Obesity and sleep: the Buffalo Police health study

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Abstract

Purpose – This study aims to look at the prevalence of obesity and its association with sleep problems among police officers.

Design/methodology/value – The authors conducted a cross-sectional study of the relationship between obesity and sleep disorders among 110 randomly selected police officers from the Buffalo, New York, Police Department in 1999. Participants, who ranged in age from 26 to 61 years (mean ± SD = 39.5 ± 7.5), responded to sleep related questions and had anthropometric measurements taken.

Findings – Results show that several measures of obesity were significantly associated with sleep-disordered breathing in police officers, but not with other sleep problems.

Originality/value – A major strength of the study was that it was conducted in a cooperative and motivated study population. It was possible to assess a wide range of anthropometric measurements, including many that are important but are rarely used to measure obesity in epidemiologic studies such as abdominal height, neck circumference, and neck-to-height ratio. In addition, the assessment of the anthropometric indices was performed by trained clinic staff using standardized procedures.

Keywords Obesity, Police, Personal health, United States of America

Paper type Research paper

Introduction

Obesity and sleep problems are becoming major public health problems in industrialized countries (Stein and Colditz, 2004; National Sleep Foundation, 2005). Several studies have shown that there is a positive association between obesity and

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various sleep problems (Sharma *et al.*, 2004; Dancey *et al.*, 2003; Young *et al.*, 2005). Spiegel *et al.* (1999) reported that chronic short sleep duration and/or poor sleep quality may increase the risk of obesity, and that short sleep duration may increase the risk of Type 2 diabetes. In a prospective cohort study of young adults, sleep duration was a strong and significant predictor of weight gain (Hasler *et al.*, 2004). There was a monotonic trend toward lower weight gain among those with longer sleep duration and there were significant cross-sectional associations between short sleep duration and obesity in persons younger than 35 years.

Gangwisch *et al.* (2005) conducted a study using the National Health and Nutrition Examination Survey I (NHANES I) Follow-up studies to assess the relationship between sleep duration, obesity, and weight gain. Their results showed that sleep duration was inversely related to obesity among the younger age group. Among persons 32 to 49 years, those who got two to four hours of sleep per night at baseline gained the most weight over the follow-up period, while those who got ten or more hours of sleep gained the least weight. Results from the National Sleep Foundation survey conducted in 2005 on American adults also found that duration of sleep was inversely related to obesity (National Sleep Foundation, 2005).

The occurrence of certain sleep problems also may increase the risk of morbidity and mortality. Decreased sleep time has been associated with increased risk of hypertension (Gangwisch *et al.*, 2006) and reduced life expectancy (Yousaf and Sedgwick, 1996), and daytime sleepiness has been associated with impaired cognition (Foley *et al.*, 2001). A cohort study by Yaggi *et al.* (2005) found that obstructive sleep apnea significantly increased the risk of stroke or death. The seriousness of sleep apnea is underscored by the fact that only a small proportion of persons afflicted with the condition is diagnosed clinically (Young *et al.*, 1997). Fatigue due to moderate sleep loss affects performance similar to moderate alcohol intoxication (Dawson and Reid, 1997; Williamson and Feyer, 2000). A vicious cycle can be created whereby poor sleep quality increases the risk for a variety of chronic disorders and, in turn, these disorders further decrease the quality of sleep.

Police officers experience poorer sleep quality and fewer hours of sleep than the general public (Neylan *et al.*, 2002; Vila, 2006). Although we do not know the extent to which obesity affects police officers, anecdotal evidence suggests that they are at least as likely to be obese as the general public (Morioka and Brown, 1970). The main objective of this study is to investigate cross-sectional associations between anthropometric indices of obesity and sleep problems for persons in this occupational group.

Methods

Study population and design

This study utilized a cross-sectional design. The Center for Preventive Medicine, State University of New York (SUNY) at Buffalo, School of Public Health and Health Professions, Buffalo, NY, served as the data collection site (Violanti *et al.*, 2006). Informed consent was obtained from all participants and this study was approved by the State University of New York at Buffalo's Internal Review Board and the National Institute for Occupational Safety and Health Human Subjects Review Board. In 1999, a random sample of 115 police officers was selected from 934 officers employed by the Buffalo Police Department. The participation rate was 100 percent – five officers who

did not have information on several of the anthropometric variables were excluded from the study resulting in a sample size of 110, 44 females and 66 males.

Assessment of sleep

The outcomes of interest were sleep quality and sleep quantity. The self-reported questionnaire on sleep elicited information on behaviors or characteristics while sleeping and on daytime sleepiness. Table I provides a complete list of questions used. No questions were asked about insomnia. Several of these questions are validated in instruments such as the Pittsburgh Sleep Quality Index questionnaire (Buysse *et al.*, 1989) and the sleep apnea survey used by Maislin *et al.* (1995). The sleep questions were evaluated on a six-point scale that included "not sure/don't know/not applicable", "strongly disagree/never", disagree/<1 per week, somewhat agree/1-2 times per week, agree/3-4 times per week, and "strongly agree/5-7 times per week". All sleep problems were analyzed as yes vs.. never, or as "3-7 times per week," " $<$ 1-2 times per week," and "never."

Participants were also asked how many hours they slept each night during the previous five weekdays (i.e. Sunday through Thursday) and during the previous weekends (i.e. Friday and Saturday nights). We combined the hours of sleep reported daily for each period to give total hours of sleep per 24-hour period. Sleep duration was categorized as 0-4.5, 5-6.5, and $>$ = seven hours.

Assessment of anthropometric measurements for obesity

Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared. Waist circumference, hip circumference, and neck circumference were measured and rounded to the nearest 0.5 centimeter. Abdominal height (in centimeters) was measured three times and the average value was used in analyses. Neck-to-height ratio, waist-to-hip ratio, and waist-to-height ratio were also calculated. Taller people are expected to have larger neck and waist circumferences, so the inclusion of neck-to-height, waist-to-hip, and waist-to-height ratios in this study was necessary to account for body height and hip size. This standardization also served to minimize the impact of normal phenotypic differences between men and women. BMI is not the ideal measure of obesity since larger muscle mass may also increase this index. Therefore, several other indices (mentioned above) were used to provide a more accurate assessment of obesity.

Assessment of covariates

Participants were given a self-administered questionnaire to provide information on demographic characteristics, lifestyle behaviors, medical history, and sleep quality and quantity. Police officers reported their highest level of education and their marital status. Participants indicated the number of years employed as a police officer and their present rank in the police force (e.g. police officer, lieutenant, detective, etc.). Participants were asked how often they consumed alcoholic beverages: 12 oz. can or bottle of beer, one medium glass of wine, and one shot of liquor. The total number of drinks per month (of each type) was summed and then divided by four to give the approximate total number of drinks consumed per week. Participants reported their smoking status as current, former, or never. The Center for Epidemiological Studies Depression scale (CES-D) was used to measure psychological distress and depression

Table I.
Prevalence of sleep problems among police officers by sex

Sleep problems	All			Women			Men		
	Total	Yes	%	Total	Yes	%	Total	Yes	%
At night, my sleep disturbs my bed partner's sleep	74	57	77.0	21	15	71.4	53	42	79.3
I am told I snore in my sleep	89	74	83.2	29	22	75.9	60	52	86.7
I am told I stop breathing in my sleep	79	8	10.1	28	2	7.1	51	6	11.8
I suddenly wake up gasping for breath during the night	94	16	17.0	36	7	19.4	58	9	15.5
I have or have been told that I have restless legs	82	28	34.2	32	11	34.4	50	17	34.0
I feel tired upon awakening and want to go back to sleep	99	89	89.9	36	33	91.7	63	56	88.9
I am very sleepy during the daytime and struggle to stay awake	100	72	72.0	38	33	86.8	62	39	62.9*
Hours of sleep per 24-hour period during the previous 7 days	110			44			66		
0-4.5		13	11.8		7	15.9		6	9.1
5-6.5		52	47.3		19	43.2		33	50.0
≥ 7		45	40.9		18	40.9		27	40.9
Mean and SD		6.1	1.7		6.0	1.9		6.2	1.6

Note: *p-value for difference between women and men <0.05.
Source: Charles *et al.* (1999)

in the participants (Radloff, 1977). The CES-D, a 20-item scale with responses ranging from "rarely" to "most of the time", has been widely used and has good reliability for measuring symptoms of depression and stress.

Information was obtained on physical activity during the previous seven days. Participants also reported the degree (hours per week, hours per weekend) and intensity (moderate, hard, very hard) of three types of physical activity (occupational, household and sports). The data were then used to create a total physical activity score that was computed by summing the intensities of the three types (i.e. occupational, household and sports) of physical activity performed during the weekday and the weekend. Intensity score was computed as the product of number of hours and intensity of physical activity where moderate, hard and very hard were assigned intensities of 1, 2 and 3 respectively.

Statistical methods

Analytical methods included univariate measures, *t*-tests, Pearson's correlation, analyses of variance and covariance. The prevalence of each sleep problem was determined for the population. The association between duration of sleep and obesity was assessed using Pearson's correlation and analysis of variance. Analyses of variance and covariance were used to obtain the mean values of covariates by sleep quality problems, categorized as never (0 times a week), low ($<1-2$ times a week), and high (3-7 times a week). The *p*-values for linear trend across these categories were based on orthogonal contrast coefficients. The following variables were evaluated for their potential role as effect modifiers and/or confounders: age, physical activity, smoking status, alcohol intake, sex, depression, and shift work status. All analyses were conducted using the SAS system, version 9.1 (SAS Institute, 2002).

Results

Demographic and anthropometric characteristics of the study population are presented in Table II. The participants ranged in age from 26 to 61 years and women and men had similar average ages (39 years). As expected, mean levels of all anthropometric measures were significantly larger in men compared to women. The mean years of police service reported by men was 14.8 years compared to 10.2 years for women. Highest level of education attained was similar between the sexes but a higher proportion of women (70.5 percent) held the rank of police officer than men (59.1 percent). Overall, the prevalence of reported current smoking was low (19.3 percent), but it was somewhat higher, though not statistically significant, among women (25.0 percent) than among men (15.4 percent). The majority (62.7 percent) of the officers were married.

Table I provides the prevalence of sleep problems by sex. The two sleep problems with the highest prevalence were tiredness upon awakening (89.9 percent) and snoring (83.2 percent). "Stop breathing during sleep" had the lowest reported prevalence (10.1 percent). The percentage of women who reported daytime sleepiness (86.8 percent) was significantly higher than men who reported this problem (62.9 percent). Similar proportions of women and men reported that they slept $\geq$ seven hours per 24-hour period during the previous seven days.

Mean values of the anthropometric measures for three sleep-disordered breathing problems are presented in Table III. The other sleep problems were not associated with

Covariates	All Range	Women N	Women Mean	Women (SD)	Men N	Men Mean	Men (SD)
Age (years)	26.0–61.0	44	39.1	(6.3)	66	39.8	(8.2)
Years of service	1.0–36.0	44	10.2	(6.6)	66	14.8	(9.6)*
Weight (lbs)	117.0–273.4	44	160.9	(28.8)	66	205.6	(31.0)*
Height (inches)	157.0–196.5	44	166.7	(5.9)	66	179.0	(6.9)*
BMI (Kg/m^2)	19.5–39.8	44	26.3	(4.5)	66	29.1	(3.9)*
Waist circumference (cm)	64.5–126.0	44	80.5	(10.1)	66	97.1	(10.3)*
Waist-to-hip circumference ratio	0.67–0.99	44	0.77	(0.06)	66	0.90	(0.06)*
Waist-to-height circumference ratio	0.36–0.69	44	0.48	(0.06)	66	0.54	(0.06)*
Hip circumference (to nearest 0.5 cm)	83.0–133.3	44	104.2	(11.2)	66	108.5	(8.0)*
Abdominal height (cm)	14.3–32.5	44	19.0	(2.9)	65	21.9	(2.8)*
Neck circumference (cm)	31.3–48.5	40	35.8	(3.6)	65	41.5	(2.9)*
Neck- to-height ratio	0.19–0.30	40	0.21	(0.02)	65	0.23	(0.02)*
Alcohol – number of drinks/wk	0.0–17.3	44	2.2	(3.3)	66	3.3	(4.0)
Depression score (CES-D)	0.0–38.0	42	8.2	(8.2)	62	6.9	(5.7)
Physical activity score	0.0–120.0	44	11.3	(13.6)	66	11.2	(18.4)
Education (%):							
< = High school/GED	19.1	7		15.9	14		21.2
<4 yrs college	54.6	24		54.6	36		54.6
> = 4 yrs college	26.4	13		29.6	16		24.2
Rank (%):							
Police officer	63.6	31		70.5	39		59.1
Sergeant/lieutenant/captain	16.4	6		13.6	12		18.2
Detective	16.4	4		9.1	14		21.2
Other	3.6	3		6.8	1		1.5
Smoking status (%):							
Current	19.3	11		25.0	10		15.4
Former	32.1	18		40.9	17		26.2
Never	48.6	15		34.1	38		58.5
Marital status (%):							
Single	23.6	13		29.6	13		19.7*
Married	62.7	21		47.7	48		72.7*
Divorced	13.6	10		22.7	5		7.6*
Shift work (%):							
Day/afternoon shift	82.1	36		90.0	51		77.3
Night shift	17.9	4		10.0	15		22.7

Table II.
Characteristics[a] of the study population

Notes: *p-value for difference between women and men <0.05.
Source: Charles *et al.* (1999)

any of the anthropometric variables and so were not included in this table. Except for waist-to-hip ratio, all anthropometric variables were significantly associated with snoring before and after adjustment for age, physical activity, smoking, alcohol intake, sex, depression, and shift-work. In addition, positive stepwise trends (although non-significant) were observed between five anthropometric measures and sleep apnea after full risk factor adjustment. BMI, hip circumference, abdominal height, neck

Table III. Adjusted mean values of anthropometric obesity measurements by sleep problems

Anthropometric obesity measurements	Frequency of sleep problems	Snoring N^a	Snoring Model 1 Mean	Snoring Model 1 (SE)	Snoring Model 2 Mean	Snoring Model 2 (SE)	Stop breathing N^a	Stop breathing Model 1 Mean	Stop breathing Model 1 (SE)	Stop breathing Model 2 Mean	Stop breathing Model 2 (SE)	Gasping for breath N^a	Gasping for breath Model 1 Mean	Gasping for breath Model 1 (SE)	Gasping for breath Model 2 Mean	Gasping for breath Model 2 (SE)
BMI	Never	15	25.9	(1.0)	25.4	(1.2)	71	28.1	(0.5)	27.7	(0.7)	78	27.8	(0.5)	27.1	(0.6)
	<1–2 times/wk	50	27.5	(0.6)	26.8	(0.7)	4	28.3	(2.2)	28.6	(2.0)	13	29.0	(1.2)	28.9	(1.4)
	3–7 times/wk	24	30.9	(0.8)	29.6	(1.0)	4	30.8	(2.2)	29.9	(2.2)	3	32.0	(2.5)	32.3	(2.5)
	P_{trend}			<0.001		0.002			0.235		0.312			0.108		0.036
Hip circumference	Never	15	102.8	(2.2)	100.5	(2.6)	71	107.8	(1.1)	107.0	(1.5)	78	106.8	(1.1)	104.9	(1.4)
	<1–2 times/wk	50	106.2	(1.2)	105.6	(1.6)	4	105.4	(4.6)	106.6	(4.5)	13	107.8	(2.6)	106.5	(3.1)
	3–7 times/wk	24	112.3	(1.8)	109.9	(2.2)	4	112.1	(4.6)	111.0	(4.7)	3	115.9	(5.4)	116.7	(5.5)
	P_{trend}			0.001		0.003			0.366		0.391			0.105		0.036
Waist	Never	15	84.9	(3.0)	85.2	(2.8)	71	91.6	(1.5)	91.6	(1.8)	78	90.6	(1.4)	89.8	(1.6)
	<1–2 times/wk	50	90.2	(1.7)	89.2	(1.7)	4	93.2	(6.5)	93.4	(5.3)	13	91.1	(3.6)	92.8	(3.4)
	3–7 times/wk	24	99.0	(2.4)	95.6	(2.3)	4	92.7	(6.5)	92.7	(5.6)	3	99.2	(7.5)	101.0	(6.1)
	P_{trend}			<0.001		0.002			0.868		0.845			0.265		0.068
Abdominal height	Never	15	19.0	(0.7)	18.7	(0.8)	70	20.9	(0.4)	20.5	(0.5)	77	20.6	(0.4)	20.2	(0.4)
	<1–2 times/wk	50	20.6	(0.4)	20.1	(0.5)	4	21.1	(1.6)	21.0	(1.4)	13	20.6	(0.9)	20.5	(0.9)
	3–7 times/wk	23	22.8	(0.6)	21.7	(0.7)	4	22.6	(1.6)	22.1	(1.5)	3	23.8	(1.8)	24.3	(1.6)
	P_{trend}			<0.001		0.002			0.283		0.254			0.091		0.014
Waist-to-hip ratio	Never	15	0.82	(0.02)	0.85	(0.02)	71	0.85	(0.01)	0.85	(0.01)	78	0.85	(0.01)	0.85	(0.01)
	< 1–2 times/wk	50	0.85	(0.01)	0.85	(0.01)	4	0.88	(0.04)	0.87	(0.03)	13	0.84	(0.02)	0.87	(0.02)
	3–7 times/wk	24	0.88	(0.02)	0.87	(0.01)	4	0.83	(0.04)	0.84	(0.03)	3	0.86	(0.05)	0.87	(0.03)
	P_{trend}			0.038		0.225			0.665		0.622			0.764		0.606
Waist-to-height ratio	Never	15	0.49	(0.01)	0.50	(0.02)	71	0.52	(0.01)	0.53	(0.01)	78	0.52	(0.01)	0.52	(0.01)
	<1–2 times/wk	50	0.52	(0.01)	0.52	(0.01)	4	0.52	(0.03)	0.52	(0.03)	13	0.52	(0.02)	0.53	(0.02)
	3–7 times/wk	24	0.56	(0.01)	0.55	(0.01)	4	0.53	(0.03)	0.54	(0.03)	3	0.57	(0.04)	0.58	(0.04)
	P_{trend}			<0.001		0.006			0.847		0.844			0.200		0.089
Neck circumference	Never	13	38.0	(1.1)	36.8	(1.0)	67	39.4	(0.5)	38.4	(0.6)	74	39.2	(0.5)	38.5	(0.5)
	<1–2 times/wk	48	38.9	(0.6)	37.8	(0.6)	4	403	(2.0)	39.7	(1.7)	13	40.3	(1.2)	41.0	(1.1)
	3–7 times/wk	24	42.0	(0.8)	40.3	(0.8)	4	42.0	(2.0)	40.3	(1.8)	3	43.3	(2.4)	43.2	(2.0)
	P_{trend}			0.004		0.002			0.206		0.275			0.096		0.023
Beck-to-height ratio	Never	13	0.22	(0.006)	0.21	(0.010)	67	0.22	(0.003)	0.22	(0.004)	74	0.22	(0.003)	0.22	(0.003)
	<1–2 times/wk	48	0.22	(0.003)	0.22	(0.003)	4	0.23	(0.011)	0.23	(0.010)	13	0.23	(0.006)	0.24	(0.007)
	3–7 times/wk	24	0.24	(0.004)	0.23	(0.004)	4	0.24	(0.011)	0.23	(0.011)	3	0.25	(0.013)	0.25	(0.013)
	P_{trend}			0.004		0.010			0.156		0.316			0.057		0.042

Notes: [a]The sample sizes are for model 1. Model 1: Adjusted for age; Model 2: Adjusted for age, physical activity, smoking, alcohol intake, sex, depression, and shift-work.
Source: Charles *et al.* (1999)

circumference, and neck-to-height ratio were significantly associated with reports of waking up gasping for breath after adjustment for age, physical activity, smoking, alcohol intake, sex, depression, and shift-work. In almost every case, persons who reported experiencing a sleep-disordered breathing problem three to seven times per week had the largest mean anthropometric measurement. An inverse trend was observed between duration of sleep and mean waist circumference: 0-4.5 hrs (92.1 cm), 5-6.5 hrs (90.3 cm), and $\geq$ seven hrs (89.2 cm), but the trend was not statistically significant ($p = 0.381$).

Additional analyses were performed to determine which of the anthropometric measures best predicted the association with snoring (data not shown). Logistic regression analyses, using various methods (e.g. stepwise, forward, backward, and anthropometric measures in the models simultaneously and separately), identified abdominal height as the best predictor of snoring. In addition, the prevalence of snoring was obtained for each quartile of the anthropometric measures and the difference between the first and fourth quartiles was calculated. A total of 100 percent of persons in the fourth quartile of abdominal height reported snoring, and the interquartile difference in snoring prevalence was also the largest for abdominal height (31.6 percent).

Discussion

The results of this study showed statistically significant associations between all anthropometric measures (except waist-to-hip ratio) and snoring. Abdominal height was consistently identified as the best predictor of snoring prevalence. Significant trends were also observed between some of the anthropometric measures and waking up gasping for breath. Positive trends were observed between some of the other anthropometric measures and "stop breathing during sleep", but these were not statistically significant, probably due to the small sample sizes. Our results are in concordance with previous studies. Young *et al.* (2005) estimated that about 17 percent of American adults aged 30-69 years have mild or worse sleep-disordered breathing and that in 41 percent of these persons, the sleep-disordered breathing is attributable to having a BMI $> = 25\,kg/m^2$. They also estimated that about 5.7 percent of these adults have moderate or worse sleep-disordered breathing and that the sleep-disordered breathing is attributable to excess weight in 58 percent of these adults. In a cross-sectional study, Khoo *et al.* (2004) identified obesity and neck circumference, among several other factors, as risk factors for snoring and sleep-disordered breathing in an Asian population. In a large cohort study, patients with obstructive sleep apnea syndrome were found to be more obese (Yaggi *et al.*, 2005). In the present study, persons reporting sleep problems three to seven times per week had a mean BMI of approximately $30\,kg/m^2$, which is indicative of obesity. Anatomical reasons for sleep-disordered breathing problems include large tonsils, a long pharyngeal airway, and the collapsibility potential of the airway (Schellenberg *et al.*, 2000; Malhotra *et al.*, 2002).

We found no significant association between any of the anthropometric measures and duration of sleep – although these results may have been partially due to small sample size. These results contradict some previous findings (Hasler *et al.*, 2004). Results from the National Sleep Foundation survey found that those who were considered obese were more likely than those who were underweight or average weight

to sleep less than six hours per night on weekdays (18 percent vs. 11 percent) and to be at risk for sleep apnea (57 percent vs. 10 percent) (National Sleep Foundation, 2005). In a prospective study of 1,001 patients from four primary care practices in Virginia, total sleep time decreased as BMI increased, except in the extremely obese group (Vorona *et al.*, 2005). This association was found even after patients with sleep disorders were excluded.

Physiology may play an important role in the obesity-sleep association. In a clinical trial, sleep restriction was observed to increase appetite, especially for calorie-dense foods with high carbohydrate content, and reduce secretion of the anorexigenic hormone leptin (Spiegel *et al.*, 2004). Among 1024 participants of the Wisconsin Sleep Cohort Study, serum ghrelin, leptin, adiponectin, insulin, and glucose were significantly correlated with BMI (Taheri *et al.*, 2004). There was a significant increasing trend in leptin with increasing average nightly sleep duration, and a significant decreasing trend in ghrelin with increasing total sleep time. Leptin suppresses appetite while ghrelin stimulates appetite (Taheri *et al.*, 2004). It is possible that a vicious cycle is created when sleep loss results in decreased leptin production causing an increase in appetite which results in obesity. Then obesity may increase the risk of sleep-disordered breathing problems which would exacerbate the sleep-deprived condition and decrease leptin levels. These potential pathways could be explored in future prospective studies.

Depression may also play an integral role in the association between obesity and sleep. Several studies have shown that obese persons tend to experience more symptoms of depression than persons of normal weight (Kress *et al.*, 2006; Herva *et al.*, 2006; Simon *et al.*, 2006) and that depression can also result in obesity (Goodman and Whitaker, 2002). There is also evidence to support the fact that depressed persons have more disturbed sleep than those who are not depressed (Kaneita *et al.*, 2006). Disturbed sleep affects levels of melatonin, a substance that is primarily secreted by the pineal gland and is produced during the night to promote sleep (Pandi-Perumal *et al.*, 2006). In turn, low levels of melatonin are associated with depression (Pandi-Perumal *et al.*, 2006), which creates or further exacerbates any existing sleep disorders and obesity.

There are limitations to this study. The information on sleep quality was obtained by subjective reporting with no objective means of validating the responses and the possibility exists that sleep problems may have been overstated or understated. Such bias would likely have been non-differential, with a tendency to weaken any association that may have existed. The use of self-reported instead of measured sleep duration is less likely to be problematic because the congruency between self-reported sleep duration is likely to be good with those obtained through actigraphic monitoring. Due to the cross-sectional design of the study, we are unable to determine the temporal nature of the associations between sleep problems and obesity. Another limitation is the relatively small sample size, which prevented stratification of the models by sex.

A major strength of the study was that it was conducted in a cooperative and motivated study population. We were able to assess a wide range of anthropometric measurements, including many that are important but are rarely used to measure obesity in epidemiologic studies such as abdominal height, neck circumference, and neck-to-height ratio. In addition, the assessment of the anthropometric indices was performed by trained clinic staff using standardized procedures. Although we did not

use a standardized sleep questionnaire, several of the sleep questions used in this study are also used in validated questionnaires. Finally, we were able to assess the potential effects of confounding.

In conclusion, results show that several measures of obesity were significantly associated with sleep-disordered breathing problems in this sample of police officers. Previous studies have shown that severe sleep-disordered breathing is associated with an increased risk of cardiac arrhythmias, stroke, and death (Mehra *et al.*, 2006; Yaggi *et al.*, 2005) and that police officers are disproportionately at risk for such health problems (Violanti *et al.*, 1998). Future studies investigating this question are recommended and would be enhanced by using a prospective design and optimal indicators of obesity.

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