Prevalence of Night Eating in Obese and Nonobese Twins

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The aim of this study was to assess the prevalence of night eating (NE) and associated symptoms in a population-based sample of Swedish twins. A total of 21,741 individuals aged 20–47 years completed a questionnaire in 2005/2006. NE was defined as ≥25% of daily food intake after the evening meal and/or awakening at least once per week with eating episodes. The prevalence of NE was 4.6% in men and 3.4% in women. Among obese men and women, the prevalence was 8.4 and 7.5%, respectively. Men and women with NE had 3.4 and 3.6 times higher risk of binge eating compared to individuals without NE. The risk of sleep-related problems was 1.6–3.4 times higher in men and 2.5–3.3 times higher in women with NE compared to those without NE. This epidemiological study has estimated the prevalence of NE in a twin population. It revealed that NE is 2.5 and 2.8 times more common in obese men and women compared to normal weight men and women. Furthermore that NE is associated with binge eating and sleep-related problems.

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INTRODUCTION

Given the increasing prevalence of obesity worldwide (1), and the documented association between sleep-related problems and obesity (2–4), it is of considerable scientific interest to explore how symptoms of night eating (NE) relate to both of these public health problems. As early as 1955, Stunkard described the night-eating syndrome (NES) in a study of severely obese women (5). NES was initially defined as nocturnal hyperphagia, insomnia, and morning anorexia (i.e., loss of appetite). In the decades following this report, only a limited number of studies have been conducted to determine the prevalence and nature of NES. As described under Methods section, NE is a more broadly defined condition than NES, making it essential to distinguish between these conditions.

The use of varying diagnostic criteria applied to relatively small convenience or clinical samples has resulted in a wide range of prevalence estimates with low precision (6,7). Moreover, the highly select nature of study samples has limited the ability to assess accurately the relation between NE and associated symptoms such as obesity, binge eating, and sleep-related problems (8–14). Therefore, research on large and population-based samples is needed.

NES is not included in the current version of the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV), but provisional diagnostic criteria are available. The current conceptualization defines NES as present when >25% of daily caloric intake takes place after the evening meal and/or when nocturnal ingestions of food occur ≥3 times per week (15).

The causes for the suggested, disturbed circadian pattern of food intake in NES are not clear. The evening hyperphagia and NE may be related to total overeating and obesity (16). However, O'Reardon *et al.* studied the eating patterns and food intake in those with NE and controls and found that despite large differences in the timing of the eating between those with NE and controls, total energy intake did not differ (17). The causes for the delayed circadian pattern of food intake in NES are not clear; however, neuroendocrine differences between individuals with NES and controls seem to be consequences rather than causes of the altered pattern and timing of food intake (15).

With reference to the relation between binge eating and NES, Allison *et al.* studied three groups of individuals recruited by advertisements in Pennsylvania, USA: 177 participants with binge eating disorder (BED), 68 individuals with NES, and 45 overweight/obese comparison individuals without BED or NES (9). The BED group had more episodes of binge eating and episode days of binge eating than the NES group which reported having more episodes of binge eating and episode days of binge eating than the control group. Similarly overeating episodes were more frequent among the BED group than the NES and comparison groups, although

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the two later groups did not differ. Based on these and other findings the authors concluded that NES and BED are different entities (9). In a recent study from Australia, Colles *et al.* compared a NES only group, a binge eating only group and a comorbid NES and binge eating group (18). In the NES group, 40% reported binge eating and in the binge eating group, 37% also reported NES. The authors also compared these groups with respect to psychological distress and BMI. The comorbid NES/binge eating group and the binge eating only group showed similar patterns of psychological distress, while the NES only group revealed lower psychological distress than the comorbid NES/binge eating group. Mean BMI values were similar in the NES only group (40.2 kg/m^2), binge eating only group (43.7 kg/m^2), and the comorbid NES/binge eating group (43.7 kg/m^2) (18).

Exploring the relation between BMI and NE, previous studies have yielded inconsistent results (14,19–24). Several reports have shown positive associations between NES and BMI (20,21,25,26). In contrast, Striegel-Moore *et al.* (14) and also Rand *et al.* (23) found no association between NE and BMI in two different and large random samples of adults from the United States. In samples of 682 black and 659 white young women from the United States who participated in a follow-up study of risk factors for cardiovascular diseases, Striegel-Moore *et al.* found no association between NE and BMI (7). Based on analyses of National Health Nutrition Examination Survey-III data from the United States, Striegel-Moore *et al.* reported a weak inverse association between NE, defined as eating ≥25% after 7 PM, and BMI in adolescents and adults (24). However, analyses according to other definitions, e.g., eating 50% or more after 7 PM, revealed no associations.

In light of the inconsistencies in previous research and the dearth of population-based studies, the objectives of the current study were: (i) to determine the prevalence of NE in a large population of Swedish men and women; (ii) to assess the relation of NE to BMI, sleep-related problems, and binge eating.

METHODS AND PROCEDURES

In 2005, all twins in Sweden born between 1959 and 1985 (42,582 individuals aged 20–47 years) were invited to complete a web-based questionnaire (STAGE) conducted by the Swedish Twin Register at the Karolinska Institute, Stockholm. The questionnaire was extensive and included demographics, education and occupation, medical history, smoking, alcohol consumption, eating disorders, depression, sleep patterns, and other symptoms and disorders (27). Nonrespondents were followed-up by three mailed reminders. Thereafter nonrespondents were approached by telephone and invited to participate in a telephone interview. The final response rate was 59.6% (N = 25,378).

A total of 21,741 twins aged 20–47 years in 2005/2006 were eligible for participation in this study as described in detail below. We also analyzed a subset by excluding 7,242 individuals who answered "yes" to one or more of the following three questions: "Have you ever worked during night time?" (N = 5,773), "Are you currently on maternity/paternity leave?" (N = 795) and "Are you currently a student?" (N = 1,410). In this subset 14,499 individuals remained. The reasoning was that shift work or permanent night work, small children or the potentially more irregular circadian life habits of students might to some extent increase the probability of being awake during the night for reasons irrelevant for NE.

Questions about NE, binge eating, BMI, and sleep-related problems

We applied both a broad and a narrow definition of NE. Broad NE was defined as awakenings with food intake during the night at least once a week and/or ≥25% of daily food intake after the evening meal. Narrow NE was defined as awakenings with food intake at least once a week and/or ≥50% of daily food intake after the evening meal. Intake of water or other beverages only did not count as food intake. Our definitions and categories of NE were based on the following two questions: (i) "How often do you get up at night to eat?" with response alternatives never, once or twice, weekly, nightly, and don't know/don't wish to answer; and (ii) "What proportion of your daily food intake takes place after the evening meal?" with response alternatives 0, 1–24, 25–49, 50–74, 75–100, and don't know/don't wish to answer.

Men and women with present or past symptoms of binge eating were identified through the following two questions: "Have you ever had binges when you ate what most people would regard as an unusually large amount of food in a short period of time?" with response alternatives yes, no, and don't know/refuse; and "When you were having eating binges, did you feel that your eating was out of control?" with response alternatives not at all, slightly, moderately, very much, extremely, and don't know/don't wish to answer. Those who answered "yes" to the first question and "very much" or "extremely" to the second question were defined as binge eaters.

BMI (kg)/height (m^2) was calculated from self-reported height and weight and participants were categorized as normal weight (BMI 18.5–24.9 kg/m^2), overweight (BMI 25.0–29.9 kg/m^2), or obese (BMI ≥30 kg/m^2) according to the World Health Organization criteria (28).

Participants with missing data on both NE questions were excluded (n = 1,928) as were individuals who did not endorse one NE question and had missing data on the other (n = 605). As described above the final main study population comprised 21,741 individuals with complete data on NE symptoms and BMI.

Nonresponse to questions about sleep-related problems, located in an "elective" section of the questionnaire, was higher and results requiring access to this information were thus calculated for a subsample (n = 6,208) as described below.

Information on sleep-related problems was obtained through the following questions: "Have you had difficulty falling asleep (during the past 3 months)?", "Have you had feelings of not having had enough sleep on awakening (during the last 6 months)?", "Have you had disturbed or restless sleep (during the last 6 months)?" For each question, those who answered "usually" or "always" were classified as having sleep problems and those who answered "sometimes," "seldom," or "never" as not having a sleeping problem.

Statistical analysis and research ethics

Statistical analyses were conducted in STATA version 9.2 (StataCorp, College Station, TX). All prevalence estimates were age-standardized separately for men and women and the corresponding confidence intervals were adjusted for within-pair correlation using the cluster option. Odds ratios (OR) were estimated by logistic and linear regression models using generalized estimating equations to account for within twin-pair correlations. All regression models were age-adjusted. Wilcoxon's nonparametric rank sum test was used to test differences in BMI distributions between groups with and without NE. The Ethics Committee at the Karolinska Institute, Stockholm, Sweden, has approved this study.

RESULTS

Basic demographic and anthropometric data of participants are shown in **Table 1**. In men, 86.2% had never experienced awakenings with food intake during the night, 11.7% had experienced it once or twice, 1.9% had weekly, and 0.2% daily awakenings with food intake. In women, 89.6% had

never experienced awakenings with food intake, 9.2% had experienced it once or twice, 1.1% reported weekly, and 0.1% daily awakenings with food intake. Table 2 shows proportions of daily food intake after the evening meal among men and women.

Table 1 Basic characteristics of study participants

	Men (*N* = 9,743)		Women (*N* = 11,998)	
	Mean (s.d.)		Mean (s.d.)	
Age (years)	34.7 (7.7)		34.5 (7.6)	
Height (cm)	180.9 (6.6)		167.1 (6.1)	
Weight (kg)	80.7 (12.0)		64.5 (11.4)	
BMI (kg/m^2)	24.6 (3.2)		23.1 (3.9)	
	N	Prevalence (%)	*N*	Prevalence (%)
Underweight	86	0.9	462	3.9
Normal weight	5,870	60.2	8,879	74.0
Overweight	3,232	33.2	2,004	16.7
Obese	555	5.7	653	5.4

Table 2 Proportion of the daily food intake consumed after the evening meal among men and women

Proportion of the daily food intake after the evening meal (%)	Men (*N* = 9,743), %	Women (*N* = 11,998), %
0	45.9	49.2
1–24	51.5	48.6
25–49	2.2	1.7
50–74	0.3	0.4
75–100	0.1	0.1

The prevalence of broadly defined NE was 4.6% in men and 3.4% in women (Table 3). The age-standardized risk ratio among men compared to women was 1.40 ($P < 0.001$). The highest prevalence of broad NE was observed in obese men, 8.4%, and women, 7.5%. The OR for broad NE was 2.47 in obese men and 2.80 in obese women compared with their normal weight same-sex counterparts. Among men, the prevalence of broad NE was 4.3 and 5.1% in the age categories 20–34 years and 35–47 years ($P = 0.047$), respectively. The corresponding figures among women were 3.2 and 3.6% ($P = 0.267$). The prevalence of narrowly defined NE was 2.5% in men and 1.7% in women in the main study population ($N = 21,741$) and 4.6% in obese men and 4.5% in obese women, respectively (Table 3). The age-standardized risk ratio among men compared with women was 1.46 ($P < 0.001$).

The mean BMI was higher in men with broad NE than in men without NE as seen in Table 4. The difference between the means was 0.6 kg/m^2 (95% CI: 0.3; 0.9). The mean BMI among women with broad NE was also higher than among those without NE. The difference between the means was 0.9 kg/m^2 (95% CI: 0.5; 1.3). Among men the prevalence of overweight and obesity was higher among those with broad NE than without NE. The same pattern was seen among women. The BMI distributions differed significantly between those with and without broad NE, both among men ($P < 0.001$) and women ($P < 0.001$) (Table 4). The risk of obesity was about twice as high in men (OR = 1.98, 95% CI: 1.46; 2.69) and women (OR = 2.36, 95% CI: 1.73; 3.22) with broad NE compared with same-sexed individuals without NE.

The mean BMI values were also higher in men and women with narrow NE than in those without these symptoms (Table 5). The mean differences were 0.7 kg/m^2 (95% CI: 0.3; 1.2) for men and 1.2 kg/m^2 (95% CI: 0.6; 1.9) for women. The risk for obesity was increased in men (OR = 2.03, 95% CI:

Table 3 Prevalence and OR of broad and narrow night eating in underweight, normal weight, overweight, and obese men and women

	Men (*N* = 9,743)			Women (*N* = 11,998)		
	Number of cases	Prevalence (%) of night eating (95% CI)	OR (95% CI)	Number of cases	Prevalence (%) of night eating (95% CI)	OR (95% CI)
Broad night eating						
All	449	4.6 (4.2; 5.0)		402	3.4 (3.0; 3.7)	
Underweight	5	3.2 (0.5; 6.0)	1.33 (0.52; 3.39)	21	3.8 (2.0; 5.7)	1.53 (0.96; 2.45)
Normal weight	232	3.8 (3.3; 4.3)	1	252	2.8 (2.5; 3.2)	1
Overweight	163	5.2 (4.4; 6.0)	1.38 (1.12; 1.71)	81	4.2 (3.3; 5.1)	1.51 (1.17; 1.96)
Obese	49	8.4 (6.1; 10.7)	2.47 (1.80; 3.41)	48	7.5 (5.4; 9.5)	2.80 (2.03; 3.86)
Narrow night eating						
All	239	2.5 (2.1; 2.8)		207	1.7 (1.5; 2.0)	
Underweight	2	1.3 (–0.5; 3.1)	1.03 (0.21; 5.00)	11	2.1 (0.7; 3.6)	1.61 (0.83; 3.12)
Normal weight	120	2.0 (1.6; 2.4)	1	125	1.4 (1.2; 1.6)	1
Overweight	89	2.7 (2.1; 3.3)	1.36 (1.03; 1.80)	41	2.1 (1.5; 2.8)	1.53 (1.07; 2.19)
Obese	28	4.6 (2.9; 6.2)	2.50 (1.65; 3.77)	30	4.5 (2.9; 6.2)	3.47 (2.29; 5.24)

CI, confidence interval; OR, odds ratio.

1.37; 3.00) and in women (OR = 2.87, 95% CI: 1.92; 4.27) with narrow NE compared with their counterparts without NE. Furthermore, the Wilcoxon's rank sum test showed that the BMI distributions in individuals with and without narrow NE were significantly different ($P < 0.001$ in both men and women).

Of all men and women in the main study population, 0.3% (95% CI: 0.2; 0.4) and 2.7% (95% CI: 2.4; 3.0) reported past or present symptoms of binge eating. The prevalence of binge eating in women with broad NE was 8.9% and in women with narrow NE 11.8%. In men, the prevalence of binge eating was 0.9% in those with broad NE and 1.7% in those with narrow NE. The risk of binge eating was elevated both in men with broad NE (OR = 3.44, 95% CI: 1.17; 10.12) and narrow NE (OR = 6.76, 95% CI: 2.34; 19.54) compared to men without NE.

The risk of binge eating was also higher in women with broad NE (OR = 3.56 with 95% CI: 2.44; 5.18) and narrow NE (OR = 4.81 with 95% CI: 3.10; 7.48) compared to women without NE.

As mentioned above, the nonresponse rate to questions about sleep-related problems were higher compared to the questions on NE and anthropometry because sleep-related problems were presented in an optional part of the questionnaire. Only about 29% of all study participants in the cohort answered these questions. Amongst responders, men and women with NE had higher frequencies of the three different aspects of sleep-related problems than those without NE (Table 6). The risk of having difficulty falling asleep was 3–4 times higher in men and women with broad and narrow NE compared with individuals without NE. As shown in Table 6, risks were also elevated (about 1.5–3 times) for feeling that they needed more sleep on awakening and for disturbed or restless sleep (about 2.5–3.5 times).

Table 4 Mean BMI and prevalence of normal weight, overweight, and obesity among men and women with and without broad night eating

	Men		Women	
	Not broad night eating (*N* = 9,294)	Broad night eating (*N* = 449)	Not broad night eating (*N* = 11,596)	Broad night eating (*N* = 402)
Mean BMI	24.6	25.2	23.1	24.0
Prevalence (%)				
Underweight	0.9	1.0	3.8	4.9
Normal weight	60.7	50.3	74.4	62.4
Overweight	33.0	37.2	16.6	20.5
Obese	5.4	11.5	5.2	12.2

Table 5 Mean BMI and prevalence of normal weight, overweight, and obesity among men and women with and without narrow night eating

	Men		Women	
	Not narrow night eating (*N* = 9,504)	Narrow night eating (*N* = 239)	Not narrow night eating (*N* = 11,791)	Narrow night eating (*N* = 207)
Mean BMI	24.6	25.4	23.1	24.3
Prevalence (%)				
Underweight	0.9	0.9	3.8	5.0
Normal weight	60.5	50.7	74.2	60.0
Overweight	33.1	36.9	16.6	20.0
Obese	5.5	11.6	5.3	14.9

Exploration of a subset of study participants

As reported above, our main study population included subsets of students, individuals who were currently on maternity leave with small children, and individuals who answered affirmative to the question "have you ever worked during night time?" Because these individuals (N = 7,242 individuals) might have had irregular circadian life habits for reasons unrelated to NE, we repeated our analyses on the 14,449 remaining individuals. In this subset prevalence of NE was 4.3% in men and 3.3% in women. Among obese men and women, the prevalence was 7.2 and 6.4%, respectively. These results are almost identical to the findings from the main study population and as were all other results (data not shown).

Table 6 Prevalence of sleeping problems and OR for sleeping problems among men and women with and without night eating according to the broad and the narrow definition

	Men (*N* = 2,588)					Women (*N* = 3,620)				
		Broad night eating		Narrow night eating			Broad night eating		Narrow night eating	
	N	No	Yes	No	Yes	*N*	No	Yes	No	Yes
Difficulties falling asleep	206	7.3	21.6	7.5	26.2	425	11.1	29.6	11.3	31.6
OR (95% CI)		3.41 (2.14; 5.41)		3.75 (2.04, 6.87)			3.29 (2.21; 4.91)		3.42 (2.06; 5.66)	
Not enough sleep on awakening	589	22.3	31.2	22.5	33.8	1,046	28.2	49.8	28.4	54.5
OR (95% CI)		1.56 (1.05; 2.32)		1.67 (1.01, 2.77)			2.51 (1.74; 3.62)		3.14 (1.97; 5.01)	
Disturbed or restless sleep	234	8.5	20.0	8.6	23.0	603	16.2	33.7	16.3	38.6
OR (95% CI)		2.76 (1.72; 4.44)		3.41 (1.95, 5.96)			2.65 (1.80; 3.89)		3.19 (1.97; 5.16)	

CI, confidence interval; OR, odds ratio.

DISCUSSION

Our detailed exploration of NE in a large population-based Swedish twin sample yielded several intriguing findings. In contrast to previous investigations (9,18,19), this large epidemiological twin study suggests that NE is more common in men than in women. We found a rather weak and positive association between age and NE in men as well as in women. We observed a strong association between obesity and NE with NE being ~2.5 times more common in obese than in normal weight individuals. This finding replicates several previous investigations (12,18,20), but is inconsistent with other studies (7,11,13,14,23–25,29). We also revealed positive associations between NE and binge eating, with binge eating episodes being 3.5 times more common in both men and women with broadly defined NE compared to subjects of the same gender without symptoms of NE. The observed risk for binge eating was even higher (5–6 times) in men and women with narrowly defined NE. Finally, our hypothesized association between NE and sleep-related problems was also confirmed with those with NE being more likely to report different sleep-related problems with the strongest association observed between difficulties falling asleep in men and women with narrow NE relative to those without NE. Although perhaps unsurprising that a symptom cluster defined by nocturnal eating would be associated with disrupted sleep, our results indicate that the sleep problems faced by individuals with NE surpass those awakenings with food ingestion and include insomnia and other aspects of disturbed sleep. Despite the sleep disturbance, studies have shown the same sleep onset and offset of those with NE and control subjects (16). Kept together, these findings suggest that NE is associated with a cluster of dysregulated behaviors in the domains of weight, appetite, and sleep.

Marshall *et al.* suggested that NES may be a risk factor for obesity based on two findings, namely the age difference and difference in duration of NE between obese and nonobese persons with NE (22). This author found that in 52% of obese persons with NE onset of NE preceded onset of obesity. By contrast, a study by de Zwaan *et al.* found that 60% of obese participants had been overweight before onset of NES (30). However, in a true longitudinal study of NE and weight change in middle-aged men and women Andersen *et al.* found that getting up at night to eat contributed to further weight gain in already obese women (19). As already stated, we found strong statistical associations between obesity and NE and our results provide support for the suggestion that the same association observed in many smaller clinical studies is not merely a consequence of selection bias. In women we observed a tendency to a J-shaped association of BMI with risk of broadly as well as narrowly defined NE, but the association was not statistically significant for the underweight group. However, due to the cross-sectional design of our study we are not able to contribute to the important question about the direction of potential causal relation between obesity and NE.

Our results showing increased risk for binge eating in both men and women with NE compared to individuals without NE are in accordance with several studies based on clinical samples (8,12,13,18), although Allison *et al.* reported a lesser degree of overlap between these conditions in persons seeking bariatric surgery (10). It should kept in mind that available data did not allow us to apply full DSM-IV-TR criteria, i.e., binge eating for at least 2 days during the past 6 months, with loss of control, accompanied by distress. In addition, different definitions of study samples, NE and binge eating have been applied by various authors making comparisons less straightforward.

The results of this study must be considered within the bounds of its strengths and limitations. A considerable strength is that the study was based on questions answered by a large population-based sample of twins from throughout the country of Sweden not relying on clinical case series, which inevitably introduces selection bias in estimates. Previous studies have not presented confidence intervals for their estimates making it impossible to appraise the scope of random variability. Our confidence intervals revealed good to excellent precision reflecting the large sample size of the study.

The primary limitation to be considered is the definition of NE. As noted previously, no established DSM-IV criteria for the symptoms of NE or NES exist and only provisional criteria have been established. Lack of consistent definitions complicates the comparisons between studies. As is true in any large-scale population-based survey, concessions have to be made to balance quality and depth of information with participant burden and fatigue. Given the number of available questions about NE, we were unable to assess the prevalence of NES according to the provisional criteria, i.e., 25% of daily food intake after the evening meal and/or nocturnal ingestions of food ≥3 times per week (9). We were able to assess broad and narrow NE as defined above and caution the reader to distinguish between the full syndrome (NES) and symptoms of NE reported here. On one hand this poses a limitation; however, it also poses advantages. Although diagnostic-level findings are meaningful, it is also important to assess eating disorders at the symptom level (31). Understanding disordered eating at the symptom level may facilitate the refinement of phenotypes and may clarify sources of variation for specific components of eating disorder symptomatology that will be relevant to refining the diagnostic syndrome of NES (32).

Another limitation is how NE was assessed. In the first of the two NE questions we ask the participants how often they get up to eat. If this question was interpreted literally, NE may have been underestimated if individuals had woken up for other reasons (e.g., to use the bathroom) and then decided to eat after they were already awake. Furthermore the study is limited by the self-reported nature of our data as many obese individuals underreport their weight (33). The rather high overall nonresponse rate (40%) and the higher nonresponse rate on the optional sleep section (71%) may have resulted in some selection bias in the study group, expected to be leaner and with less deviant eating patterns and sleep-related problems than nonparticipants. Finally, our main study population included subsets of students, individuals who were currently on maternity leave with small children and individuals who had worked during nighttime. When we

excluded groups and repeated our analyses on the remaining study subjects we got essentially the same results as for the full study population, indicating that potential irregular circadian habits in these groups may not have introduced any important bias in our results.

We expect the net effect to be some underestimation of NE and associated conditions. Our study was limited to twins and it is sometimes argued that twins may differ from singletons with respect to risk for various diseases. Although this may be true for some conditions closely related to exposures in fetal life and growth in infancy, for most other diseases and conditions, previous research has failed to verify differences in occurrence between singletons and multiples (34). We are not aware of any research indicating that the prevalence of eating disorders, NES or other dysfunctional eating patterns differs between singletons and twins.

In spite of the limitations discussed above, our results highlight important aspects of the phenomenon of NE and associated symptoms. Most striking is the higher prevalence of NE in men than women and substantially elevated risk for obesity in both genders. Although this investigation cannot answer whether it is most fruitful to consider NE as an eating disorder, a sleep-related disorder or both, our results clearly show that NE is positively associated with overweight, obesity, binge eating, and sleep-related problems. The genetically informative nature of this twin sample will allow us to explore the extent to which genetic and environmental factors contribute to the etiology of NE. Such studies may unravel the overlapping or distinct genetic factors influencing NE, binge eating, and associated symptoms.

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DISCLOSURE

The authors declared no conflict of interest.

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