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Original Article

Habitual sleep patterns and the distribution of body mass index: cross-sectional findings among Swedish men and women

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ABSTRACT

Objective: To compare distributions of body mass index (BMI) between individuals with different habitual sleep patterns.
Methods: We performed cross-sectional analyses of 40,197 Swedish adults (64% women), who reported sleep duration and quality, weight, height, and possible confounding factors in 1997. Using quantile regression, we estimated associations between sleep patterns and selected percentiles of the distribution of BMI.
Results: While the medians were similar, larger adjusted values of BMI were estimated in the upper part of the distribution among men and women with short sleep (≤5 h) compared with medium-length sleep (6–8 h). For example, in men, the 90th percentile of BMI was 0.80 kg/m^2 (95% confidence interval: 0.17–1.43 kg/m^2) higher among short sleepers. In women, long sleepers (≥9 h) also showed larger values in the upper part of the BMI distribution; the 90th percentile was 1.23 kg/m^2 (0.42–2.04 kg/m^2) higher than in medium-length sleepers. In male long sleepers, smaller values were estimated in the lower part of the BMI distribution; the 10th percentile was 0.84 kg/m^2 lower (0.35–1.32 kg/m^2) than in medium-length sleepers. The 90th percentile of BMI in women with poor-quality compared with good-quality sleep was larger by 0.82 kg/m^2 (0.47–1.16 kg/m^2); the 10th percentile was smaller by 0.17 kg/m^2 (0.02–0.32 kg/m^2).
Conclusions: Short, long or poor-quality sleepers showed larger, or smaller, values at the tails of the BMI distribution, but similar medians. Hence, unfavorable sleep patterns and BMI were associated only in a subset of this study population.

1. Introduction

Between 1980 and 2008, worldwide obesity prevalence nearly doubled from 5% to 10% in men and from 8% to 14% in women [1]. Alongside the obesity epidemic, sleep loss also has become more prevalent, as reflected in the increased percentage of people sleeping ≤6 h [2]. Hence, research into the possible link between sleep loss and obesity is mounting.

Several cross-sectional studies have reported an association between self-reported short sleep duration and higher body mass index (BMI, weight in kilograms divided by height in meters squared) or increased obesity risk [3,4]. Whether sleep duration is related to weight gain, however, is not clear. Prospective studies, from which inferences on the direction of possible causality may be drawn, have yielded mixed results [5]. The literature on sleep quality or sleep disturbances in relation to body weight is less extensive, but studies have demonstrated that worse self-reported sleep quality or sleep disturbances are positively linked to obesity and weight gain [6–8].

Most of the previous studies analyzed the association between sleep and body weight measures using linear or logistic regression models to estimate mean BMI or the probability of obesity, respectively. Associations of sleep patterns with other parts of the BMI distribution have rarely been explored. Quantile regression, which allows for evaluation of predictors across the entire distribution of an outcome variable, such as BMI, has only been used in two studies on the relationship between sleep and body weight in

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adult populations. Both studies indicated that the distribution of BMI differed according to level of habitual sleep duration, so that shorter sleep was associated with higher values of BMI at the upper part of the distribution, particularly in men [9,10]. Better sleep quality was associated with lower values of BMI at the lower part of the BMI distribution in women only [10]. Limited evidence thus suggests that the association with short or poor sleep varies across the distribution of BMI. Similar studies have not been conducted in European populations.

Analyses taking account of the entire distribution of BMI have the potential of providing a more comprehensive picture of the nature of the association between sleep and body weight. They also offer an opportunity to identify subgroups of the population that could be especially susceptible to the putative effects of poor sleep habits. Those subgroups would likely not be identified by approaches analyzing the influence of sleep habits on mean BMI [11]. Furthermore, the vast majority of studies within this research area have focused on sleep duration, typically using one sleep question. There are considerably fewer data on sleep quality and other potentially relevant dimensions of sleep in relation to body weight.

Our aim was to compare the entire distributions of BMI between people with different habitual sleep patterns using quantile regression as analytical approach in a large sample of Swedish men and women. Self-reported sleep assessments were wide-ranging and included sleep duration separately for weekdays and weekends, sleep quality, restorative power of sleep, and daytime sleepiness.

2. Methods

2.1. Study population and setting

We used data from the National March Cohort, established in September 10–14, 1997 as a cohort of volunteers who took part in the National March, a nationwide promotional and fundraising event for the Swedish Cancer Society [12]. Participants in this event, which included a voluntary walk for cancer, were invited to fill out a 36-page questionnaire on lifestyle and medical history. Walking the walk was not a prerequisite for study participation. The Regional Ethics Review Board at the Karolinska Institutet approved the study, and all study participants provided informed consent. The National March took place in 3600 sites throughout the country, and the total number of participants was not assessed. From the 43,880 individuals who completed the questionnaire, we excluded those with inconsistent data ($n = 4$), missing data on age ($n = 13$), age <18 years ($n = 1741$), and missing data on height or weight ($n = 1925$). The final sample included 40,197 participants (14,407 men; 25,790 women).

2.2. Data collection

2.2.1. Body mass index

BMI (kg/m^2) was the outcome variable of interest. Participants self-reported their weight and height in the questionnaire.

2.2.2. Sleep measures

We considered sleep duration on weekdays and weekends, sleep quality, restorative feeling of sleep, and daytime sleepiness as predictor variables. They were assessed using the Karolinska Sleep Questionnaire [13,14], which constituted a part of the study questionnaire. Participants were asked the following: "How many hours do you usually sleep per day on workdays or weekdays?" and "How many hours do you usually sleep per day on off days?" on a six-level scale (<5, 5, 6, 7, 8, or ≥9 h). In our analysis, we categorized sleep duration as ≤5, 6–8 (reference category), and ≥9 h to reflect short, medium-length, and long sleep, respectively. Sleep quality, restorative power of sleep, and daytime sleepiness were assessed using questions on frequency (never, rarely, sometimes, mostly, or always) of relevant symptoms. Sleep quality was a combination of four insomnia-related items: "Have you . . ." (1) "had difficulty falling asleep," (2) "woken up during the night with difficulty going back to sleep," (3) "had restless sleep," and (4) "woken up too early?" Quality was defined as "poor" if participants responded mostly or always to at least one item, "moderate" if they responded sometimes to all items, and otherwise as "good" (reference category). Restorative power of sleep was a combination of three items: "Have you . . ." (1) "had difficulty waking up," (2) "woken up feeling unrested," and (3) "woken up fatigued?" The variable was defined as "poor (nonrestorative)," "moderate," and "good" analogously to sleep quality. Daytime sleepiness could be a consequence of having too short, poor-quality, or poorly restorative sleep. It was assessed with a single item: "Have you been sleepy during the day?" Sleepiness was defined as "yes" if participants responded mostly or always; otherwise as "no". Finally, snoring ("Have you snored heavily?") was defined as "frequent" if participants responded sometimes, mostly or always and "infrequent" if the response was never or rarely. Participants who did not know whether they snored were excluded from analysis.

2.2.3. Other characteristics

Information on age, highest level of education attained (7–9, 10–12, >12 years), level of daily physical exercise (low/moderate/high), smoking status (never/former/current), frequency of alcohol consumption (never, ≤3 times per month, 1–4 times per week, ≥5 times per week), and work schedule (daytime/shift including nights/other/no work) was also obtained from the study questionnaire.

2.3. Data analysis

The distribution of all characteristics by sex and sleep duration on weekdays was examined. Numerical variables were summarized by their median and interquartile range and categorical variables by their frequencies. Quantile regression was used to explore the association of each sleep variable with the 5th, 10th, 25th, 50th, 75th, 90th, and 95th percentiles of BMI. Each 95% confidence interval (CI) was estimated with 500 bootstrap samples. Men and women were analyzed separately because of substantial differences between sexes in the association of sleep duration on weekdays with the considered percentiles of BMI. Age, education, physical exercise, smoking, alcohol consumption, and work schedule were added as covariates. In a secondary analysis, we explored potential effect measure modification on the additive scale between the sleep variables and age or physical activity by visual inspection of stratified distributions. Age and physical activity were strong predictors of BMI, but did not modify the association between the sleep variables and BMI. The relation between sleep duration on weekdays and BMI stratified by sleep quality was also analyzed; individuals with "poor" or "moderate" quality were merged into one category. Finally, the sample was stratified by levels of heavy snoring to examine potential effect measure modification by sleep apnea/snoring, as previously reported [15]. For this analysis, we focused on the upper tail of the BMI distribution, where the potential modifying effect by snoring could be expected to be most pronounced and clinically relevant. We also used multinomial logistic regression to estimate the probability of being in any BMI class (normal range, 18.5–24.99; overweight, 25–29.99; and obese; ≥30 kg/m^2 [16]) given the covariates.

Missing information on the predictor variables affected 5.4% of the initial sample for sleep duration on weekdays; 7.5% for sleep duration on weekends; 0.5% for sleep quality; 0.9% for restorative power of sleep; and 1.1% for daytime sleepiness. For the covariates, the percentage of missing values was <2.0% for education, physical exercise, alcohol consumption, and snoring; 8.0% lacked information on smoking and 8.9% on work schedule. In the