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ORIGINAL ARTICLE

Night eating syndrome and its association with weight status, physical activity, eating habits, smoking status, and sleep patterns among college students

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Abstract

Background Night eating syndrome (NES) is characterized by evening hyperphagia and/or nocturnal ingestion.

Objective The main objective of this study was to assess the percentage of students complying with symptoms and behaviors consistent with the diagnostic criteria for NES, and explore its association with body mass index (BMI), dietary habits, physical activity, smoking status, and sleep patterns, among a sample of college students.

Methods A cross-sectional survey was conducted among a sample of 413 undergraduate students, mean age of 20.6 ± 1.68 SD, at Central Michigan University. Students completed an online survey including demographic information and the Night Eating Diagnostic Questionnaire (NEDQ) and Pittsburgh Sleep Quality Index Questionnaire (PSQI). Participants were grouped based on self-reporting of the presence and frequency of night eating-related symptoms and behaviors related to the diagnostic criteria for NES as follows: normal, mild night eater, moderate night eater, and full-syndrome night eater. Pearson's Chi-squared, Student's *t* test, and Wilcoxon rank-sum test were used to test the association between students with and without any night eating behavior in relation to BMI, lifestyle variables, and sleep duration/quality.

Results Results showed that the proportion of students complying with symptoms and behaviors consistent with full-syndrome of NES was 1.2%. There were no significant differences between students complying with symptoms

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and behaviors consistent with any level of NES and those without any night eating behavior regarding BMI, eating habits, physical activity, and smoking status. NES was significantly related to sleep duration ($P = 0.023$). Students complying with symptoms consistent with any level of NES reported shorter sleep time and had higher total PSQI score (6.73 ± 4.06) than students without the syndrome (5.61 ± 2.61) ($P = 0.007$).
Conclusion Although the percentage of students complying with full-syndrome NES was relatively low in our student sample, those students had shorter sleep time and poorer sleep quality than the other groups. However, it is unclear whether evening hyperphagia is a response to a lack of sleep or vice versa, and further research is needed.
Level of Evidence Level III, case-control analytic study.

Keywords Night eating syndrome · Obesity · Sleep quality · Night Eating Diagnostic Questionnaire · NEDQ · University students · Eating disorders

Background

Data from the American College Health Association-National College Health Assessment (ACHA-NCHA), a nationwide survey conducted in Fall 2015 among 19,861 university students at 2- and 4-year institutions to assess students' general health and other related factors, indicated that 84.5% of the surveyed students described their health as good, very good or excellent [1]. However, one-third (30.3%) of the surveyed students reported having sleep difficulties, 20.4% reported having stress, 14.6% reported having depression, and 16.3% were obese [1]. Literature suggests that sleep disturbance, stress, and depressed mood may be associated with weight concerns and abnormal eating behaviors [2–7]. A recent study by Tavolacci et al. conducted among 3457 college students found that 52.8% of the surveyed students were at risk for eating disorders, and were stressed and depressed, and 26.3% reported being on a diet [8]. Authors suggested that those students who were at risk for developing eating disorders were also experiencing weight concerns which interfered with their academic performance [8]. Another study estimated the prevalence of eating disorders among college students to be 4.5% in women and 1.4% in men [9]. College students, in particular, face various stressors such as exams, schoolwork, academic demands to succeed in a competitive environment, social demands, and body image concerns, all of which may trigger abnormal eating behaviors [2, 7, 10–12]. Other studies suggest that poor sleep quality, stress, anxiety, and depression may be associated with weight gain and delayed circadian patterns of food intake as identified in the Night eating syndrome (NES) [13–15].

The American Psychiatric Association recognizes NES as a disordered eating pattern, and it is currently included in the fifth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) under the section "Other Specified Feeding or Eating Disorders" [16]. The main feature of NES is recurrent episodes of night eating, as manifested by eating after awakening from sleep or by excessive food consumption after the evening meal [16, 17]. NES was reported among college students and appeared to be linked to stress, depressed mood, poor sleep quality, and elevated body mass index (BMI) [7–9, 14, 18]. Runfola et al. conducted a study among 1636 American College students aged 18–26 years and reported a prevalence of 4.2% of NES among the surveyed students [18]. The authors reported that students with NES had more eating disorders symptoms, mental health problems, self-injurious behavior, and poorer quality of life than the students with no night eating (NE) [18]. Another study by Nolan and Geliebter conducted among 246 American college students indicated that 5.7% of their study sample had NES, and those students with NES had significantly higher emotional eating scores and lower sleep quality than students without the syndrome or in the mild category [9].

Although the diagnosis of NES is best done with a structured clinical interview, researchers have used various tools to screen for NES among college students [9, 13, 18, 19]. The most common tool is the Night Eating Questionnaire (NEQ) [17], which is a validated 14-item survey that assesses the core features and associated symptoms of NES using 0- to 4-point Likert responses [20]. Another tool is the Night Eating Diagnostic Questionnaire (NEDQ) [21], which is a self-report questionnaire to classify NES based on the presence and frequency of night eating-related symptoms and behaviors using the proposed diagnostic criteria for NES [17, 20]. In a recent publication by Nolan and Geliebter, convergent validity between the NEDQ and the NEQ was demonstrated, indicating that NEDQ is a valid measure for the diagnosis of NES [22]. A recent study by Tu et al. examined the reliability and validity of administrating the NEQ in an online format compared to a paper-and-pencil form using the translated version of NEQ in Chinese among Chinese subjects. The authors found both versions to have good reliability and validity [23].

NES was originally described in 1955 as a pattern of eating among obese individuals who were resistant to weight loss in an obesity treatment program [24]. NES has since been associated with weight gain and obesity [25, 26]. Among college students, researchers found a positive association between NES and BMI [27]. However, others found no relationship between night eating severity and BMI suggesting that weight gain may occur only at

later ages after longer periods of engaging in night eating [9, 13, 22].

Also, NES was found to be linked to poor sleep quality, and poor sleep quality/quantity was positively associated with obesity [28, 29]. Individuals with NES experience a delay in caloric intake relative to a normal sleep–wake cycle [30–32]. Among college students, poor sleep quality/quantity was also linked to poor academic performance. In a previous study conducted among 414 college students, students who reported poor sleep quality performed less well on academic measures than similar students with a better quality of sleep [33].

Although NES has been documented in previous studies in a student population [9, 18], college students appear to be at particular risk for disordered eating behaviors and sleep problems [34–37]. Eating pathology tends to emerge in late adolescence [38], with a peak between the ages of 18–20 years [39]. Thus, identifying students who may be at risk for symptoms/behaviors consistent with NES is important because those students may benefit from preventive interventions at an early stage. Accordingly, the primary objective of this exploratory study was to estimate the frequency of students who comply with symptoms and behaviors consistent with the diagnostic criteria for NES in a sample of undergraduate students at Central Michigan University (CMU). The secondary objectives were to explore whether students complying with the symptoms of NES differ from those without NES in weight status, eating habits, physical activity, smoking status, or sleep patterns. Unhealthy dietary practices, physical inactivity, smoking, poor sleep are all modifiable factors that can be used as target elements in preventive interventions to reduce disordered eating behaviors and obesity among college students.

Methods

Design and sample

Data were obtained from a cross-sectional study that was conducted in a convenience sample of CMU students. Four hundred and sixty-two students were recruited via announcements in foods and nutrition classes and on blackboard by a CMU Nutrition and Dietetics professor during the spring 2015 and fall/spring 2016 semesters. Inclusion criteria were the following: not having a serious disease or symptoms of a serious disease, age between 18 and 25 years; having access to the internet; not on a diet; not pregnant, and not taking any medications. Of 462 respondents, 413 students (323 female and 90 male) chose to participate (89%) in the study voluntarily and were provided information about the study's protocol and methodology and asked to sign a consent form approved by the CMU Institutional Review Board (IRB), and to come for anthropometric measurements. Upon completion of the measurements, students were provided with a numerical code and a link to an online questionnaire. Codes were given to students to protect their personal identity while completing the online questionnaire. Students were not given any incentives for their participation.

Data collection

Anthropometric measurements

Anthropometric measurements were taken for all participants by a CMU Nutrition and Dietetics professor and trained undergraduate senior students, using a standardized protocol [40]. Weight, body mass index, percentage body fat, and visceral fat score were measured using a body composition scale (Tanita body composition analyzer SC-331S) (Tanita, Arlington Heights, IL, U.S.). A detailed description of the anthropometric measurement procedures has been provided previously [41]. In brief, the student's height, age, and gender were entered into the Tanita device. Then, the student stepped into the Tanita scale footpads with bare feet (both feet touching the electrodes). Students were instructed to wear light clothing, abstain from eating, and refrain from any heavy physical activity before they came in the morning (within 3 h after waking up) for body composition measurements since fluctuations in body hydration status may affect body composition results. Also, students were asked to wipe the bottom of their feet before stepping onto the measuring platform, since unclean foot pads may interfere with conductivity [41–43]. Weight, percentage body fat, visceral fat, and body mass index were recorded from the Tanita body composition analyzer readings.

For height measurements, students were asked to take off their shoes. Height was measured to the nearest 0.1 cm using a height rod (Seca stadiometer model 217, Quick Medical, Issaquah, WA, U.S.). Waist circumference was measured using a non-stretchable tape (QM2000 Measure Mate, Quick Medical, Issaquah, WA, U.S.) according to the CDC's Anthropometry Procedures Manual [40].

Body mass index (BMI) was used to assess relative weight status [40]. Using the guidelines published by the Centers for Disease Control and Prevention (CDC) for BMI classifications, weight was stratified into four groups: underweight (BMI <18.5 kg/m^2), normal weight ($18.5 \leq$ BMI < 24.9 kg/m^2), overweight [($25 \leq$ BMI < 29.9 kg/m^2), and obese (BMI ≥ 30 kg/m^2) [40, 44]. The healthy range for body fat percentage was considered as 8–19% for males and 17–32% for females (Tanita body fat ranges for healthy adults). Visceral fat ratings from 1 to 12 were considered

healthy while ratings from 13 to 59 indicated an excess level of visceral fat (Tanita visceral fat ranges for healthy adults) [41–43].

Online questionnaire

Demographic and student characteristics After completing the anthropometric measurements, students were asked to complete an online questionnaire via SurveyMonkey (SurveyMonkey.com, LLC, Palo Alto, CA). The questionnaire consists of questions related to the student's age, gender, year in school, study major, living condition (on/off campus), dietary habits, physical activity, sleep pattern, smoking status, and included the results of their anthropometric measurements [41]. The demographic and student characteristics questions were adapted from Yahia et al. [43]. The dietary habits questions were adopted from a previous study by Turconi et al. [45] and were validated for use among university students in previous studies [43, 45].

Physical activity Physical activity was assessed using the International Physical Activity Questionnaire-short form (IPAQ-S) [46]. The IPAQ-S form consists of seven questions that assess physical activity at three levels (vigorous intensity, moderate intensity, and walking) undertaken by students for the last consecutive 7 days across four different physical activity domains (leisure time physical activity, domestic and gardening (yard) activities, work-related physical activity, and transport-related physical activity) [41]. A detailed description of the scoring methodology is available online at http://www.ipaq.ki.se [47] and discussed in previous publications [41, 48].

Sleep pattern Pittsburgh Sleep Quality Index (PSQI) questionnaire was used to assess students' sleep patterns [41, 49]. The PSQI is a standardized self-rated questionnaire consisting of 19 questions that assess a wide variety of factors related to sleep quality, including estimates of sleep duration and latency and the frequency and severity of specific sleep-related problems, over a 1-month time interval (for the last 30 days) [41]. Using the PSQI scoring protocol, the questions were grouped into seven component scores; each weighted equally on a scale of 0–3. The seven component scores were then summed to yield a global PSQI score, which ranged between 0 and 21; the higher the score, the worse the sleep quality [41, 49]. A detailed description of the scoring methodology is described by the author of PSQI in a previous study [49] and discussed in a previous publication [41].

Night eating syndrome The Night Eating Diagnostic Questionnaire (NEDQ) was used to assess the percentage of students complying with the symptoms of NES. NEDQ is a self-reported questionnaire used to classify diagnostic categories of NES, which was validated for use among college students in previous studies [9, 14]. The questionnaire consists of 19-item questions related to eating behaviors such as nocturnal ingestion, evening hyperplasia, mood/sleep disturbance, and morning loss of appetite. Examples of the questions include the following: On most days, do you experience loss of appetite in the morning?; How often do you typically eat breakfast (after your final morning awakening); How much food do you, generally, eat after 7 p.m. as a percentage (%) from 0 to 100?; Do you awake from sleep during the night to eat; Have you been feeling depressed or down nearly every day?, and so on. Most of the questions are in the "yes" or "no" format or as frequency per week (times/week) [21]. Using the diagnostic criteria for NES proposed by the authors of NEDQ [17], students were stratified into four groups based on NES severity: non-night eater (normal), mild night eater, moderate night eater, and full-syndrome night eater. The NEDQ and its scoring key are presented in Fig. 1 [21]. Also, a copy of NEDQ with instructions for its use and scoring is available in a publication by Nolan and Geliebter [14, 21]. Permission to use the NEDQ questionnaire before its use was obtained from the authors [21].

The online questionnaire was available online via SurveyMonkey (http://www.surveymonkey.com) for about ten weeks to accommodate students' response times. Instructions on how to fill out the questionnaire completely were given to students. Students were also informed that they could withdraw from the study at any time [41]. A random sample of 20 students took the online questionnaire as part of a pilot test before it was administrated to all participants [41].

Data analysis

Statistical analyses were performed using the SAS (9.3, Cary, NC) software. Gender differences for study variables were assessed using Student's independent *t* test for normally distributed continuous variables, Wilcoxon rank-sum test for non-normally distributed continuous variables, and Chi-squared test for independence or Fisher's exact test for categorical variables. The same analyses were used to assess differences in student characteristics, physical activity, and sleep duration/quality between subjects with any level of NES (mild, moderate or full syndrome) and subjects without any NES (normal). Analyses to assess the differences in anthropometric measures and lifestyle choices were stratified by gender. Chi-squared test for independence was used to assess gender differences in the percentage of NES. Results are expressed as mean ± SD (standard deviation) for continuous variables and percent

I. The daily pattern of eating demonstrates a significantly increased intake in the evening and/or night time, as manifested by one or both of the following:
A. At least 25% of food intake is consumed after the evening meal
Q 8 ≥ 25% and Q 8a ≥ 3 months
B. At least two episodes of nocturnal eating per week
Q 13 = yes AND Q 13a ≥ 2 d/wk AND Q 13b ≥ 3 months
II. Awareness and recall of evening and nocturnal eating episodes are present.
Q 13d = somewhat or extremely and/or Q 13e = sometimes or always
III. The clinical picture is characterized by ***at least three*** of the following features:
A. Lack of desire to eat in the morning and/or breakfast is omitted on four or more mornings per week
Q3 = yes OR Q4 ≤ 3 times/week
B. Presence of a strong urge to eat between dinner and sleep onset and/or during the night
Q 9 = yes
C. Sleep onset and/or sleep maintenance insomnia are present four or more nights per week
Q 10 or Q 11 = Yes and Q 10a or Q 11a ≥ 4 times/week
D. Presence of a belief that one must eat in order to initiate or return to sleep
Q 13c = Yes
E. Mood is frequently depressed and/or mood worsens in the evening
Q 17 = yes OR Q 18 = evening/night-time
IV. The disorder is associated with significant distress and/or impairment in functioning.
Q 14a OR Q 14 b = somewhat or extremely
V. The disordered pattern of eating has been maintained for a minimum of 3 months.
14c = 3-6 months OR 6-12 months OR more than 1 year
VI. The disorder is not secondary to substance abuse or dependence, medical disorder, medication, or another psychiatric disorder: **This cannot be assessed using the questionnaire but should be noted.**
Standard Scoring based on Above
Dichotomous
0. Non-NE = *normal* (does not meet criteria category below)
1. NES = *full syndromenight eater* has 1 criterion from I **plus** ≥ 3 of 5 qualifiers from criteria III **plus** IV and V
Experimental Scoring
Hierarchical
0. Non-NE = *normal* (does not meet any criteria category below)
1. N = *mild night eater* has 1 criteria from I (but does not meet criteria NE or NES)
2. NE = *moderate night eater* has 1 criteria from I**plus** ≥ 3 of 5 qualifiers from criteria III (but does not meet criteria NE or NES)
3. NES = *full syndromenight eater* has ≥1 from I **plus** ≥ 3 of 5 qualifiers from criteria III **plus** IV and V

Adopted with permission from the author [32].

Fig. 1 Criteria and scoring method of night eating syndrome (NES) diagnosis in our sample

Table 1 Characteristics of participants

Characteristic	Males	Females	Total	*P*
N (%)	**90 (21.8)**	**323 (78.2)**	**413**	
Age (mean ± SD)	20.8 ± 1.95	20.5 ± 1.60	20.6 ± 1.68	0.192[c]
Race/ethnicity *n* (%)	**89**	**322**	**411**	0.835[b]
White/Caucasian	82 (92.13)	293 (90.99)	375 (91.24)	
Non-white/Caucasian	7 (7.87)	29 (9.01)	36 (8.76)	
Smoking status *n* (%)	**90**	**323**	**413**	0.126[a]
Current	3 (3.33)	2 (0.62)	1 (1.21)	
Former	3 (3.33)	13 (4.02)	16 (3.87)	
Infrequent	11 (12.22)	21 (6.50)	32 (7.75)	
Never smoked	73 (81.11)	287 (88.85)	360 (87.17)	
Anthropometric characteristics				
BMI category (kg/m^2) *n* (%)	**74**	**278**	**352**	0.004[a]
Underweight (BMI <18.5 kg/m^2)	1 (1.35)	15 (5.47)	16 (4.60)	
Healthy (BMI ≥18.5–24.9 kg/m^2)	38 (51.35)	179 (64.39)	215 (61.65)	
Overweight (BMI ≥25–29.9 kg/m^2)	32 (43.24)	64 (23.02)	94 (27.27)	
Obese (BMI ≥30 kg/m^2)	3 (4.05)	20 (7.30)	23 (6.61)	
BMI (mean kg/m^2 ± SD)	**74**	**278**	**352**	
	24.76 ± 2.26	23.74 ± 3.66	23.96 ± 3.60	0.030[c]
Waist circumference (mean cm ± SD)	**70**	**258**	**328**	
	85.22 ± 8.22	78.85 ± 11.62	80.21 ± 11.28	<0.0001[c]
Body fat (mean % ±SD)	**76**	**276**	**352**	
	13.69 ± 5.63	27.74 ± 6.80	24.71 ± 8.74	<0.0001[c]
Visceral fat score (mean ± SD)	**57**	**188**	**245**	
	2.56 ± 2.86	2.34 ± 3.15	2.39 ± 3.08	0.630[c]
Sleep duration, *n* (%)	**87**	**317**	**404**	0.458[a]
<7 h	22 (25.29)	93 (29.34)	115 (28.47)	
≥7 h	65 (74.71)	224 (70.66)	289 (71.53)	
Sleep duration, (mean h ± SD)	7.21 ± 0.90	7.26 ± 1.07	7.25 ± 1.04	0.677[c]
PSQI total, *n*	**80**	**306**	**386**	
(Mean h ± SD)	5.35 ± 2.42	5.85 ± 2.75	5.75 ± 2.69	0.136[c]
Physical activity, *n*				
Median (25% q, 75% q)				
Walking MET-minutes/week	**87**	**314**	**401**	
	990 (247.5, 1386)	693 (264, 1386)	693 (264, 1386)	0.834[d]
Moderate MET-minutes/week	**90**	**323**	**413**	
	480 (80, 1200)	480 (60, 960)	480 (80, 960)	0.485[d]
Vigorous MET-minutes/week	**90**	**323**	**413**	
	2400(0, 4320)	640 (0, 2400)	960 (0, 2520)	<0.0001[d]
Sitting time (h)	**76**	**279**	**355**	
	4 (3, 6)	5 (4, 7)	5 (3, 7)	0.139[d]
Year in school	**90**	**321**	**411**	0.514[a]
First year	24 (26.67)	76 (23.68)	100 (24.33)	
Second year	23 (25.56)	69 (21.50)	92 (22.38)	
Third year	15 (16.67)	62 (19.31)	77 (18.73)	
Fourth year	18 (20.00)	88 (27.41)	106 (25.79)	
Fifth year	10 (11.11)	26 (8.10)	36 (8.76)	

Continuous variables are expressed as mean ± SD (standard deviation) and categorical variables are expected as frequency (percent). *N* number of students (N for a title question is in "bold" font)

PSQI the Pittsburgh Sleep Quality Index ranges 0–21. The higher score, the poorer sleep quality

[a] Chi-squared test

[b] Fisher's exact test

[c] Student's independent *t* test

[d] Wilcoxon rank-sum test

frequency for categorical variables. All reported P values were based on 2-sided tests with a significance level of 5%.

Results

Participants' characteristics

Students' characteristics are depicted in Table 1. A total of 413 students participated in this study. The mean age of participants was 20.6 ± 1.68 years. The majority of students were female (78.2%), self-reported to be white (91.2%), and non-smokers (87.2%).

Mean BMI was 23.9 ± 3.60 kg/m^2 and mean percentage body fat was 24.7 ± 8.74 (Table 1). Almost two-thirds (61.6%) of the surveyed students were in the healthy weight range. There was a gender difference in BMI category between male and female students ($P = 0.004$) with more males (43.2%) than females (23.0%) in the overweight category. However, the proportion of obesity in women (7.3%) was higher than in men (4.0%). Male students had a significantly lower percentage of body fat, but higher waist circumference (13.7% ± 5.63; 85.2 cm ± 8.22) than female students (27.7% ± 6.80; 78.8 cm ± 11.6) ($P < 0.0001$) (Table 1). For visceral fat, there were no significant differences between male and female students. However, women had a lower mean visceral body fat value (2.3 ± 3.2) than men (2.5 ± 2.9) (Table 1).

Most students (71.5%) reported sleeping more than 7 h per night. The mean total PSQI was 5.75 ± 2.69 (Table 1). Male students reported being more active than female students. Vigorous activity was significantly more common among male students than female students ($P < 0.001$) (Table 1).

Using the diagnostic criteria for NES, we grouped participants into four categories based on the self-reported severity of symptoms and behaviors consistent with the diagnostic criteria for NES as follows: 1. not night eater; 2. mild night eater; 3. moderate night eater; and 4. full-syndrome night eater. Results showed that only 1.2% of the students complied with the symptoms consistent with the diagnostic criteria proposed for full syndrome of NES, 2.7% for moderate night eater, and 8.5% for mild night eater (Table 2). A slightly higher percentage of female students met the criteria for moderate night eater (3.1%) and full-syndrome night eater (1.2%) compared to male students, (1.1%) and (1.1%), respectively. However, there was no significant association between the four levels of NES and gender. Overall, most students (87.7%) did not meet any of the diagnostic categories for NES (Table 3).

Characteristics of students complying with symptoms consistent with the diagnostic criteria for NES and without NES

In exploratory analyses, participants were stratified into two groups by NES status: group 1: no NES (normal, does not meet any criteria of NES) and group 2: with NES (combination of the last three categories of NES: mild, moderate, and full-syndrome category). Results showed that there were no significant differences between NES and non-NES groups regarding age, gender, ethnicity, year in school, smoking status, BMI category, or physical activity. However, students complying with symptoms for any level of NES reported shorter sleep time (7.03 ± 1.12 h)

Table 2 Prevalence of night eating syndrome by gender

Night eating syndrome[b]	Male *N* (%)	Female *N* (%)	Total *N* (%)	*P* value
Total	90	323	413	0.222[a]
Non-NE (normal)	76 (84.4)	286 (88.5)	362 (87.7)	
Mild night eater	12 (13.3)	23 (7.1)	35 (8.5)	
Moderate night eater	1 (1.1)	10 (3.1)	11 (2.7)	
Full-syndrome night eater	1 (1.1)	4 (1.2)	5 (1.2)	

[a] Chi-squared test

[b] The criteria for night eating syndrome is referenced to Nolan and Geliebter [9]

Table 3 Prevalence of any NES criteria by gender

Night eating syndrome	Male *N* (%)	Female *N* (%)	Total *N* (%)	*P* value
Non-NES (normal)	76 (84.44)	286 (88.54)	362 (87.65)	0.296[a]
Any NES (mild, moderate and full)	14 (15.56)	37 (11.46)	51 (12.35)	

[a] Chi-squared test

Table 4 Association of student characteristics with any night eating syndrome (mild, moderate or full NES)

Characteristic	With NES[e]	No NES	Total	*P*
N (%)	**51 (12.35)**	**362 (87.65)**	**413**	
Age (mean ± SD)	20.75 ± 2.01	20.57 ± 1.63	20.60 ± 1.68	0.498[c]
Gender *n* (%)	**51**	**362**	**413**	0.283[b]
Male	14 (27.45)	76 (20.99)	90 (21.79)	
Female	37 (72.55)	286 (79.01)	323 (78.21)	
Race/ethnicity *n* (%)	**51**	**360**	**411**	0.186[b]
White/Caucasian	44 (86.27)	331 (91.94)	375 (91.24)	
Non-white/Caucasian	7 (13.73)	29 (8.06)	36 (8.76)	
Year in school	**50**	**361**	**411**	0.426[c]
First year	14 (28.00)	86 (23.82)	100 (24.33)	
Second year	7 (14.00)	85 (23.55)	92 (22.38)	
Third year	8 (16.00)	69 (19.11)	77 (18.73)	
Fourth year	17 (34.00)	89 (24.65)	106 (25.79)	
Fifth year	4 (8.00)	32 (8.86)	36 (8.76)	
Smoking status *n* (%)	**51**	**362**	**413**	0.437[a]
Current	1 (1.96)	4 (1.10)	5 (1.21)	
Former	2 (3.92)	14 (3.87)	16 (3.87)	
Infrequent	7 (13.73)	25 (6.91)	32 (7.75)	
Never smoked	41 (80.39)	319 (88.12)	360 (87.17)	
BMI category (kg/m^2) *n* (%)	**45**	**303**	**348**	0.193[a]
Underweight (BMI <18.5 kg/m^2)	2 (4.44)	14 (4.62)	16 (4.60)	
Healthy (BMI ≥18.5–24.9 kg/m^2)	34 (75.56)	181 (59.74)	215 (61.67)	
Overweight (BMI ≥25–29.9 kg/m^2)	8 (17.78)	86 (28.38)	94 (27.01)	
Obese (BMI ≥30 kg/m^2)	1 (2.22)	22 (7.27)	23 (6.61)	
Sleep duration, *n* (%)	**50**	**354**	**404**	0.023[a]
<7 h	21 (42.00)	94 (26.55)	115 (28.47)	
≥7 h	29 (58.00)	260 (73.45)	289 (71.53)	
Sleep duration, (mean h ± SD)	7.03 ± 1.12	7.28 ± 1.02	7.25 ± 1.04	0.100[c]
PSQI total, (mean h ± SD)	**48**	**338**	**386**	
	6.73 ± 4.06	5.61 ± 2.61	5.75 ± 2.69	0.007[c]
Physical activity, median (25% q, 75% q)				
Walking MET-minutes/week	**50**	**351**	**401**	
	1089 (396, 1386)	693 (247.5, 1386)	693 (264, 1386)	0.505[d]
Moderate MET-minutes/week	**51**	**362**	**413**	
	480 (0, 1200)	480 (80, 960)	480 (80, 960)	0.759[d]
Vigorous MET-minutes/week	**51**	**362**	**413**	
	960 (0, 2880)	960 (0, 2400)	960 (0, 2520)	0.352[d]
Sitting time (h)	**45**	**310**	**355**	
	5 (3, 6)	5 (3.5, 7)	5 (3, 7)	0.554[d]

N number of students (N for a title question is in "bold" font)

[a] Chi-squared test

[b] Fisher's exact test

[c] Student's independent *t* test

[d] Wilcoxon rank-sum test

[e] Any level of NES: mild, moderate and full

compared to the other group (7.28 ± 1.02 h) (Table 4). Students with any level of NES had a significantly higher mean total PSQI score (6.73 ± 4.06) compared to students with no NES (5.61 ± 2.61) ($P = 0.0068$) (Table 4).

Analyses of anthropometric measurements showed that there were no significant differences between students complying with symptoms for any level of NES and those with no NES regarding BMI, percentage of

Table 5 Association of any night eating syndrome (mild, moderate or full NES) with anthropometric characteristics, stratified by gender

Variable	Male			Female		
	With NES[a]	No NES	*P* value[b]	With NES[a]	No NES	*P* value[b]
BMI, *n*	**12**	**62**		**33**	**245**	
kg/m^2, mean (SD)	23.35 (2.45)	25.04 (3.34)	0.101	22.83 (2.89)	23.87 (4.74)	0.126
Body fat, *n*	**12**	**64**		**33**	**243**	
%, mean (SD)	12.91 (3.70)	13.84 (5.93)	0.601	27.99 (5.89)	27.70 (6.92)	0.821
Visceral fat score, *n*	**10**	**47**		**22**	**166**	
Mean (SD)	2.00 (1.49)	2.68 (3.07)	0.499	2.27 (2.39)	2.35 (3.24)	0.919

N number of students (N for a title question is in "bold" font)

[a] Any level of NES: mild, moderate and full

[b] Student's independent *t* test

body fat, and visceral fat scores for either males or females (Table 5).

The association of any level of NES and behavioral lifestyle choices by gender showed that for both male and females students, there were no significant differences regarding eating habits, physical activity, smoking status, and sleep duration between those with any level of NES and those with no NES (Table 6). However, male students complying with symptoms and behaviors consistent with the diagnostic criteria for any level of NES showed a trend to skip daily breakfast more than male students without NES (42.86 vs 30.67%, $P = 0.056$) and more reported sleeping less than 7 h compared to male students with no NES (46.15 vs 21.62%, $P = 0.061$) (Table 6).

Discussion

This study aimed to assess the prevalence of students complying with symptoms and behaviors consistent with the diagnostic criteria for NES and to examine the association of NES with BMI, physical activity, eating habits, smoking status, and sleeping patterns among a sample of Midwestern college students. As this study was exploratory, structured clinical interviews were not utilized to diagnose NES; rather the night eating diagnostic questionnaire (NEDQ) was used to estimate the percentage of students who reported symptoms and behaviors complying with the diagnostic criteria for NES [14]. Results showed that most of our participants (87.7%) did not meet any of the diagnostic criteria for NES. Only 1.2% of students reported symptoms consistent with the proposed diagnostic criteria for the full syndrome of NES. This percentage was lower than that found in two previous studies conducted by Runfola et al. (2.9%) [18] and Nolan and Geliebter (5.69%) [9] in a sample of American college students, but similar to that reported by Fischer et al. [50]. Fischer and colleagues conducted a study among a sample of 1514 young adults aged 18–26 years from the general population in Switzerland and found a prevalence of 1.3% of NES [50]. Runfola et al. reported that individuals with NES had more eating disorder symptoms, mental health problems, self-injurious behavior, and poorer quality of life than those of the control group [18]. Thus, the importance of early screening to identify those students who are at risk for or may be experiencing symptoms consistent with the proposed diagnostic criteria for the full syndrome of NES should be emphasized. Early detection and intervention of this condition at its initial stages among this vulnerable population are essential [9, 18].

Concerning the associations between students who comply with symptoms consistent with the proposed diagnostic criteria for any level of NES and those with no NES, our results indicated that there were no significant differences regarding BMI, eating habits, physical activity, and smoking status. In the current study, the majority of our students were non-smokers and were not on a diet [51]. Similar findings were also reported in previous studies [9, 18, 52].

Only sleep duration was found to be significantly different between students complying with symptoms for any level of NES/vs no NES. Students complying with symptoms consistent with the proposed diagnostic criteria for any level of NES reported shorter sleep time and poorer sleep quality compared to those students with no NES. The total PSQI score was significantly higher for students complying with symptoms consistent with the proposed diagnostic criteria for any level of NES than for those students with no NES. Nolan and Geliebter [22] reported that students with moderate and full NES had significantly lower sleep quality than students with no NES or in the mild category [9]. These findings are consistent with the increased likelihood of those with NES to get up from sleep to eat resulting in less total sleep and poorer quality. However, those with NES were not more likely to have sleep apnea [53].

A recent study by Poggiogalle et al. conducted among 137 obese subjects (76.6% women, mean age 49.8 years)

Table 6 Association of any night eating syndrome (mild, moderate or full NES) with lifestyle choices, stratified by gender

Variable	Male			Female		
	Any NES[a]	No NES	*P* value	Any NES[a]	No NES	*P* value
Dietary habits, *n* (%)						
Daily breakfast intake	**14**	**75**	0.056[b]	**36**	**278**	0.913[b]
No	6 (42.86)	23 (30.67)		13 (36.11)	103 (37.05)	
Yes	8 (57.14)	52 (69.33)		23 (63.89)	175 (62.95)	
≥2 portions of fruits/vegetables a day	**14**	**75**	0.226[b]	**36**	**278**	0.788[b]
No	5 (35.71)	40 (53.33)		12 (33.33)	99 (35.61)	
Yes	9 (63.29)	35 (46.67)		24 (66.67)	179 (64.39)	
≥One glass of milk/yogurt a day	**14**	**74**	0.707[b]	**36**	**279**	0.549[b]
No	2 (14.29)	8 (10.81)		5 (13.89)	50 (17.92)	
Yes	12 (85.71)	66 (89.19)		31 (86.11)	229 (82.08)	
Eating three meals a day	**14**	**75**	0.221[b]	**36**	**278**	0.745[b]
No	6 (42.86)	20 (26.67)		14 (38.89)	116 (41.73)	
Yes	8 (57.14)	55 (73.33)		22 (61.11)	162 (58.27)	
Physical activity, *n*						
Median (25% q, 75% q)						
Walking	**14**	**73**		**36**	**278**	
MET-minutes/week	1287 (594, 1782)	693 (247.5, 1386)	0.371[d]	841.5 (363, 1386)	693 (247.5, 1584)	0.783[d]
Moderate	**14**	**76**		**37**	**286**	
MET-minutes/week	520 (0, 960)	480 (120, 1200)	0.590[d]	480 (0, 1200)	480 (80, 960)	0.917[d]
Vigorous	**14**	**76**		**37**	**286**	
MET-minutes/week	2160 (720, 2880)	2400 (0, 4560)	0.879[d]	480 (0, 2880)	680 (0, 2160)	0.471[d]
Smoking habit, *n* (%)	**14**	**76**	0.649[c]	**37**	**286**	0.072[c]
Non-smoker	0 (0.00)	3 (3.95)		1 (2.70)	1 (0.35)	
Current smoker	1 (7.14)	2 (2.63)		1 (2.70)	12 (4.20)	
Former smoker	2 (14.29)	9 (11.84)		5 (13.51)	16 (5.59)	
Infrequent smoker	11 (78.57)	62 (81.58)		30 (81.08)	257 (89.86)	
Sleep time, *n* (%)	**13**	**74**	0.061[c]	**37**	**280**	0.111[c]
<7 h	6 (46.15)	16 (21.62)		15 (40.54)	78 (27.86)	
≥7 h	7 (53.85)	58 (78.38)		22 (59.46)	202 (72.14)	

N number of students (N for a title question is in "bold" font)

[a] Any level of NES: mild, moderate and full

[b] Chi-squared test

[c] Fisher's exact test

[d] Wilcoxon rank-sum test

on sleep and health using an actigraphic measure for sleep duration and DXA for measuring body composition reported a negative association between sleep duration and fat mass [29]. Authors found that the absolute and relative fat mass and truncal fat mass were higher in subjects sleeping ≤300 min (short sleepers) when compared to their counterparts despite no significant differences in the BMI between the two groups. Moreover, authors noted that short sleepers seemed to consume more carbohydrate, despite consuming a similar number of calories [29].

Despite the popular notion that skipping breakfast and eating late at night may increase the risk of elevated BMI [54, 55], in the present study, there was no association between BMI and NES. This finding was also reported in previous studies [9, 18]. It is possible that physical activity and age may have played a role in maintaining BMI among our students as most of them reported engaging in moderate/vigorous activities and were relatively young. Also, it is possible that age moderates the relationship between night eating and BMI as weight gain may only occur after longer periods of night eating; thus, in younger adults such as students there was no or only little relationship between NES and BMI [13, 56–58]. Therefore, the students complying with symptoms consistent with the proposed diagnostic criteria for any level of NES could experience elevated BMI later in life. This observation mirrors that of

Runfola et al. who reported that students with NES were significantly more likely to have a history of underweight and a prior diagnosis of anorexia nervosa in spite of the fact that their current weight status did not differ from those students without the symptom [18].

As far as eating habits, in this study, there was no significant difference between students complying with symptoms consistent with the proposed diagnostic criteria for any level of NES and those without NES. Skipping daily breakfast and not consuming three meals a day were not significantly different among students complying with the symptoms of NES and without NES. However, findings on disturbed eating behaviors among college students with NES were reported in previous studies [14, 18, 59, 60]. O'Reardon et al. found that students with NES had a delay in their pattern of food intake as most of their food was consumed after their evening meal [59]. These observations are consistent with features of NES, which include morning loss of appetite and evening hyperphagia (consumption of at least 25% of total daily food intake in the evening and nighttime) [14, 16, 17]. However, it remains unclear whether the evening hyperphagia exhibited in those students complying with the symptoms of NES is a response to a lack of sleep or vice versa, and further longitudinal research among college students is needed. Also, in the current study, age, gender, race/ethnicity did not significantly differ between students with and without NES.

Overall, the results of the present study indicate that the percentage of students who reported symptoms consistent with the proposed diagnostic criteria for the full syndrome of NES in our sample is low. Also, results showed that students with any level of NES had shorter sleep time and poorer sleep quality compared to students without night eating. Also, results indicated that NES was not associated with BMI, eating habits, physical activity, or smoking status. However, it may take a number of years before NES leads to significant weight gain. This exploratory study is the first to examine the percentage of students complying with symptoms and behaviors consistent with the diagnostic criteria for NES in relation to with sleep patterns and lifestyle variables among Midwestern college students.

Limitations

One of the limitations is the cross-sectional design, which does not permit causal inferences. Another limitation is that the majority of the students were females. Having more male students may have allowed for better detection of gender difference in the proportion of students complying with symptoms consistent with the proposed diagnostic criteria for NES. However, previous studies on the prevalence of NES among college students did not report any significant difference between male and female students. Also, our study sample was limited to college students at Central Michigan University. Thus, our results may not reflect all university students. However, our results were in agreement with findings reported in previous studies on NES among college students. Another possible limitation is related to the voluntary nature of the student recruitment as students were self-selected. In this study, student participation was voluntary and not mandatory. This sampling procedure may introduce a "selection bias" regarding students' interest in filling out the survey as students with disordered eating pattern may not have chosen to participate in this study, leading to underestimation in the percentage of students complying with symptoms consistent with NES in our sample. Another possible limitation is due to the nature of university students in general regarding psychological distress, skipping breakfast, consuming high-energy foods late in the evening, and staying awake until late hours. These factors may be potential confounding variables; however, this study was exploratory in nature, and controlling for these possible potential confounding factors in future studies is advisable. Nevertheless, strengths of the present study include, anthropometric measurements for all students by one faculty professor and well-trained senior students using a standardized protocol and no self-reported weight and heights. Thus, the results of our study contribute to the literature on the prevalence of students complying with symptoms consistent with NES among college students and its associations with lifestyle variables. Our study would suggest early screens of students who may be at risk for NES so that appropriate intervention strategies can be developed early to reduce NES occurrence and its associated complications.

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Author contributions NY carried out questionnaire design, manuscript preparation, data collection and study coordination. HS, KS, LP, and CH contributed in data collection and data entry. AG provided the NEDQ and reviewed the final draft of the manuscript. CB, ZF, and MC performed all the statistical analysis. All authors read and approved the final manuscript.

Compliance with ethical standards

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Conflict of interest The authors declare that they have no competing interests.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants included in the study.

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