Both Weight at Age 20 and Weight Gain Have an Impact on Sleep Disturbances Later in Life: Results of the EpiHealth Study FREE

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Sleep, Volume 41, Issue 1, January 2018, zsx176, https://doi.org/10.1093/sleep/zsx176

Published: 19 January 2018

Abstract

Study Objectives

Obesity is often associated with impaired sleep, whereas the impact of body mass index (BMI) at younger age and previous weight gain on sleep problems remains unknown.

Methods

The present study utilized data from the Swedish EpiHealth cohort study. A total of 15845 participants (45–75 years) filled out an internet-based questionnaire. BMI was calculated from both measured data at study time and self-reported data at age 20 from the questionnaire.

Results

Sleep-related symptoms were most common among obese individuals (BMI > 30 kg/m^2). An association between weight gain and sleep problems was found and those with a low BMI at age 20 were most vulnerable to weight gain when it came to risk of sleep problems. Among those who were underweight (BMI < 18.5 kg/m^2) at age 20, weight gain (kg/year) was associated with difficulties initiating sleep with an adjusted OR of 2.64 (95% CI: 1.51–4.62) after adjusting for age, sex, smoking, alcohol consumption, physical activity, education, and civil status. The corresponding adjusted OR's among those who had been normal weight (BMI 18.5–24.99) and overweight (BMI 25–29.99 kg/m^2) at age 20 were 1.89 (1.47–2.45) and 1.02 (0.48–2.13), respectively. Also difficulties maintaining sleep and snoring were most strongly related to weight gain among those who were underweight at age 20 with decreasing odds with increasing BMI at that age.

Conclusions

Sleep problems are related to weight gain and obesity. The impact of weight is most pronounced among those who had a low BMI when young.

epidemiology, insomnia, obesity, aging, weight gain, EpiHealth study, body mass index (BMI), Epworth Sleepiness Scale (ESS), sleep problems, snoring

Statement of Significance

This study provides novel evidence that sleeping problems in older adults are associated with weight gain and body weight. To the best of

authors' knowledge, this is the first study of the association between sleeping problems and being underweight in young adulthood. This study presents areas for future research that may improve health outcomes for this population.

INTRODUCTION

Sleep disturbances have a profound negative effect on quality of life.[1] In addition, several studies have identified sleep problems, including difficulties initiating sleep (DIS) and difficulties maintaining sleep (DMS), as independent risk factors for negative health outcomes such as diabetes, myocardial infarction, dementia, and mortality.[2] Moreover, sleep-disordered breathing, characterized by frequent snoring and daytime sleepiness, is closely related to cardiovascular disease.[3] Identifying factors that can influence the prevalence of sleep disturbances are therefore important to public health.

A deterioration in sleep quality has been shown to be more common among middle-aged and elderly subjects.[4–6] Studies have estimated that up to 40%–50% of adults over the age of 60 report disturbed sleep.[6] There are many studies reporting that risk factors such as female gender, smoking, and the consumption of alcohol have an impact on sleep.[7–9] Studies examining the relationship between sleep and obesity, therefore, need to control adequately for potential confounding variables.[10]

Over the past decades, the rising prevalence of overweight and obesity has become a major public health challenge across the world.[11] A recent population-based study involving more than 3400 participants from eight European centers (EMAS study) showed that about half of the participants were overweight or obese, with an even higher prevalence in Eastern transitional countries (Poland, Hungary, and Estonia).[12] Globally, the proportion of adults with a body mass index (BMI) of ≥25 kg/m^2 increased from 29% in 1980 to 37% in 2013 for men and from 30% to 38% for women, respectively.[11] Weight gain and obesity occur as a result of an imbalance between energy intake and energy expenditure, and sleep has been identified as an underlying cause for alterations in energy balance.[13,14] Additionally, a large number of studies have, for example, shown that sleep duration is associated with the development of obesity or being overweight and/or experiencing weight gain over time.[15–19] However, measuring only sleep duration as a single measurement of an individual's overall sleep quality may be insufficient, since sleep quality involves both quantitative (e.g., sleep duration) and qualitative aspects, such as sleep satisfaction and sleep disturbances, that are important to physical and mental health.[10,20] Furthermore, both weight gain and obesity seem to be important risk factors for sleep problems among middle-aged and elderly,[21,22] but whether this association is influenced by weight and BMI in young adulthood is unknown.

With this in mind, and considering the impact of sleep disturbance can have on health, the present investigation aimed to study whether higher BMI, when comparing BMI at study time with the past (at age 20), as well as a greater weight gain, was associated with a higher prevalence of sleep disturbances in a middle-aged and old population when taking account of other lifestyle variables.

MATERIAL AND METHODS

Cohort Description

The present study utilized data from the Swedish EpiHealth cohort study (www.epihealth.se).[23] The EpiHealth study started in 2011 and the primary objective was to study how interactions between lifestyle factors and genotypes contribute to the development of common disorders in humans, such as cardiovascular and respiratory diseases. To realize this aim, participants derived from the population and aged between 45 and 75 years filled out an internet-based questionnaire, as well as visiting one of the two Swedish test centers (located in Malmö and Uppsala, Sweden). The initial sample size was 19135 participants. In the present study, the participants who did not answer the questions about the weight and height at age 20 were excluded. A total of 15845 participants were, therefore, considered eligible for the present analysis. The study was approved by the Ethics Committee at Uppsala University (Dnr 2010/402) and all the participants gave their written informed consent to participate.

Sleep Problems

The participants were asked to grade the frequency of their sleep problems including DIS, DMS, early morning awakening (EMA), and loud snoring on a four-grade scale. The response options were "never or rarely," "1 to 3 times/month," "1 to 3 times/week," and "at least 4 times/week." If the participants answered "at least 4 times/week," they were considered positive for the respective sleep problems.[24] Daytime sleepiness was assessed by the Epworth Sleepiness Scale (ESS), which is an eight-item assessment of somnolence, with possible scores from 0 to 24. A score of over 10 is considered to be an indication of having daytime sleepiness.[25]

Body Mass Index

Weight and height were measured when participants visited one of the two Swedish test centers. The BMI was calculated using the body weight in kilograms and the height in meters squared (kg/m^2). The data on BMI at study time were calculated using data from the physical measurements at the test center, whereas the BMI at age 20 (BMI_{20}) was calculated using the self-reported data from the questionnaire. Based on BMI results, the participants were categorized into underweight (BMI < 18.5 kg/m^2), normal weight (BMI = 18.5–24.99 kg/m^2), overweight (BMI = 25–29.99 kg/m^2), and obese (BMI ≥ 30 kg/m^2). Moreover, the mean weight change per year (kg/year) was calculated as follows: (weight at study time − weight at age twenty)/(age at study time − 20).

Other Lifestyle Factors

The participants' educational status, physical activity during leisure time, frequency of alcohol consumption, civil status (married vs. not married), and smoking habits (nonsmokers vs. former smokers vs. current smokers at the time of the survey) were assessed using the internet-based questionnaire. The participants' educational status was defined as follows: primary and elementary school (up to 9 years of formal schooling) vs. secondary high school (up to 12 years of formal schooling) vs. university. The participants reported their level of physical activity during leisure time on a four-point scale. In the statistical analysis, the level of physical activity during leisure time was categorized into three groups. A low level of physical activity was defined as score 1: spending most time watching television, reading, and being sedentary for most of their leisure time. A medium level was defined as score 2: some physical activity, such as walking and cycling, at least 1 to 2 hours a week. A high physical activity level was defined as scores 3: including more strenuous exercise at least 3 hours per week.[26] Alcohol consumption frequency during the last 12 months was categorized as "never/seldom," "less than once per week," "2–3 times a week," and "4 times a week or more often," yielding a four-level ordinal variable.

Statistical Analyses

The differences between groups were compared with the χ^2 test for categorical variables and analysis of variance (ANOVA) for continuous variables. Multiple logistic regression analysis was used to examine the statistical independence of the suggested risk factors for developing sleep disorders. Separate models were used for each exposure of interest. Due to high number of missing data on smoking (n = 3586), a category of "unknown smoking status" was added to all models including the smoking variable but the results for this category are not presented in the tables. The results are presented as odds ratios (OR) and 95% confidence intervals (95% CI). Interaction analysis was performed using two-degree of freedom likelihood ratio test to examine whether interaction existed between the degree of weight gain and sex and also between weight gain and weight group at age 20. Statistical analyses were performed using Stata 12.1 (Stata Corp, College Station, TX, USA). A p-value of <.05 was considered statistically significant.

RESULTS

Population Data

A total of 15845 participants (6889 men and 8956 women) were included in this study. Their mean age was 60 years (range: 45–75 years). The characteristics of the population are shown in Table 1. At the time of the survey, both normal weight and overweight groups comprised each more than 40% of the participants, whereas 16% were obese and less than 1% were underweight. In contrast, at age 20 (BMI_{20}), most of the participants (82%) were categorized as normal weight, whereas less participants were overweight (6%), underweight (11%), and obese (<1%). The distribution of BMI categories at study time and at age 20 is shown in Supplementary Figure S1.

Table 1

Characteristics (Percentage) of the Population in Total and by BMI (Body Mass Index) Categories at Age 20.

Variables	Category	Total (%) *n* = 15845	Underweight[a] (%) *n* = 1772	Normal weight (%) *n* = 13027	Overweight (%) *n* = 970	Obese (%) *n* = 75
Age groups	<55	30.7	23.6	30.7	43.5	50.0
	55–<65	33.0	38.1	32.4	32.0	32.9
	≥65	36.3	38.3	36.9	24.5	17.1
Gender (% women)		56.5	86.5	53.9	37.2	48.7
BMI at study time (kg/m^2)	Underweight[a]	0.5	1.9	0.3	0	0
	Normal weight	41.0	56.9	41.3	11.4	2.6
	Overweight	42.9	32.6	44.6	41.1	27.6
	Obese	15.6	8.6	13.8	47.4	69.7
Education	Primary and elementary school	17.0	18.8	16.6	18.1	17.6
	Secondary high school	28.7	28.3	27.9	38.3	50.0
	University	54.3	52.9	55.4	43.6	32.4
Civil status	Unmarried	24.5	29.5	24.1	21.1	23.7
	Married	75.5	70.5	75.9	78.9	76.3
Smokers	Never	34.5	31.2	34.9	34.9	36.5
	Former	55.6	57.2	55.4	54.8	49.2
	Current	9.9	11.6	9.7	10.3	14.3
Physical activity level	Low	0.5	0.8	0.5	0.7	4.0
	Medium	80.5	87.4	79.7	78.0	82.7
	High	19.0	11.8	19.8	21.3	13.3
Alcohol consumption frequency	Never drink	3.9	4.3	3.7	4.3	6.8
	≤1 time per week	53.9	53.5	53.3	61.7	60.8
	2–3 times per week	33.1	33.2	33.4	29.6	28.4
	≥4 times per week	9.1	9.0	9.6	4.4	4.0

[a]BMI (kg/m^2) categories for underweight (<18.5), normal weight (18.5–24.99), overweight (25–29.99), and obese (≥30).

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In the present study, the participants who did not answer the questions about the weight and height at age 20 (*n* =3174) were excluded. When comparing the characteristics of these excluded participants and the population of the present study, those who were included in the study were more often married (75.5% vs. 70.0%, $p < .001$) and had more often been to university (54.3% vs. 47.3%, $p < .001$), but there were no significant differences in age, BMI at study time, sex distribution, or prevalence of the studied sleeping problems between the two groups.

Prevalence of Sleeping Problems

The prevalence of sleeping problems in men and women is summarized in Supplementary Table S1. Women had a significantly higher prevalence of

DIS, DMS, and EMA than men. Around one-fifth of the participants reported loud snoring and had an ESS score of over 10. Loud snoring was significantly more common in men than women, whereas the prevalence of daytime sleepiness did not differ between sexes.

Prevalence of Sleeping Problems in Relation to BMI

The prevalence of sleeping problems in relation to BMI categories at study time and at age 20 is shown in Table 2. In the whole group, the prevalence of sleep problems was most common among those who were obese at the time of the study, except the prevalence of EMA that was somewhat more common among the underweight participants. In contrast, the sleep problems of DIS, DMS, and EMA were less common in those with a higher BMI at age 20 compared with those who were underweight at age 20. However, the prevalence of loud snoring was most common among those who were overweight at the age of 20 years, and high daytime sleepiness (i.e., ESS score > 10) was most common among those who were obese at the age of 20 years.

Table 2

Prevalence of Sleeping Variables by BMI Categories.

Sleep problems	BMI at study time				*p**	BMI at age 20 (BMI_{20})				*p**
	Under weight[a] (*N* = 71)	Normal weight (N = 6505)	Over weight (*N* = 6804)	Obese (*N* = 2465)		Under weight[a] (*N* = 1772)	Normal weight (*N* = 13027)	Over weight (*N* = 970)	Obese (*N* = 75)	
DIS	5 (7.4)	463 (7.1)	543 (8.0)	253 (10.3)	<.001	217 (12.3)	979 (7.5)	62 (6.4)	6 (8.0)	<.001
DMS	5 (7.0)	558 (8.6)	579 (8.6)	283 (11.6)	<.001	224 (12.7)	1116 (8.6)	77 (8.0)	8 (10.7)	<.001
EMA	10 (14.3)	692 (10.7)	720 (10.7)	320 (13.1)	.005	248 (14.2)	1392 (10.8)	94 (9.8)	8 (10.7)	<.001
Loud snoring	5 (8.1)	760 (12.5)	1436 (22.5)	820 (36.3)	<.001	338 (20.9)	2418 (19.8)	246 (27.2)	19 (25.3)	<.001
ESS(>10)	5 (7.6)	1078 (17.0)	1322 (19.9)	577 (24.1)	<.001	338 (19.5)	2417 (19.0)	207 (21.9)	20 (26.7)	.051

Results are presented as *n* (%).

[a]BMI (kg/m^2) categories for underweight (<18.5), normal weight (18.5–24.99), overweight (25–29.99), and obese (≥30).

**p*-value: the differences between groups were compared using the χ2test.

DIS = difficulties initiating sleep; DMS = difficulties maintaining sleep; EMA = early morning awakening; ESS (>10) = Epworth Sleepiness Scale (a score of >10).

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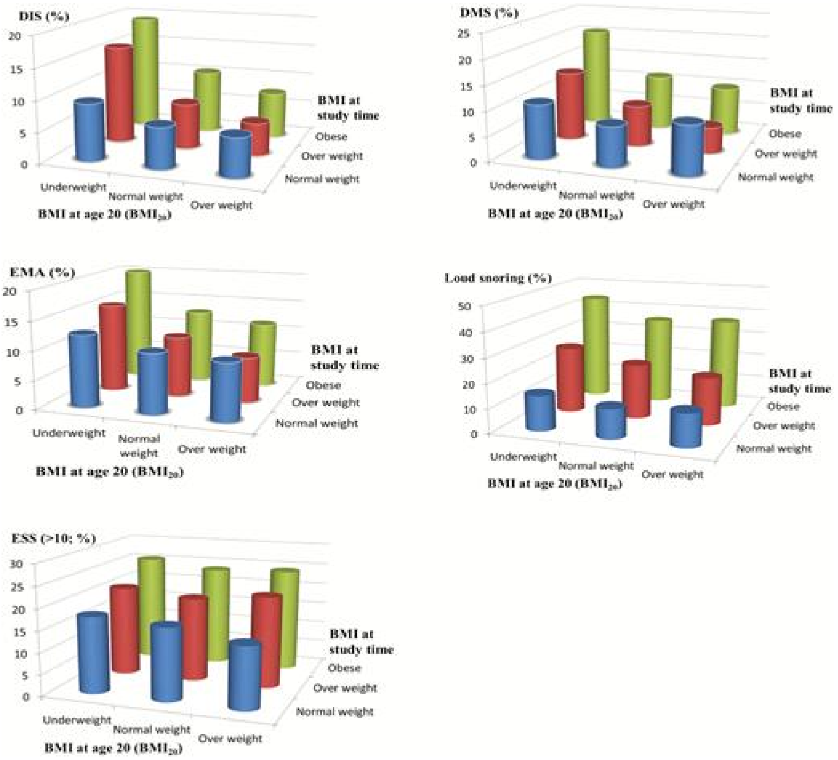
To further analyze the associations between present BMI and BMI at age 20 (BMI_{20}) and sleep problems, the prevalence of sleep problems was calculated for each BMI category (Figure 1). Those who were obese at age 20 (n = 75) and underweight at study time (n = 70) were not included in this figure because of too few participants in these groups. The figures showed that the highest prevalence of the studied sleep problems was found in the group that had a low BMI at age 20 and a high BMI at the time of the survey.

Figure 1



The prevalence of sleeping problems by factors of BMI (kg/m^2) categories at study time and at age 20 (BMI_{20}). Underweight: BMI < 18.5 kg/m^2, normal weight: BMI = 18.5–24.99 kg/m^2, and overweight: BMI = 25–29.99 kg/m^2. Participants who were obese at age 20 (*n* = 75) and underweight at study time (*n* = 70) are excluded from the figures due to low number of participants. DIS = difficulties initiating sleep, DMS = difficulties maintaining sleep, EMA = early morning awakening, ESS (>10) = Epworth Sleepiness Scale (a score of >10).

Associations Between Sleep Problems and the Mean Change in Weight

The mean for "mean weight change per year" since age 20 was 0.34 kg/year (range from −0.87 to 3.01) for men and 0.34 kg/year (range from −0.99 to 2.59) for women. There was a clear association between mean weight change and sleep problems in both men and women (Table 3).

Table 3

Associations Between Mean Weight Change Since Age 20 and Sleep Problems in the Whole Cohort and by Gender.

Sleep variables	Mean weight change per year, OR (95 % CI)[a]		
	Total	Men	Women
DIS	2.25 (1.86–2.72)	2.22 (1.54–3.20)	2.24 (1.79–2.80)
DMS	1.67 (1.39–2.01)	1.54 (1.08–2.19)	1.75 (1.41–2.17)
EMA	1.41 (1.19–1.66)	1.52 (1.15–2.00)	1.36 (1.10–1.67)
Loud snoring	5.63 (4.88–6.48)	5.00 (4.07–6.16)	6.23 (5.13–7.58)
ESS (>10)	1.54 (1.35–1.76)	1.52 (1.24–1.88)	1.57 (1.32–1.86)

[a]The mean weight change per year was calculated as follows: (weight at study time − weight at age twenty)/(age at study time − 20).

OR = Odds Ratio, calculated per increase in weight 1 kg/year (results are presented as age and sex adjusted in the total group and age adjusted for men and women); 95% CI = 95% confidence interval.

DIS = difficulties initiating sleep; DMS = difficulties maintaining sleep; EMA = early morning awakening; ESS (>10) = Epworth Sleepiness Scale (a score of >10).

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Prevalence of Sleeping Variables by Lifestyle Factors

The prevalence of sleep problems by other lifestyle factors is shown in Supplementary Table S2. There was a significantly lower prevalence of the studied sleep problems among those with high physical activity at leisure time. Moreover, the lowest prevalence of DIS, DMS, EMA, and loud snoring was found among the participants who were in the higher education levels groups, never smokers, and the married participants.

Multiple Logistic Regression Analyses

To further examine the impact of changes in weight with BMI at age 20 on sleep problems, multiple logistic regression analysis was performed (adjusting for potential confounding factors, i.e., age, sex, smoking, alcohol consumption, physical activity during leisure time, education, and civil status) (Table 4). Those who were obese at age 20 were not included in the multiple logistic regression analysis and they were also excluded from the interaction analyses because of too few participants in this group (n = 75). Weight gain was significantly associated with DIS and DMS among underweight and normal weight and with loud snoring in all the BMI categories at age 20. Moreover, for DIS, DMS, and loud snoring, the highest odds were found among those who were underweight at age 20, followed by a decline among those who were normal- or overweight at that time. Among those who were overweight at age 20, only loud snoring was significantly associated with mean weight change. In contrast, mean weight change was associated with EMA and high daytime sleepiness (i.e., ESS score > 10) only in those who were normal weight at age 20.

Table 4

Associations Between Weight Gain and Sleep Problems by BMI Categories at Age 20 (BMI_{20}).

Sleep variables	BMI_{20}, OR[a] (95 % CI)		
	Underweight[b]	Normal weight	Over weight
DIS	2.64 (1.51–4.62)	1.89 (1.47–2.45)	1.02 (0.48–2.13)
DMS	1.77 (1.02–3.07)	1.55 (1.22–1.97)	0.86 (0.42–1.73)
EMA	1.45 (0.84–2.49)	1.25 (1.00–1.56)	0.88 (0.46–1.70)
Loud snoring	7.81 (4.69–13.01)	5.49 (4.59–6.58)	3.67 (2.31–5.83)
ESS (>10)	1.56 (0.98–2.47)	1.62 (1.36–1.92)	1.08 (0.68–1.71)

[a]Data are presented as the adjusted odds ratio (95% CI) per increase of 1 kg/year after adjusting for age, sex, smoking, alcohol consumption, physical activities during leisure time, education, and civil status.

[b]BMI (kg/m^2) categories at age 20 for underweight (<18.5), normal weight (18.5–24.99), and overweight (25–29.99). The results of participants who were obese at age 20 are not showed here due to low number of participants (75 in total).

DIS = difficulties initiating sleep; DMS = difficulties maintaining sleep; EMA = early morning awakening; ESS (>10) = Epworth Sleepiness Scale (a score of >10).

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Interaction analyses were performed to investigate a possible modifying effect of BMI categories at age 20 and sex on the association between weight changes and sleep-related symptoms that are presented in Table 4. There was a statistically significant interaction between BMI category at age 20 and weight gain in relation to DMS ($p_{interaction}$ = .02). There was also an interaction between BMI group at age 20 and weight gain in relation to snoring ($p_{interaction}$ = .004) and ESS > 10 ($p_{interaction}$ = .003) and a tendency for interaction in relation to DIS ($p_{interaction}$ = .09) when BMI at age 20 was subdivided into tertiles. There was no further significant interaction between weight gain and sex for any of the studied sleep-related symptoms. When including 75 participants who had been obese at age 20 to the overweight group, the results presented in Table 4 and the interaction analyses did not significantly change (data not shown).

DISCUSSION

The main finding in this study is that, in this middle-aged to elderly population (aged 45–75 years), BMI and weight gain are highly associated with the prevalence of sleep problems. The second main finding is that the impact of weight gain on sleep problems is dependent on BMI at age 20 and that those who had a low BMI in young adulthood (at age 20) are most vulnerable to weight gain.

All insomnia symptoms, i.e., DIS, DMS, and EMA, were significantly more prevalent in women compared with men and this is in accordance with several previous studies.[7,21] We also found a clear association between weight gain and subsequent sleep problems, and the influence of weight gain was of a similar magnitude in both genders. These results are similar to those recently reported from another Swedish cohort of men and women aged 40–79 years.[21] Moreover, the multiple logistic regression analysis showing that participants who already had a higher BMI at age 20 appeared to have a less vulnerability of sleep symptoms associated with weight gain. This could have clinical implications and is also important for research purposes when evaluating obesity and weight gain as risk factors for insomnia symptoms. To the best of our knowledge, this is a novel finding, and we can therefore only speculate about the explanations of this finding. In a large retrospective cohort study of men and women, a rapid gain in BMI in late childhood resulted in relatively larger increases in fat mass in adulthood, despite the concurrent rise in lean mass.[27] If this is also true for young adulthood, it could at least partly explain our results, as central obesity is associated with insomnia,[28] and BMI has been shown to be a strong determinant of persistent and increasing insomnia symptoms.[29] Furthermore, it has been shown in a large Chinese cohort that participants that less frequently ate so-called rich nutrients (meat, fish, milk, and so on) during late childhood had poorer health outcomes, perceived a greater amount of physical pain or discomfort, and suffered more from insomnia and depression when they grew up. They also gained more weight as adults and were more likely to become obese.

The finding that the prevalence of self-reported loud snoring is higher in men is in accordance with other studies.[30–32] However, the present study also shows that weight gain is even more strongly associated with snoring among those who were underweight at age 20 and the odds ratio decreased with increasing BMI when young. Snoring is an effect of narrow upper airways and is the most important symptom of obstructive sleep apnea. Central obesity with increasing neck circumference appears to be even more important than general obesity, as the pharyngeal fat pad area increases and reduces the pharyngeal area.[33,34] If lean participants who gain weight are more prone to develop central obesity, this would explain why they are more vulnerable when it comes to starting snoring.

The prevalence of daytime sleepiness was most common among those who were obese both at study time and at age 20. Similar results were found by Mondal *et al*.[35] Moreover, in a previous community-based follow-up study, those who increased their BMI by >2 kg/m^2 during the follow-up period of 10–13 years ran a significantly increased risk of developing daytime sleepiness also after adjusting for several confounders including BMI at baseline and snoring.[21] It is further known that obesity is associated with increased daytime sleepiness due to increased levels of inflammatory markers.[36] The importance of obesity as a cause of daytime sleepiness has been further emphasized by a randomized-controlled trial aiming to evaluate the effect of a very-low energy diet on sleep apnea in obese men.[37] The intervention group had a mean weight reduction of 18.7 kg and reduced their ESS scores significantly more than the control group, despite both groups being effectively treated with CPAP.[37]

The strengths of this study include the large population and the fact that we have information on important covariates and weight in young adulthood. However, there are some limitations. Firstly, although we have longitudinal assessments of BMI, there was only one measurement of sleep problems. Conclusions about changes in sleep problems cannot therefore be drawn; it is possible that those participants who experience a greater increase in BMI had sleep problems throughout their life. Unfortunately, we did not have the data for the patterns of weight gain or changes in weight status (steady weight gain vs. sudden weight gain or years of overweight or obese) from age 20 to the study time which could be a limitation of the studied data set. Secondly, although the actual BMI was calculated from measured weight and height, BMI at age 20 was self-reported and hence less reliable, and there were no objective sleep measurements. Previous literature has shown a discrepancy between self-reported and objective sleep quality, especially among participants with sleep problems.[38,39] However, the advantage of self-report measurements is that they can provide an insight into subjective components of sleep, such as sleep satisfaction and daytime sleepiness, which may be relevant to obesity.[10] Finally, the population with missing data on weight and height at age 20 was excluded in this study which could be a potential selection bias. However, when comparing the characteristics of this excluded population with the studied population, there was no significant difference in the prevalence of the studied sleeping problems between these two groups. Therefore, this selection bias is less likely.

In conclusion, in this cohort of middle-aged and elderly adults, weight gain and obesity were related to sleep problems. The association between weight gain and sleeping problems was strongest in those who had a low BMI at the age of 20 years. This indicates that the health hazards of weight gain may be higher in the participants that have a low BMI in young adulthood.

SUPPLEMENTARY MATERIAL

Supplementary material is available at *SLEEP* online.

FUNDING

The study was supported by the Swedish Research Council.

WORK PERFORMED

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DISCLOSURE STATEMENT

None declared.

ACKNOWLEDGMENTS

We thank the Swedish Research Council for supporting the strategic research network Epidemiology for Health (EpiHealth) and thereby also the EpiHealth screening cohort.

REFERENCES

1. Lee M, Choh AC, Demerath EWet al. Sleep disturbance in relation to health-related quality of life in adults: the Fels Longitudinal Study. *J Nutr Health Aging* . 2009; 13(6): 576–583.
   Google Scholar Crossref PubMed

2. Mallon L, Broman JE, Hetta J. High incidence of diabetes in men with sleep complaints or short sleep duration: a 12-year follow-up study of a middle-aged population. *Diabetes Care* . 2005; 28(11): 2762–2767.
   Google Scholar Crossref PubMed

3. Bauters F, Rietzschel ER, Hertegonne KB, Chirinos JA. The link between obstructive sleep apnea and cardiovascular disease. *Curr Atheroscler Rep* . 2016; 18(1): 1.
   Google Scholar Crossref PubMed

4. Roepke SK, Ancoli-Israel S. Sleep disorders in the elderly. *Indian J Med Res* . 2010; 131: 302–310.
   Google Scholar PubMed

5. Ancoli-Israel S. Sleep and its disorders in aging populations. *Sleep Med* . 2009; 10 (Suppl 1): S7–S11.
   Google Scholar Crossref PubMed

6. Ancoli-Israel S. Insomnia in the elderly: a review for the primary care practitioner. *Sleep* . 2000; 23 (Suppl 1): S23–S30; discussion S36-8.
   Google Scholar PubMed

7. Rodríiguez-Muñoz A, Moreno-Jiménez B, Fernández-Mendoza JJ, Olavarrieta-Bernardino S, de la Cruz-Troca JJ, Vela-Bueno A. [Insomnia and quality of sleep among primary care physicians: a gender perspective]. *Rev Neurol* . 2008; 47(3): 119–123.
Google Scholar PubMed

8. Wallander MA, Johansson S, Ruigómez A, García Rodríguez LA, Jones R. Morbidity associated with sleep disorders in primary care: a longitudinal cohort study. *Prim Care Companion J Clin Psychiatry* . 2007; 9(5): 338–345.
Google Scholar Crossref PubMed

9. Smagula SF, Stone KL, Fabio A, Cauley JA. Risk factors for sleep disturbances in older adults: evidence from prospective studies. *Sleep Med Rev* . 2016; 25: 21–30.
Google Scholar Crossref PubMed

10. Magee CA, Iverson DC, Huang XF, Caputi P. A link between chronic sleep restriction and obesity: methodological considerations. *Public Health* . 2008; 122(12): 1373–1381.
Google Scholar Crossref PubMed

11. Ng M, Fleming T, Robinson Met al. Global, regional, and national prevalence of overweight and obesity in children and adults during 1980-2013: a systematic analysis for the Global Burden of Disease Study 2013. *Lancet* . 2014; 384(9945): 766–781.
Google Scholar Crossref PubMed

12. Corona G, Lee DM, Forti Get al. ; EMAS Study Group. Age-related changes in general and sexual health in middle-aged and older men: results from the European Male Ageing Study (EMAS). *J Sex Med* . 2010; 7(4 Pt 1): 1362–1380.
Google Scholar Crossref PubMed

13. Shlisky JD, Hartman TJ, Kris-Etherton PM, Rogers CJ, Sharkey NA, Nickols-Richardson SM. Partial sleep deprivation and energy balance in adults: an emerging issue for consideration by dietetics practitioners. *J Acad Nutr Diet* . 2012; 112(11): 1785–1797.
Google Scholar Crossref PubMed

14. Fock KM, Khoo J. Diet and exercise in management of obesity and overweight. *J Gastroenterol Hepatol* . 2013; 28 (Suppl 4): 59–63.
Google Scholar Crossref PubMed

15. Nielsen LS, Danielsen KV, Sørensen TI. Short sleep duration as a possible cause of obesity: critical analysis of the epidemiological evidence. *Obes Rev* . 2011; 12(2): 78–92.
Google Scholar Crossref PubMed

16. Magee L, Hale L. Longitudinal associations between sleep duration and subsequent weight gain: a systematic review. *Sleep Med Rev* . 2012; 16(3): 231–241.
Google Scholar Crossref PubMed

17. Patel SR, Hu FB. Short sleep duration and weight gain: a systematic review. *Obesity (Silver Spring)* . 2008; 16(3): 643–653.
Google Scholar Crossref PubMed

18. Wu Y, Gong Q, Zou Z, Li H, Zhang X. Short sleep duration and obesity among children: A systematic review and meta-analysis of prospective studies. *Obes Res Clin Pract* . 2017; 11(2): 140–150.

Google Scholar Crossref PubMed

19. Ruan H, Xun P, Cai W, He K, Tang Q. Habitual sleep duration and risk of childhood obesity: systematic review and dose-response meta-analysis of prospective cohort studies. *Sci Rep* . 2015; 5: 16160.
Google Scholar Crossref PubMed

20. Pilcher JJ, Ginter DR, Sadowsky B. Sleep quality versus sleep quantity: relationships between sleep and measures of health, well-being and sleepiness in college students. *J Psychosom Res* . 1997; 42(6): 583–596.
Google Scholar Crossref PubMed

21. Palm A, Janson C, Lindberg E. The impact of obesity and weight gain on development of sleep problems in a population-based sample. *Sleep Med* . 2015; 16(5): 593–597.
Google Scholar Crossref PubMed

22. Janson C, Lindberg E, Gislason T, Elmasry A, Boman G. Insomnia in men-a 10-year prospective population based study. *Sleep* . 2001; 24(4): 425–430.
Google Scholar Crossref PubMed

23. Lind L, Elmståhl S, Bergman Eet al. EpiHealth: a large population-based cohort study for investigation of gene-lifestyle interactions in the pathogenesis of common diseases. *Eur J Epidemiol* . 2013; 28(2): 189–197.
Google Scholar Crossref PubMed

24. Sundbom F, Lindberg E, Bjerg Aet al. Asthma symptoms and nasal congestion as independent risk factors for insomnia in a general population: results from the GA(2)LEN survey. *Allergy* . 2013; 68(2): 213–219.
Google Scholar Crossref PubMed

25. Johns MW. A new method for measuring daytime sleepiness: the Epworth Sleepiness Scale. *Sleep* . 1991; 14(6): 540–545.
Google Scholar Crossref PubMed

26. Byberg L, Melhus H, Gedeborg Ret al. Total mortality after changes in leisure time physical activity in 50 year old men: 35 year follow-up of population based cohort. *BMJ* . 2009; 338: b688.
Google Scholar Crossref PubMed

27. Ylihärsilä H, Kajantie E, Osmond C, Forsén T, Barker DJ, Eriksson JG. Body mass index during childhood and adult body composition in men and women aged 56-70 y. *Am J Clin Nutr* . 2008; 87(6): 1769–1775.
Google Scholar PubMed

28. Tan X, Alén M, Cheng SMet al. Associations of disordered sleep with body fat distribution, physical activity and diet among overweight middle-aged men. *J Sleep Res* . 2015; 24(4): 414–424.
Google Scholar Crossref PubMed

29. Lallukka T, Haario P, Lahelma E, Rahkonen O. Associations of relative weight with subsequent changes over time in insomnia symptoms: a follow-up study among middle-aged women and men. *Sleep Med* . 2012; 13(10): 1271–1279.
Google Scholar Crossref PubMed

30. Teculescu D, Benamghar L, Hannhart B, Michaely JP. Habitual loud snoring. A study of prevalence and associations in 850 middle-aged French males. *Respiration* . 2006; 73(1): 68–72.
Google Scholar Crossref PubMed

31. Al-Delaimy WK, Manson JE, Willett WC, Stampfer MJ, Hu FB. Snoring as a risk factor for type II diabetes mellitus:

a prospective study. *Am J Epidemiol* . 2002; 155(5): 387–393.
Google Scholar Crossref PubMed

32. Lindberg E, Taube A, Janson C, Gislason T, Svärdsudd K, Boman G. A 10-year follow-up of snoring in men. *Chest* . 1998; 114(4): 1048–1055.
Google Scholar Crossref PubMed

33. Pahkala R, Seppä J, Ikonen A, Smirnov G, Tuomilehto H. The impact of pharyngeal fat tissue on the pathogenesis of obstructive sleep apnea. *Sleep Breath* . 2014; 18(2): 275–282.
Google Scholar Crossref PubMed

34. Svensson M, Lindberg E, Naessen T, Janson C. Risk factors associated with snoring in women with special emphasis on body mass index: a population-based study. *Chest* . 2006; 129(4): 933–941.
Google Scholar Crossref PubMed

35. Mondal P, Gjevre JA, Taylor-Gjevre RM, Lim HJ. Relationship between the Pittsburgh Sleep Quality Index and the Epworth Sleepiness Scale in a sleep laboratory referral population. *Nat Sci Sleep* . 2013; 5: 15–21.
Google Scholar PubMed

36. Vgontzas AN. Does obesity play a major role in the pathogenesis of sleep apnoea and its associated manifestations via inflammation, visceral adiposity, and insulin resistance?*Arch Physiol Biochem* . 2008; 114(4): 211–223.
Google Scholar Crossref PubMed

37. Johansson K, Neovius M, Lagerros YTet al. Effect of a very low energy diet on moderate and severe obstructive sleep apnoea in obese men: a randomised controlled trial. *BMJ* . 2009; 339: b4609.
Google Scholar Crossref PubMed

38. Girschik J, Fritschi L, Heyworth J, Waters F. Validation of self-reported sleep against actigraphy. *J Epidemiol* . 2012; 22(5): 462–468.
Google Scholar Crossref PubMed

39. Shade MY, Berger AM, Dizona PJ, Pozehl BJ, Pullen CH. Sleep and health-related factors in overweight and obese rural women in a randomized controlled trial. *J Behav Med* . 2016; 39(3): 386–397.
Google Scholar Crossref PubMed

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