple linear regression analysis of the relationship between hedonic hunger scores (PEMS and PFS subscales) and total perceived stress scale

Hedonic Hunger Scales		**Total (n=565)**			
		β	**SE**	**95%CI**	**P-value**
PEMS					
Coping Motive	Crude	0.27	0.25	1.12– 2.10	**<0.001**
	Adjusted[1]	0.26	0.25	1.07 – 2.07	**<0.001**
Reward Enhancement Motive	Crude	0.14	0.29	0.37 – 1.50	**<0.001**
	Adjusted	0.13	0.29	0.31 – 1.44	**<0.001**
Social Motive	Crude	0.13	0.29	0.31– 1.45	**<0.001**
	Adjusted	0.13	0.29	0.30 – 1.42	**<0.001**
Conformity Motive	Crude	0.04	0.34	-0.33 –1.03	0.31
	Adjusted	0.04	0.34	-0.34 –0.99	0.34
Total PEMS	Crude	0.20	0.10	0.28 – 0.66	**<0.001**
	Adjusted	0.19	0.10	0.26 – 0.63	**<0.001**
PFS					
Food Available	Crude	0.20	0.17	0.49 – 1.16	**<0.001**
	Adjusted	0.19	0.17	0.45 – 1.13	**<0.001**
Food Present	Crude	0.22	0.25	0.85 -1.84	**<0.001**
	Adjusted	0.22	0.25	0.83– 1.81	**<0.001**
Food Tasted	Crude	0.13	0.30	0.31 – 1.51	**<0.001**
	Adjusted	0.12	0.30	0.25 – 1.44	**<0.001**
Aggregated Factor	Crude	0.23	0.30	1.08 – 2.25	**<0.001**
	Adjusted	0.23	0.30	1.04 – 2.22	**<0.001**

PEMS: Palatable Eating Motive Scale; **PFS**: Power of Food Scale; **β**: Standardized Beta coefficient; **SE**: Standard Error; **95% CI**: 95% Confidence interval

Standardized Beta coefficient, standard error, 95% confidence interval, and p-value were obtained from a multiple linear regression analysis.

[1] All models were adjusted for age, BMI, physical activity, and smoking.

Discussion

This is the first study to investigate the relationship between sleep quality and stress in relation to HH, taking into consideration possible confounding factors among university students in the UAE and BH. The current work ended up with the main findings of strong positive associations between HH with PSQI and PSS. Food consumption is regulated by two different pathways; the homeostatic and hedonic pathways. Hedonic pathways mean that during periods of energy abundance there is an increase in the desire to consume highly palatable foods [12]. According to Lutter and Nestler's review, highly palatable foods elicit responses in the mesolimbic dopamine pathway. These foods induce the release of dopamine, which is thought to coordinate food reward processes [12].

PEMS and PFS are used to identify the factors behind these HH impulses [13]. Two studies conducted among college students in the United States (US) have shown that they consume palatable foods for social motives more than the other PEMS motives [25, 27]. Likewise, in our research, the social motive score is significantly higher than the other motives. A study found that there is a positive relationship between HH and neural responsivity with brain regions associated with oral somatosensory during intake of highly palatable foods, and increased motivation of these foods' consumption [37]. Our study total PEMS score is higher than the known studies combined. This difference is supported as, in all Middle Eastern countries, the number of restaurants and fast-food chains has expanded drastically, which led to an increase in the number of people eating out. As a result, people in these countries are more inclined to consume fat and carbohydrate-rich foods [38].

Furthermore, a study conducted among college students in the US showed a positive association between the PFS subscales and the motivation of consuming highly palatable food [21]. Likewise, our research found similar results. According to findings from studies evaluating neural activity in food-seeking and reward-related regions of the brain, hedonic hunger is associated with heightened urges to eat regardless of hunger condition [11]. Another study highlighted that higher PFS scores were linked to greater activity in the postcentral gyrus areas in the brain linked to both somatosensory processing of food cues and obesity [11].

Decreased quality and quantity of sleep have been shown to increase HH as the hormone ghrelin is increased and leptin is decreased, thus increasing the prevalence of obesity in the population [40]. In our research, the multiple linear regression analysis revealed a significant relationship between HH status and overall sleep quality, HH increases with poor sleep quality. A study conducted by Almoosawi et al., PEMS scores were found to be higher in both short and long sleep duration when compared to ideal sleep duration; long periods of sleep may cause inflammation, which may lower satiety in adipocytes and hunger hormones in the brain [41]. As a result, a long sleep period will contribute to obesity and the HH process [42]. A study in Turkey among university students concluded that improving sleep quality and duration may help lower HH [13]. Long sleep time can cause systemic inflammation, which reduces satiety hormones in the brain and adipokine that provide satiety in adipocytes. The decline of systemic insulin sensitivity and glucose utilization is associated with low levels of satiety hormones in individuals. Thus, long sleep duration can affect the development of obesity and HH [42, 43]. In our research, we found a positive association between HH and sleep; higher PSQI score or poor sleep quality was associated with high coping motive score.

Physical or emotional discomfort has been linked to an increase in the consumption of highly palatable foods [16]. It is possible that high cortisol levels, in conjunction with high insulin levels, can be the reason [44]. Ghrelin, the hunger hormone, can also play a role; foods high in fat and sugar seem to have a feedback and comfort effects once consumed, which influences individuals to consume food when stressed [16]. Based on a UAE study on female university students, the total PSS was moderate stress with high consumption of fast food and soft drinks, and lower consumption of fresh fruits and vegetables [17]. The eating habits of individuals are said to change when they are stressed [45]. In our research, there was a highly significant positive association between high PSS and HH (PEMS and PFS). The PEMS sub-scale motives which are associated with high stress levels are coping, reward enhancement, and social motives only. When comparing the motive domains, it showed that most students consumed highly palatable foods to cope with negative emotions when highly stressed. Students with high PSS scored higher in food presence scale. A study in Saudi Arabia revealed that PSS was associated with unhealthy changes in eating patterns, where females students reported increased preference for sweets while males preferred consuming fast food under stress [46]. However, to our knowledge, no study has directly examined the relationship between HH (PEMS and PFS) with PSS to compare with our findings.

This study has many strengths, to our knowledge, this is the first research in GCC and in the UAE that analyzed the relationship between HH with sleep and stress among university students. Having a sufficient number for a cross-sectional study (565 participants), and having students from 33 different universities from two different countries in the GCC region (UAE and BH), instead of one university in one country. While this study investigated the relationship between PSQI and PSS with HH, some inherent limitations should be considered when interpreting its results. Since the data are self-reported, it is possible that the participants misreported and misclassified their height, weight, sleep, stress, and HH due to recall bias. Further, students are self-determined to participate in the analysis, such as online survey studies, the findings obtained might not be generalized for all university students. Considering the study was conducted middle of the COVID-19 pandemic this might or might not influence the results. Due to the design of cross-sectional studies, causality cannot be deduced.

In conclusion, this research highlights a significant positive association between HH with poor sleep quality, poor sleep components, and increased stress levels among university students. These results suggest that a reduction in HH and low-stress levels may help in improving sleep quality among university students. Future well-controlled clinical trials investigating the relationship between the hormones and related genes that control the circadian rhythm are warranted to understand the relationship better. For example, biochemical tests (blood tests or urine tests) to further assess the levels of sleep and appetite-regulating hormones such as leptin, ghrelin, cortisol, and melatonin among university students.

Declarations

Declarations

Conflicts of interest:

None

Declaration of interest

None

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Author’s Contribution:

MF and RO supervised the research and revised the manuscript. NK, MQ, AA, and MJ participated in data collection, calculating PSQI, PEMS, PFS, PSS scores and writing the manuscript; NK and SA performed the statistical analyses.

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