



## Original Contribution

### Nocturia and Obesity: A Population-based Study in Finland

Kari A. O. Tikkinen<sup>1,2</sup>, Anssi Auvinen<sup>2</sup>, Heini Huhtala<sup>2</sup>, and Teuvo L. J. Tammela<sup>1</sup>

<sup>1</sup> Department of Urology, Tampere University Hospital and Medical School, University of Tampere, Tampere, Finland.

<sup>2</sup> Tampere School of Public Health, University of Tampere, Tampere, Finland.

Received for publication July 12, 2005; accepted for publication January 5, 2006.

The authors' aim in this study was to analyze the association of nocturia with overweight and obesity. In 2003–2004, a questionnaire was mailed to 6,000 randomly selected Finns aged 18–79 years who were identified from the Finnish Population Register Centre. Information on nocturia was collected through questionnaires using the Danish Prostatic Symptom Score and the American Urological Association Symptom Index. Self-reported body weight and height were used to calculate body mass index (BMI; weight (kg)/height (m)<sup>2</sup>). Subjects were classified on the basis of BMI as nonoverweight (BMI <25), overweight (BMI 25–29.9 kg/m<sup>2</sup>), or obese (BMI ≥30). Of the 6,000 subjects, 62.4% participated. Among men, the age-standardized prevalence of nocturia, defined as at least one void per night, was 33.4% (95% confidence interval (CI): 28.5, 38.3) in the nonoverweight, 35.8% (95% CI: 31.4, 40.1) in the overweight, and 48.2% (95% CI: 38.8, 57.6) in the obese. Among women, the corresponding figures were 37.2% (95% CI: 33.0, 41.5) in the nonoverweight, 48.3% (95% CI: 42.5, 54.2) in the overweight, and 53.6% (95% CI: 43.9, 63.2) in the obese. The associations remained similar when nocturia was defined as two or more voids per night. The age-standardized attributable fraction (population) of increased BMI for nocturia was 17.7% for men and 18.5% for women, corresponding to an 8.5% increase in the crude prevalence of nocturia in men and a 13.9% increase in women. The authors conclude that obesity is associated with increased nocturia, more strongly among women than among men.

age factors; body mass index; obesity; prevalence; sex; urination disorders

Abbreviations: BMI, body mass index; CI, confidence interval.

Nocturia is one of the most common and bothersome of all urologic symptoms. It is among the most important reasons for persistent insufficient sleep, which contributes to mental and somatic disease (1). The International Continence Society defines nocturia as waking at night one or more times to void (2).

Obesity is a worldwide epidemic with numerous medical consequences (3). In the United States, obesity was not considered an issue of interest in the mid-1980s, but it had become more common; and by 2000, approximately 20 percent of the US adult population was obese (4). In Finland, body mass index (BMI; weight (kg)/height (m)<sup>2</sup>) and the

prevalence of obesity are also increasing to nearly the same magnitude (5).

Among men, prostate size or prostate growth rate has been found to be positively associated with BMI (6). The associations are still unclear for lower urinary tract symptoms. Weight gain and central adiposity may be associated with lower urinary tract symptoms (7). Rohrmann et al. (7) and Haidinger et al. (8) found a positive association between lower urinary tract symptoms and waist circumference but not between lower urinary tract symptoms and current BMI. Several controversies persist concerning an association between nocturia and benign prostatic hyperplasia. Blanker

Correspondence to Dr. Kari A. O. Tikkinen, Building K, Medical School, FIN-33014 University of Tampere, Tampere, Finland (e-mail: kari.tikkinen@uta.fi).

et al. (9) concluded that nocturia is highly associated with benign prostatic hyperplasia. On the other hand, in Japan, Homma et al. (10) reported that nocturia is the least specific symptom associated with benign prostatic hyperplasia and the symptom that is least responsive to treatment for benign prostatic hyperplasia.

Among women, a clear association between BMI and urinary incontinence has been found in several studies (11), but Elia et al. (12) did not find any association between nocturia and BMI. On the other hand, Asplund and Åberg (13) found that high BMI increased nocturia among women aged 40–64 years. Moreover, in their questionnaire study of 430 patients of both sexes with type 2 diabetes, Bulpitt et al. (14) found that reported frequency of nocturia increased with BMI independently of other symptoms.

We aimed to explore the association between nocturia and obesity in a comprehensive, population-based study comprising persons of both sexes aged 18–79 years.

## MATERIALS AND METHODS

### Study design

Between November 2003 and February 2004, a questionnaire was mailed to a random sample of 3,000 men and 3,000 women aged 18–79 years who were identified from the Finnish Population Register Centre. Stratification by age was used in subject selection, with oversampling of the younger age groups to ensure similar levels of accuracy even in age groups with lower nocturia frequency. Information on voiding symptoms was collected using the validated Danish Prostatic Symptom Score questionnaire (15), with an additional question from the American Urological Association Symptom Index (16). The questionnaire also included items related to anthropometric factors (weight and height) and comorbidity (gynecologic, internal, musculoskeletal, neurologic, psychiatric, and/or urologic diseases). Questionnaires were first mailed in late November 2003, with reminders being sent a month later. To persons who did not respond, a final round of questionnaires was mailed in February 2004.

Nocturia was defined as any nighttime voiding (2). Responses to nocturia questions from the Danish Prostatic Symptom Score (“How many times do you have to void per night?”) and the American Urological Association Symptom Index (“Had to get up to urinate from the time you went to bed at night until you got up in the morning?”) were combined. Danish Prostatic Symptom Score was elicited for the past 2 weeks, and the American Urological Association Symptom Index question pertained to the past month. In this study, the definition of nocturia was at least one void per night. A secondary analysis was conducted with nocturia defined as at least two voids per night.

Current self-reported body weight and height were used to calculate BMI. As suggested by the World Health Organization (17), subjects with BMIs of 25–29.9 were classified as overweight, and those with BMIs of 30 or more were classified as obese.

Only five male respondents (0.3 percent) were underweight (BMI <18.5), while 57 female respondents (3.0 per-

cent) were underweight. There was no difference in the prevalence of nocturia among underweight women compared with normal-weight women by either criterion ( $\geq 1$  void/night or  $\geq 2$  voids/night). Hence, we used nonoverweight (normal-weight and underweight; BMI <25) persons as the reference group for both men and women.

In accordance with Finnish regulations on questionnaire surveys, an exemption from ethical review was granted by the ethical committee of Tampere University Hospital (Tampere, Finland).

### Statistical analysis

Subjects were stratified into six 10-year age groups (18–29, 30–39, 40–49, 50–59, 60–69, and 70–79 years). Age-standardized prevalence was calculated using the European standard population (18). Logistic regression was used for multivariate analysis, with the presence or absence of nocturia used as the outcome measure. All confidence intervals were likelihood-based. All analyses were performed using the SPSS program, version 12.0.1 (SPSS, Inc., Chicago, Illinois).

Tests for trend were conducted with logistic regression by including trichotomous BMI as a continuous variable in the models. Departure from linearity was assessed by adding a continuous BMI term to a model already containing a categorical BMI variable and assessing the improvement in the fit of the model (likelihood ratio test). Effect modification was assessed on the basis of the statistical significance of the interaction term (BMI  $\times$  age) in a model containing the main effects (BMI, age).

The attributable fraction in the exposed, the attributable fraction in the population, and the attributable number were calculated according to *A Dictionary of Epidemiology* (19). The attributable fraction in the exposed ( $AF_e$ ) is the proportion by which the prevalence of nocturia among exposed persons (the overweight and the obese) would be reduced if the exposure (overweight and obesity) were eliminated. It can be estimated using the formula

$$AF_e = (P_e - P_u) / P_e,$$

where  $P_e$  is the prevalence of nocturia among the exposed (the overweight and the obese) and  $P_u$  is the prevalence of nocturia among the unexposed (the nonoverweight; BMI <25).

The attributable fraction in the population ( $AF_p$ ) is the proportion by which the prevalence of nocturia in the entire population would be reduced if overweight and obesity were eliminated. It can be estimated using the formula

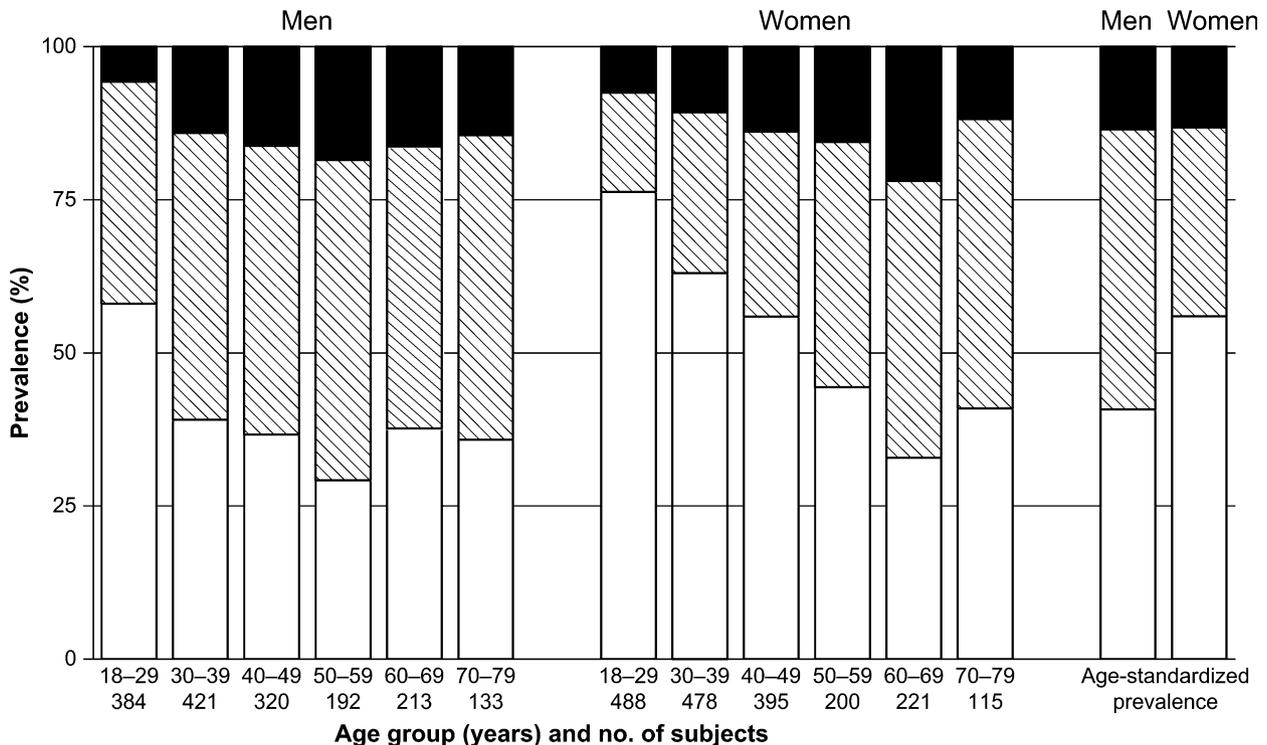
$$AF_p = (P_p - P_u) / P_p,$$

where  $P_p$  is the prevalence of nocturia in the total population and  $P_u$  is the prevalence of nocturia among the nonoverweight.

The attributable number (AN) is the number of prevalent cases of nocturia attributable to overweight and obesity. It can be estimated using the formula

$$AN = N_e \times (P_e - P_u),$$

where  $N_e$  is the number of persons in the exposed population (the overweight and the obese),  $P_e$  is the prevalence of



**FIGURE 1.** Prevalence of overweight and obesity among men and women in a random sample of 3,560 people in Finland, 2003–2004. The white bars indicate subjects with a body mass index (BMI; weight (kg)/height (m)<sup>2</sup>) under 25 (reference group); the bars with diagonal lines indicate subjects with a BMI of 25–29.9 (overweight); and the black bars indicate subjects with a BMI of 30 or more (obese). Age-standardization was performed using the European standard population (18).

nocturia among the overweight and obese, and  $P_u$  is the prevalence of nocturia among the nonoverweight.

Regarding all of the above formulas, it is assumed that causes other than the one under investigation have had equal effects on the exposed and unexposed groups. The attributable fractions in the exposed and in the population were calculated as percentages, and the attributable number was calculated as number of cases per 1,000 subjects.

The mean BMIs for all mailing rounds were calculated by sex and age group for estimation of possible selection bias due to nonresponse. The differences between rounds were small and nonsystematic (mean BMIs by round among men: 26.10, 26.39, and 26.31; mean BMIs by round among women: 24.67, 25.37, and 25.36).

## RESULTS

Of the 3,000 men approached for the study, 1,726 (57.8 percent) took part; 12 (0.4 percent) were ineligible because of serious disability or disease, death, or emigration. Of the 3,000 women approached, 2,003 (67.0 percent) participated; 11 (0.4 percent) were ineligible. Hence, overall 62.4 percent of the eligible subjects responded. Of the participants, 1,663 men (96.3 percent) and 1,897 women (94.7 percent) answered all of the nocturia questions and responded to both anthropometric questions (height and weight). Among men,

the response proportions by mailing round were as follows: first round, 47.1 percent ( $n = 784$ ); second round, 29.3 percent ( $n = 488$ ); and third round, 17.2 percent ( $n = 286$ ). Among women, the corresponding figures were: first round, 55.5 percent ( $n = 1,052$ ); second round, 25.8 percent ( $n = 490$ ); and third round, 13.2 percent ( $n = 251$ ). Mailing round could not be defined for 6.3 percent of men ( $n = 105$ ) and 5.5 percent of women ( $n = 104$ ) because they did not give the date of questionnaire completion.

The mean age of male respondents was 43.5 years (standard deviation, 16.3), and the median was 41.0 years; the corresponding figures for women were 42.0 years (standard deviation, 15.7) and 39.0 years. Of the respondents, 64.8 percent of men did not report any nocturia; 23.7 percent reported voiding once per night; and 11.5 percent reported voiding twice or more per night. Among women, 58.6 percent did not report any nocturia; 30.0 percent reported voiding once per night; and 11.4 percent reported voiding twice or more per night.

The age-standardized prevalence of obesity (BMI  $\geq 30$ ) was 13.5 percent (95 percent confidence interval (CI): 11.7, 15.4) among men and 13.2 percent (95 percent CI: 11.5, 14.9) among women. Among men, the age-standardized prevalence of overweight (BMI 25–29.9) was 45.7 percent (95 percent CI: 42.4, 49.1), and among women it was 30.8 percent (95 percent CI: 28.2, 33.5) (figure 1). The

**TABLE 1. Mean body mass index\* (BMI) by sex and age group in a random sample of 3,560 people in Finland, 2003–2004**

Age group (years)	Men		Women	
	No.	BMI	No.	BMI
18–29	384	24.8 (3.5)†	488	23.2 (4.2)
30–39	421	26.4 (4.0)	478	24.6 (4.9)
40–49	320	26.8 (4.1)	395	25.4 (5.2)
50–59	192	27.2 (3.8)	200	26.0 (4.5)
60–69	213	26.7 (4.0)	221	27.5 (5.4)
70–79	133	26.3 (3.3)	115	26.3 (4.1)
All	1,663	26.2 (3.9)	1,897	25.0 (4.9)
Age-standardized‡		26.3 (3.9)		25.2 (5.2)

\* Weight (kg)/height (m)<sup>2</sup>.

† Numbers in parentheses, standard deviation.

‡ European standard population (18).

age-standardized mean BMI was 26.3 (standard deviation, 3.9) for men and 25.2 (standard deviation, 5.2) for women (table 1).

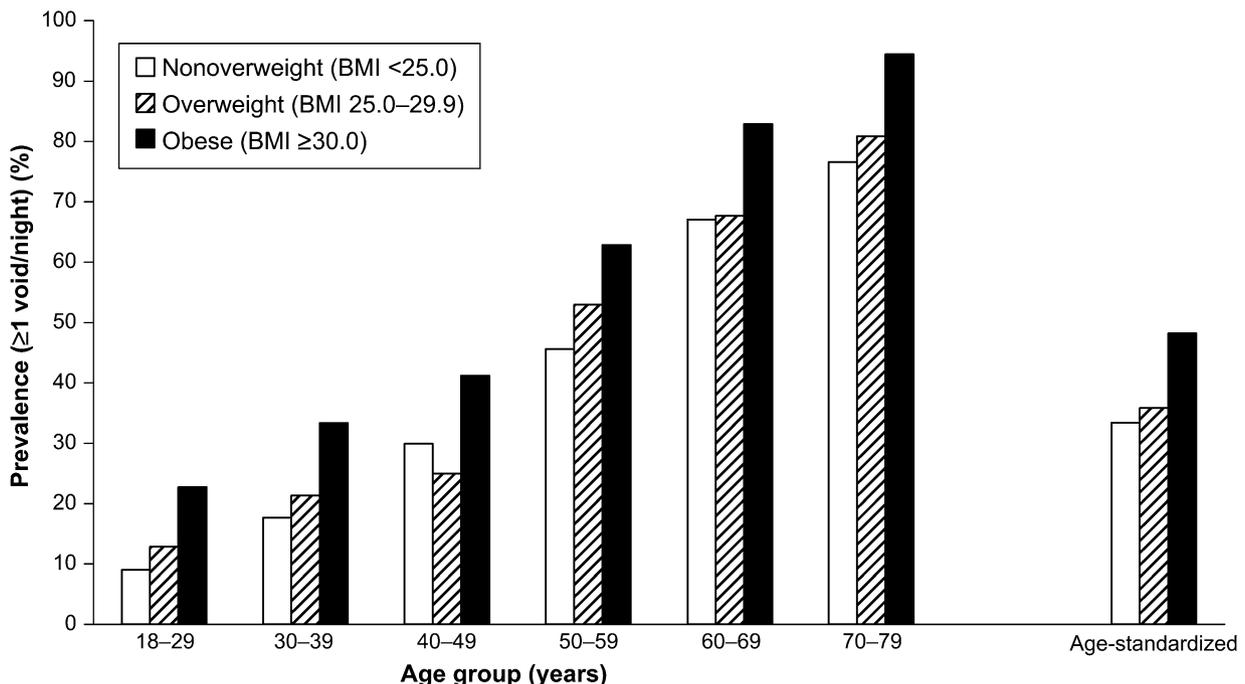
Among men, the age-standardized (European standard) prevalence of nocturia ( $\geq 1$  void/night) was 33.4 percent (95 percent CI: 28.5, 38.3) for the nonoverweight, 35.8 percent (95 percent CI: 31.4, 40.1) for the overweight, and 48.2 percent (95 percent CI: 38.8, 57.6) for the obese (figure 2). For the second criterion ( $\geq 2$  voids/night), the corresponding

figures were 10.2 percent (95 percent CI: 7.48, 12.9) for the nonoverweight, 11.2 percent (95 percent CI: 8.84, 13.6) for the overweight, and 16.6 percent (95 percent CI: 11.6, 21.5) for the obese (figure 3).

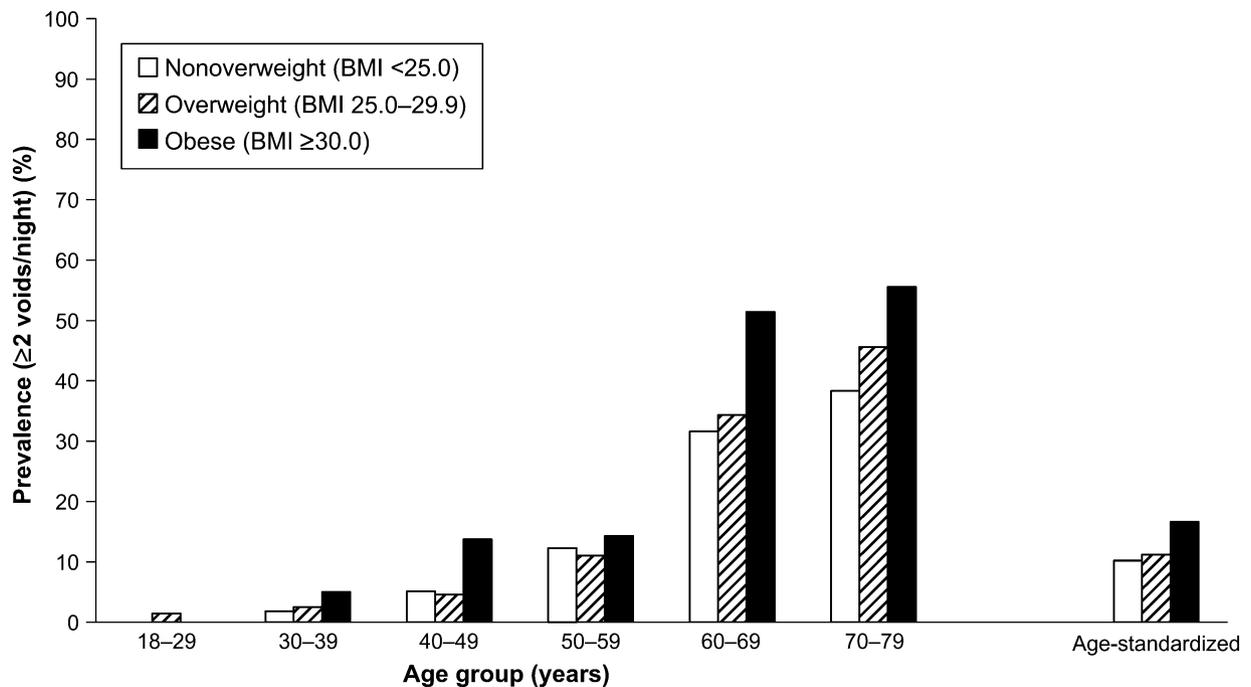
Among women, the age-standardized prevalence of nocturia ( $\geq 1$  void/night) was 37.2 percent (95 percent CI: 33.0, 41.5) for the nonoverweight, 48.3 percent (95 percent CI: 42.5, 54.2) for the overweight, and 53.6 percent (95 percent CI: 43.9, 63.2) for the obese (figure 4). For the second criterion ( $\geq 2$  voids/night), the corresponding figures were 8.2 percent (95 percent CI: 6.12, 10.3) for the nonoverweight, 14.8 percent (95 percent CI: 11.6, 18.0) for the overweight, and 22.6 percent (95 percent CI: 16.4, 28.9) for the obese (figure 5).

Among men, there was a consistent association between increasing BMI and nocturia across age groups. Nocturia (defined as  $\geq 1$  void/night) was more common among obese men than among nonoverweight men in every age group from early adulthood to old age (figure 2). In every age group, the prevalence of nocturia among obese men was approximately 15 percentage points higher than that among nonoverweight men. In the secondary analysis, nocturia (defined as  $\geq 2$  voids/night) was also more common among obese men than among nonoverweight men (figure 3).

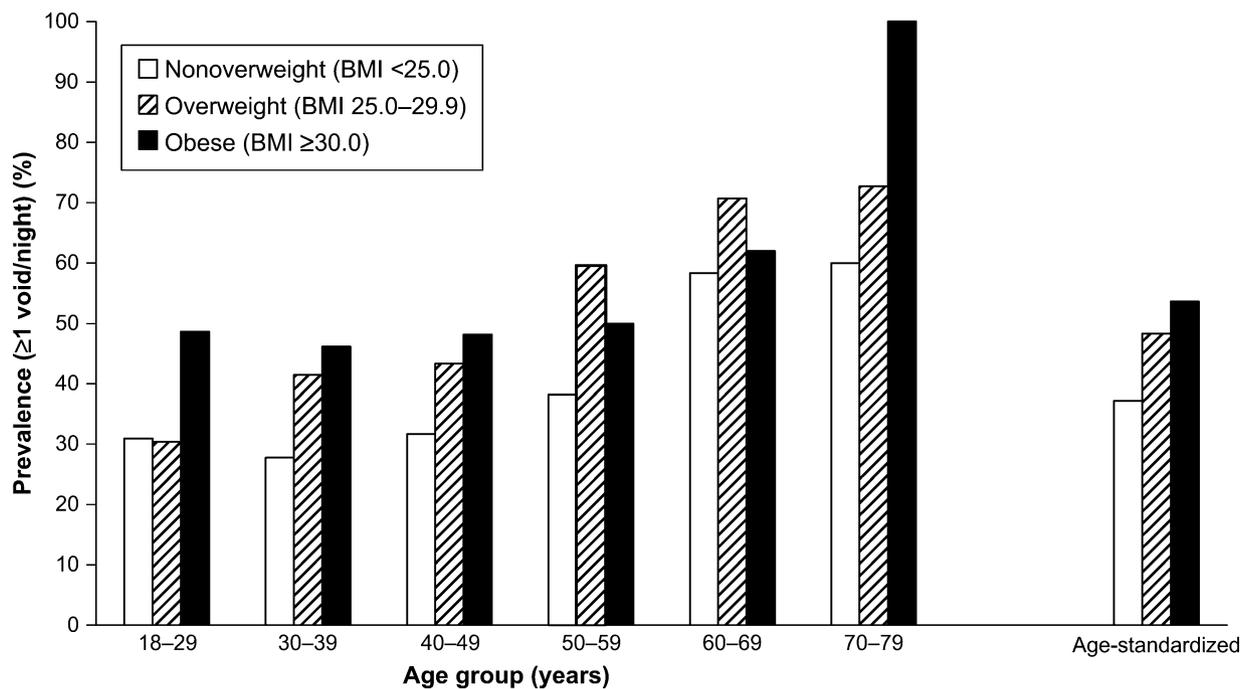
Among women, premenopausal (aged 18–49 years) obese women had an approximately 18 percentage points' higher prevalence of nocturia (defined as  $\geq 1$  void/night) than nonoverweight women. Among menopausal and postmenopausal women (aged 50–69 years), nocturia was more



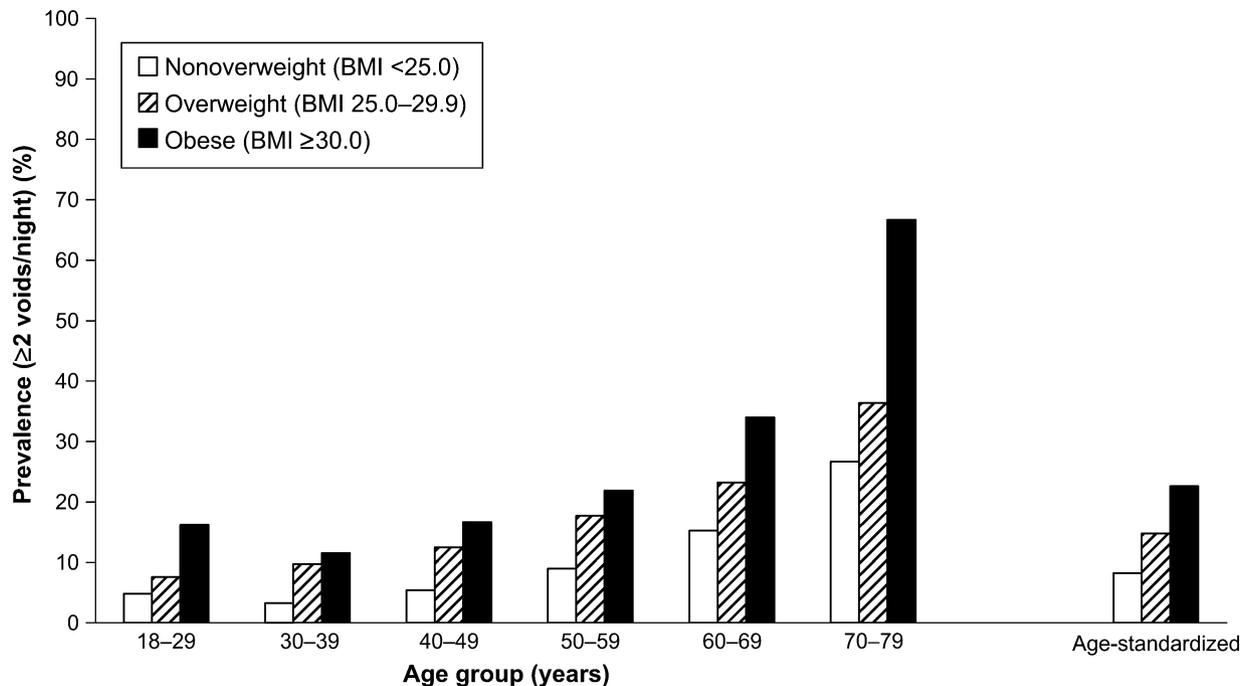
**FIGURE 2.** Prevalence of nocturia (defined as at least one void per night) in a random sample of 1,663 men in Finland, 2003–2004. The white bars indicate nonoverweight subjects (self-reported body mass index (BMI; weight (kg)/height (m)<sup>2</sup>) <25); the bars with diagonal lines indicate overweight subjects (BMI 25–29.9); and the black bars indicate obese subjects (BMI  $\geq 30$ ). Age-standardization was performed using the European standard population (18).



**FIGURE 3.** Prevalence of nocturia (defined as at least two voids per night) in a random sample of 1,663 men in Finland, 2003–2004. The white bars indicate nonoverweight subjects (self-reported body mass index (BMI; weight (kg)/height (m)<sup>2</sup>) <25); the bars with diagonal lines indicate overweight subjects (BMI 25–29.9); and the black bars indicate obese subjects (BMI ≥30). Age-standardization was performed using the European standard population (18).



**FIGURE 4.** Prevalence of nocturia (defined as at least one void per night) in a random sample of 1,897 women in Finland, 2003–2004. The white bars indicate nonoverweight subjects (self-reported body mass index (BMI; weight (kg)/height (m)<sup>2</sup>) <25); the bars with diagonal lines indicate overweight subjects (BMI 25–29.9); and the black bars indicate obese subjects (BMI ≥30). Age-standardization was performed using the European standard population (18).



**FIGURE 5.** Prevalence of nocturia (defined as at least two voids per night) in a random sample of 1,897 women in Finland, 2003–2004. The white bars indicate nonoverweight subjects (self-reported body mass index (BMI; weight (kg)/height (m)<sup>2</sup>) <25); the bars with diagonal lines indicate overweight subjects (BMI 25–29.9); and the black bars indicate obese subjects (BMI ≥30). Age-standardization was performed using the European standard population (18).

frequent among the overweight than among the obese (figure 4). Using nonoverweight (BMI <25) women as the reference group, nocturia odds ratios for the overweight women were 2.38 (95 percent CI: 1.28, 4.42) and 1.72 (95 percent CI: 0.91, 3.26) for the age groups 50–59 years and 60–69 years, respectively. In these age groups, odds ratios for overweight women in relation to obese women were 1.47 (95 percent CI: 0.64, 3.35) and 1.48 (95 percent CI: 0.72, 3.03), respectively. Thus, overweight women did not report significantly more nocturia than obese women. In every other age group, obese women had more nocturia than other women. In the secondary analysis, the obese subjects had more nocturia (defined as ≥2 voids/night) than the overweight and nonoverweight subjects in each age group. Obese women had nocturia at least twice as often as nonoverweight women in every age group (figure 5).

We also performed multivariate analysis with adjustment for gynecologic, internal, musculoskeletal, neurologic, psychiatric, and urologic diseases. Adjustment for comorbidity did not materially affect the results. The greatest difference between adjusted and unadjusted nocturia odds ratios for different BMI groups was observed among obese men (with nocturia defined as ≥2 voids/night and subjects with BMI <25 used as the reference group). The adjusted odds ratio was 2.42, and the unadjusted odds ratio was 2.25. Thus, there was no substantial confounding.

Overall, subjects with higher BMI had more nocturia. The age-standardized attributable fraction of nocturia in the ex-

posed (the overweight and obese) was 26.8 percent for men and 35.2 percent for women (table 2). The age-standardized attributable fraction in the population was 17.7 percent for men and 18.5 percent for women. After age-standardization, nocturia attributable to overweight and obesity (the attributable number) in the entire study population was 62 per 1,000 men and 77 per 1,000 women.

BMI was a risk factor for nocturia. Increasing BMI predicted nocturia overall for both men and women ( $p < 0.001$  for both). There was no statistically significant interaction between BMI and age (with nocturia defined as ≥1 void/night,  $p = 0.86$  for men and  $p = 0.13$  for women; with nocturia defined as ≥2 voids/night,  $p = 0.66$  and  $p = 0.62$ , respectively). Thus, there was no effect modification. There was no statistically significant departure from linearity in either sex.

## DISCUSSION

Overall, in our survey of approximately 3,600 subjects, nocturia increased with increasing age and BMI. Among nonoverweight subjects aged 30–39 years, only one out of 50 men and one out of 30 women reported voiding two or more times per night. Among obese subjects aged 30–39 years, the corresponding figures were one out of 20 for men and one out of nine for women. Among nonoverweight subjects aged 70–79 years, slightly more than every third

**TABLE 2. Odds ratios for nocturia (defined as at least one void per night) by body mass index,\* sex, and age group and the fraction of nocturia attributable to overweight (BMI  $\geq 25$ ) in a random sample of 3,560 people in Finland, 2003–2004**

Age group (years)	Body mass index†				p for trend	Attributable fraction in the exposed (%)	Attributable fraction in the population (%)	Attributable number (per 1,000 subjects)
	25–29.9		$\geq 30$					
	OR‡	95% CI‡	OR	95% CI				
<b>Men</b>								
18–29	1.49	0.75, 2.93	2.97	0.99, 8.91	0.050	36.5	19.5	22
30–39	1.26	0.75, 2.14	2.33	1.19, 4.55	0.021	26.7	18.2	39
40–49	0.78	0.46, 1.34	1.64	0.83, 3.25	0.342	–2.9	–1.8	–5
50–59	1.34	0.70, 2.58	2.02	0.85, 4.77	0.111	17.9	13.3	70
60–69	1.03	0.55, 1.93	2.37	0.88, 6.42	0.151	6.4	4.1	29
70–79	1.29	0.52, 3.20	5.19	0.62, 43.6	0.132	8.5	5.7	46
All men	1.38	1.11, 1.73	2.61	1.91, 3.56	<0.001	13.5	8.5	31
All men§						26.8	17.7	62
<b>Women</b>								
18–29	0.98	0.57, 1.65	2.12	1.07, 4.18	0.086	14.6	3.9	13
30–39	1.85	1.19, 2.86	2.23	1.23, 4.07	0.001	35.3	16.7	55
40–49	1.64	1.04, 2.61	2.00	1.09, 3.67	0.008	29.3	15.5	58
50–59	2.38	1.28, 4.42	1.62	0.72, 3.65	0.061	32.7	21.2	103
60–69	1.72	0.91, 3.26	1.17	0.56, 2.44	0.537	13.9	9.8	64
70–79	1.78	0.77, 4.12	—¶		0.005	23.6	15.9	113
All women	2.06	1.67, 2.53	2.32	1.75, 3.08	<0.001	25.3	13.9	60
All women§						35.2	18.5	77

\* Weight (kg)/height (m)<sup>2</sup>.

† Reference category: body mass index &lt;25 (nonoverweight).

‡ OR, odds ratio; CI, confidence interval.

§ Age-standardized (European standard population (18)).

¶ All of the subjects had nocturia.

man and approximately every fourth woman reported having at least two voids per night. In this age group, more than half of obese men and two thirds of obese women reported having at least two voids per night. The results were parallel with those obtained when nocturia was defined as at least one void per night.

Nocturia has been considered a multifactorial symptom caused by several urologic and nonurologic factors, such as nocturnal polyuria, low nocturnal bladder capacity, mixed nocturia (nocturnal polyuria and low nocturnal bladder capacity), and polyuria (1). Benign prostatic hyperplasia has been regarded as an underlying factor for a high prevalence of nocturia among men (20), but Bruskevitz et al. (21) reported nocturia in 38 percent of their patients 1 year after transurethral resection of the prostate (nocturia was defined as  $\geq 2$  voids/night). High prevalence rates of nocturia among women suggest that other factors are also involved in nocturnal voiding (12, 22, 23). Simple overproduction of urine during the night is a common etiology (24).

Obesity is a multifactorial disease with adverse health consequences such as cardiovascular disease, type 2 diabetes mellitus, hypertension, sleep apnea, and possibly depression (3). All of these diseases may be associated with

increased risk of nocturia (2, 25). However, in our study, the impact of obesity on nocturia did not materially change after results were adjusted for comorbidity, indicating lack of confounding.

Few studies have explored the association between nocturia and obesity. In earlier studies of lower urinary tract symptoms, Rohrmann et al. (7) and Haidinger et al. (8) found a positive association between greater waist circumference and lower urinary tract symptoms but not between lower urinary tract symptoms and BMI. Rohrmann et al. (7) reported incomplete emptying, hesitancy, and a weak urine stream in addition to nocturia among US men aged 60 years or more. Subjects with three symptoms out of four were defined as lower urinary tract symptom cases (if they had not undergone prostate surgery). Haidinger et al. (8) also reported on lower urinary tract symptom cases, not nocturia cases. Their study population consisted of Viennese men aged 40 years or more.

Our aim in this study was to obtain a generalizable, unbiased estimate of an association between nocturia and obesity. Therefore, no exclusion criteria (such as pregnancy) were used, and no exclusions were made except for persons with serious disability or disease and persons who had died

or emigrated. The study population was representative of the Finnish population in terms of sociodemographic factors (22, 26, 27).

Self-reported BMI was used as an indicator of obesity. Although the correlation between BMI and body fat adjusted for age is high ( $r = 0.82\text{--}0.91$ ) (28), it is not possible to distinguish lean body mass from fat on the basis of BMI. For example, the proportion of body fat is higher among women than among men with a similar BMI. In addition, body fatness has been shown to increase with age; that is, similar BMIs may correspond to a greater body fat content in older subjects compared with younger subjects (29, 30). Despite these limitations, BMI is a simple and useful measure of obesity in adults. A BMI of 30 is a widely recognized cutoff point for obesity, and the cutoff point for overweight (BMI  $\geq 25$ ) is recommended by the World Health Organization (17).

Our study population ( $n = 3,560$ ) was representative of the Finnish population in terms of BMI in comparison with population surveys carried out by the National Public Health Institute (31). On the other hand, obesity was more common (age-standardized among subjects aged  $\geq 30$  years, 21.2 percent of men and 23.5 percent of women had a measured BMI  $\geq 30$ ) in a recent population-based study of 8,000 persons (32). The former study was comparable to ours in the sense that it was based on self-reported weight and height (31). The difference in comparison with the latter population sample may be due to two facts: First, their study population was older (in our study, obesity prevalence was higher when the age group was restricted to persons aged  $\geq 30$  years—16.1 percent of men and 14.6 percent of women) (32), and second, obese people tend to underestimate their obesity in questionnaire surveys (33–35). However, regarding nocturia, postal questionnaire responses have been reported to reflect urodynamics better than interview-assisted questionnaire responses (36).

In our study, mean BMIs did not vary markedly by response round. In a previous report (22), we assessed differences between participants and nonparticipants in terms of marital status, education, employment, and urbanity and found no major differences. These findings indicate a lack of selection bias.

In the present study, nocturia was substantially more common among subjects with higher BMIs than among those with lower BMIs. The only exception was perimenopausal women (aged 50–69 years), among whom overweight subjects reported more nocturia (only with the definition of  $\geq 1$  void/night) than did obese subjects. However, the difference was not statistically significant. This is in accordance with the finding reported by Asplund and Åberg (13). Among perimenopausal women aged 40–64 years, they found more nocturia among subjects with BMI  $\geq 30$  than among subjects with BMI  $< 20$ . They reported more nocturia among obese women than among overweight women, but the difference was not significant (13). Likewise, among women aged 50–59 years, Teleman et al. (37) reported that overactive bladder was more common in subjects with increased BMI and other risk factors for metabolic syndrome. By contrast, Elia et al. (12) did not find any association between increased BMI and nocturia in their study of 540 female outpatients.

Nocturia is more common in obese men and women than in normal-weight men and women. The etiology of nocturia is still unclear, and the factors underlying an association between nocturia and obesity are even more ambiguous. Nonurologic causes of nocturia are more frequent among obese subjects. Lifestyle-related factors that increase the risk of nocturia may also be more common among the obese than among persons of normal weight. It is possible that nocturia in some obese persons is related to excessive nighttime eating (38) or drinking, especially alcohol drinking (39). However, few studies have addressed this issue.

Nocturia is one of the most bothersome of all urologic symptoms, and obesity is a worldwide epidemic with several associated comorbidities. To our knowledge, this is the first population-based study of the association between nocturia and obesity that included subjects of both sexes and all age groups, ranging from young adults to elderly persons. Age-standardization improves the comparability of these findings with those of other studies, as well as generalizability to other populations. We conclude that obesity accounts for a substantial proportion of nocturia in both sexes. Potentially, preventing obesity may also decrease nocturia, though establishing causality would ideally require an intervention study.

---

## ACKNOWLEDGMENTS

This study was financially supported in part by an unrestricted grant from Pfizer Inc. (New York, New York) and the Medical Research Fund of Tampere University Hospital (Tampere, Finland).

The authors thank Drs. Hai Tao Jin, Aila Rissanen, and Raili Salmelin for their valuable comments on earlier versions of the manuscript.

Conflict of interest: none declared.

---

## REFERENCES

- Weiss JP, Blaivas JG. Nocturia. *J Urol* 2000;163:5–12.
- van Kerrebroeck P, Abrams P, Chaikin D, et al. The standardization of terminology in nocturia: report from the standardization subcommittee of the International Continence Society. *Neurourol Urodyn* 2002;21:179–83.
- Racette SB, Deusinger SS, Deusinger RH. Obesity: overview of prevalence, etiology, and treatment. *Phys Ther* 2003;83:276–88.
- Mokdad AH, Bowman BA, Ford ES, et al. The continuing epidemics of obesity and diabetes in the United States. *JAMA* 2001;286:1195–200.
- Lahti-Koski M, Vartiainen E, Männistö S, et al. Age, education and occupation as determinants of trends in body mass index in Finland from 1982 to 1997. *Int J Obes* 2000;24:1669–76.
- Gann PH, Hennekens CH, Longcope C, et al. A prospective study of plasma hormone levels, nonhormonal factors, and development of benign prostatic hyperplasia. *Prostate* 1995;26:40–9.
- Rohrmann S, Smit E, Giovannucci E, et al. Associations of obesity with lower urinary tract symptoms and noncancer prostate surgery in the Third National Health and Nutrition Examination Survey. *Am J Epidemiol* 2004;159:390–7.

8. Haidinger G, Temml C, Schatzl G, et al. Risk factors for lower urinary tract symptoms in elderly men. For the Prostate Study Group of the Austrian Society of Urology. *Eur Urol* 2000;37:413–20.
9. Blanker MH, Bohnen AM, Groeneveld FP, et al. Normal voiding patterns and determinants of increased diurnal and nocturnal voiding frequency in elderly men. *J Urol* 2000;164:1201–5.
10. Homma Y, Yamaguchi T, Kondo Y, et al. Significance of nocturia in the International Prostate Symptom Score for benign prostatic hyperplasia. *J Urol* 2002;167:172–6.
11. Holroyd-Leduc JM, Straus SE. Management of urinary incontinence in women: scientific review. *JAMA* 2004;291:986–95.
12. Elia G, Dye TD, Scariati PD. Body mass index and urinary symptoms in women. *Int Urogynecol J* 2001;12:366–9.
13. Asplund R, Åberg HE. Nocturia in relation to body mass index, smoking and some other life-style factors in women. *Climacteric* 2004;7:267–73.
14. Bulpitt CJ, Palmer AJ, Battersby C, et al. Association of symptoms of type 2 diabetic patients with severity of disease, obesity, and blood pressure. *Diabetes Care* 1998;21:111–15.
15. Schou J, Poulsen AL, Nordling J. The value of a new symptom score (DAN-PSS) in diagnosing uro-dynamic infravesical obstruction in BPH. *Scand J Urol Nephrol* 1993;27:489–92.
16. Barry MJ, Fowler FJ Jr, O'Leary MP, et al. The American Urological Association symptom index for benign prostatic hyperplasia. The Measurement Committee of the American Urological Association. *J Urol* 1992;148:1549–57.
17. World Health Organization. Physical status: the use and interpretation of anthropometry. Report of a WHO Expert Committee. (WHO Technical Report Series no. 854). Geneva, Switzerland: World Health Organization, 1995.
18. dos Santos Silva I. Cancer epidemiology: principles and methods. 2nd ed. Lyon, France: International Agency for Research on Cancer, 1999.
19. Last JM, ed. A dictionary of epidemiology. 4th ed. New York, NY: Oxford University Press, 2001.
20. Britton JP, Dowell AC, Whelan P. Prevalence of urinary symptoms in men aged over 60. *Br J Urol* 1990;66:175–6.
21. Bruskewitz RC, Larsen EH, Madsen PO, et al. Three-year follow-up of urinary symptoms after transurethral resection of the prostate. *J Urol* 1986;113:613–15.
22. Tikkinen KAO, Tammela TLJ, Huhtala H, et al. Is nocturia equally common among men and women? A population based study in Finland. *J Urol* 2006;175:596–600.
23. Lose G, Alling-Møller L, Jennum P. Nocturia in women. *Am J Obstet Gynecol* 2001;185:514–21.
24. Asplund R. The nocturnal polyuria syndrome (NPS). *Gen Pharmacol* 1995;26:1203–9.
25. Asplund R, Henriksson S, Johansson S, et al. Nocturia and depression. *BJU Int* 2004;93:1253–6.
26. Statistics Finland. Finland in figures 2003. Helsinki, Finland: Statistics Finland, 2003. ([http://www.stat.fi/tup/suoluk/suomilukuina\\_en.html](http://www.stat.fi/tup/suoluk/suomilukuina_en.html)).
27. The Population Register Centre. Taskutieto fickfakta 2003. (In Finnish and Swedish). Helsinki, Finland: The Population Register Centre, 2003. ([http://www.vaestorekisterikeskus.fi/vrk/files.nsf/files/16C0FE257339C409C2256ECC0039A555/\\$file/Taskutieto\\_2003.pdf](http://www.vaestorekisterikeskus.fi/vrk/files.nsf/files/16C0FE257339C409C2256ECC0039A555/$file/Taskutieto_2003.pdf)).
28. Spiegelmann D, Israel RG, Bouchar D, et al. Absolute fat mass, percent body fat, and body-fat distribution: Which is the real determinant of blood pressure and serum glucose? *Am J Clin Nutr* 1992;55:1033–44.
29. Ross R, Shaw KD, Rissanen J, et al. Sex differences in lean and adipose tissue distribution by magnetic resonance imaging: anthropometric relationship. *Am J Clin Nutr* 1994;59:1277–85.
30. Gallagher D, Visser M, Sepulveda D, et al. How useful is body mass index for comparison of body fatness across age, sex, and ethnic groups? *Am J Epidemiol* 1996;143:228–39.
31. Helakorpi S, Patja K, Prättälä R, et al. Health behaviour and health among Finnish adult population, spring 2003. (In Finnish with English summary). (Publications of the National Public Health Institute, series B, no. B17/2003). Helsinki, Finland: National Public Health Institute, 2003. ([http://www.ktl.fi/attachments/suomi/julkaisut/julkaisusarja\\_b/2003b17.pdf](http://www.ktl.fi/attachments/suomi/julkaisut/julkaisusarja_b/2003b17.pdf)).
32. Aromaa A, Koskinen S, ed. Health and functional capacity in Finland. Baseline results of the Health 2000 Health Examination Survey. (In English). (Publications of the National Public Health Institute, series B, no. B12/2004). Helsinki, Finland: National Public Health Institute, 2004. (<http://www.ktl.fi/terveys2000/index.uk.html>).
33. Kuskowska-Wolk A, Karlsson P, Stolt M, et al. The predictive validity of body mass index based on self-reported weight and height. *Int J Obes* 1989;13:441–53.
34. Nieto-Garcia FJ, Bush TL, Keyl PM. Body mass definitions of obesity: sensitivity and specificity using self-reported weight and height. *Epidemiology* 1990;1:146–52.
35. Kuskowska-Wolk A, Bergstrom R, Boström G. Relationship between questionnaire data and medical records of height, weight and body mass index. *Int J Obes Relat Metab Disord* 1992;16:1–9.
36. Khan MS, Chaliha C, Leskova L, et al. The relationship between urinary symptom questionnaires and urodynamic diagnoses: an analysis of two methods of questionnaire administration. *BJOG* 2004;111:468–74.
37. Teleman PM, Lidfeldt J, Nerbrand C, et al. Overactive bladder: prevalence, risk factors and relation to stress incontinence in middle-aged women. *BJOG* 2004;111:600–4.
38. Blundell JE, Gillett A. Control of food intake in the obese. *Obes Res* 2001;9(suppl 4):263S–70S.
39. Roehrs T, Roth T. Sleep, sleepiness, sleep disorders and alcohol use and abuse. *Sleep Med Rev* 2001;5:287–97.