Sleep apnoea, anxiety, depression and somatoform pain: a community-based high-risk sample

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ABSTRACT: Community-based studies that measure both psychiatric diagnoses and obstructive sleep apnoea (OSA) are lacking. This study reports current psychiatric disorders in community-dwelling adults at high risk for OSA identified by the Berlin Questionnaire. Furthermore, associations between OSA and current psychiatric disorders, unadjusted and adjusted for putative confounders, are reported.

A subsample of the Akershus Sleep Apnoea Project consisting of 290 adults, aged 30–65 yrs, with positive Berlin Questionnaire screening underwent the Structured Clinical Interview for the Diagnostic and Statistical Manual of Mental Disorders, version IV and polysomnography. Auxiliary analyses of depression are provided.

The median apnoea/hypopnoea index score in the sample was 7.7 (interquartile range 2.4–22.2). Major depressive disorder, current anxiety and somatoform pain disorder were diagnosed in 12.4%, 14.8% and 19.3% of participants, respectively. At least one psychiatric disorder was diagnosed in 110 participants. The odds ratio of participants with OSA having a psychiatric disorder compared with participants without OSA was 0.54 (95% CI 0.33–0.88). A negative association did not exist among Berlin Questionnaire low-risk participants.

In conclusion, more than one-third of participants in a community-based, Berlin Questionnaire high-risk sample were diagnosed with a psychiatric disorder. A negative association between OSA and psychiatric morbidity was found.

KEYWORDS: Berlin questionnaire, mental disorders, polysomnography, psychology, sleep apnoea syndrome

In several studies of clinical populations, obstructive sleep apnoea (OSA) has been linked to symptoms of psychiatric disorders such as depression, mania, anxiety, psychosis, hypochondriasis and somatisation [1–4]. However, the actual strength of such associations may be overestimated when studied in a clinical sample [5].

Five community-based studies have investigated the relationship between OSA and symptoms of depression [6–10]. Three of these studies reported increased prevalence of depression in those with OSA [6–8], one found an effect for females only [9] and the last study did not observe any association between OSA and symptoms of depression [10]. Except for a study by OHAYON [6], which also assessed psychotic symptoms, there seem to be no

community-based studies that have assessed the relationship between OSA and symptoms of other psychiatric disorders.

Most previous clinical and community-based studies of the relationship between anxiety, depression and OSA have assessed psychiatric symptoms by self-reported instruments and not by diagnostic interviews [11]. Only one community-based study of OSA assessed psychiatric comorbidity with a diagnostic interview and reported that 17.6% of participants with OSA had major depressive disorder (MDD) [6]. A weakness of that study, however, is that OSA was assessed by self-report, which may contribute to misclassification.

Although the comorbidity between OSA and psychiatric disorders has been assumed to involve

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several disorder-specific mechanisms, it has still been argued that symptoms of depression co-occur with OSA exclusively, because of shared risk factors [12]. For example, it has been shown that established predictors for OSA, such as subjective sleepiness [13] and obesity [14], are associated with psychiatric disorders in community-based samples. Other putative confounders of these associations are sex [9] and other demographic factors [15]. However, previous studies have not consistently controlled for these variables.

Against this background, we conducted a study involving a large, community-based sample of participants identified by the Berlin Questionnaire (BQ) [16] to be at high risk for OSA, and included polysomnographic recordings for a subsample. The BQ is a widely used screening tool for OSA that has recently been used as a proxy for OSA diagnosis in large surveys [17, 18] and has been validated in the Norwegian general population [19]. The present study reports current psychiatric disorders in community-dwelling adults at a high risk for OSA, as identified by the BQ. Furthermore, we report associations between OSA and current psychiatric disorders unadjusted and adjusted for putative confounders (demographic factors (age, sex, higher education and cohabitation) or established predictors for OSA included in the BQ).

MATERIAL AND METHODS

Study participants and design

The participants took part in the Akershus Sleep Apnoea Project (ASAP), which is a two-phase, cross-sectional, community-based study designed to investigate psychological, otolaryngeal, neurological and cardiovascular aspects of OSA. A one-page screening questionnaire was posted to 30,000 age- and sex-stratified adults (aged 30–65 yrs, 50% female) randomly drawn from the National Population Register. Because 742 letters were returned unopened or we received information that the selected person was deceased or abroad, the final study population consisted of 29,258 persons who received the screening questionnaire containing a Norwegian translation of the BQ (fig. 1) [16].

A total of 16,302 (55.7%) people responded, of whom 3,960 (25.4%) were classified as being at high risk for OSA by a previously published BQ scoring algorithm [20]. BQ high-risk categories were self-reported snoring, daytime somnolence and obesity/hypertension. When confirming symptoms within two or three of these categories, the participant was regarded as screening positive and categorised as a BQ high-risk individual.

Of the 3,960 BQ high-risk individuals, 1,085 (27.4%) were randomly chosen in five consecutive selections. The selections were organised to fill pre-defined BQ high-risk age- and sex-strata. Those with established cardiovascular disease, diabetes mellitus or previous otitis media surgery were oversampled. The reasons for not participating are presented in figure 1. This recruitment procedure resulted in 378 participants (44.3% of 852 BQ high-risk individuals invited to participate in the ASAP).

In this sub-study of the ASAP, diagnostic and psychiatric interviews were only scheduled from June 1, 2006, until March 31, 2007, among BQ high-risk participants. During this time, 654 of the 852 BQ high-risk individuals invited to participate in

FIGURE 1. Flow chart of the study population through to the clinical sample. BQ: Berlin Questionnaire; ASAP: Akershus Sleep Apnoea Project. #: use of continuous positive airway pressure (n=10), pregnancy (n=4), inadequate Norwegian language skills (n=4) and severe physical impairment, defined by inability to climb the stairs of the sleep laboratory (n=2).

the ASAP were approached and 290 of the 378 participants (44.3% of 654 BQ high-risk individuals invited to participate in the sub-study) were included.

In addition, the study comprised an auxiliary sample consisting of 157 age- and sex-stratified BQ low-risk participants were included in the ASAP. The inclusion procedure for this sample has been reported elsewhere [19].

Methods

Current psychiatric disorders (criteria met within the past month) were diagnosed by the Structured Clinical Interview for the Diagnostic and Statistical Manual of Mental Disorders, version IV (DSM-IV), axis I disorders (SCID-I) [20]. This interview involves the assessment of affective disorders (MDD, mania, hypomania and dysthymia), anxiety disorders (panic disorder with and without agoraphobia, social phobia, specific phobia, obsessive compulsive disorder, post-traumatic stress disorder and generalised anxiety disorder), somatoform disorders (somatisation disorder, somatoform pain disorder and hypochondriasis), psychotic symptoms, substance abuse and adjustment disorder. Because there were few cases of each anxiety disorder, a composite anxiety category termed “current anxiety” was defined, which included participants who suffered from at least one current anxiety disorder. Specific phobia was not included because the disorder was regarded as clinically less important. The interviews were conducted in the

evening before sleep registration by a trained physician (H. Hrubos-Strøm). To test the reliability of the obtained diagnoses, 40 audiotapes recorded from participants with one or more diagnoses of MDD, anxiety and somatoform pain disorder were randomly selected. The tapes were rescored by an experienced psychiatrist (T. Dammen), blinded to the results of the first investigator. The inter-rater reliability scores for presence/absence of the three selected diagnoses were excellent (Cohen's kappa=1.0) [21]. Participants of the ASAP received the Beck Depression Inventory (BDI), a 21-item self-report questionnaire reflecting somatic, affective and cognitive symptoms of depression [22]. Each item is scored from zero to three, thus total scores from zero to 63 are possible.

All participants underwent an in-hospital polysomnography registration. Specifications of scoring and the technical equipment have been published elsewhere [19]. Sleep quality was assessed by minutes of sleep latency, waking after sleep onset, total sleep time and percentage of sleep efficiency. Obstructive apnoeas were scored when airflow dropped below 10% of the reference amplitude for >10 s. Hypopnoeas were scored when airflow dropped below 70% for >10 s with a subsequent oxygen desaturation of 4%. The apnoea/hypopnoea (AHI) was calculated as the average of the total number of apnoeas and hypopnoeas per hour of sleep. Because all participants were included in the study based on a positive screening on more than one BQ symptom category, all participants with an AHI ≥ 5 events·h⁻¹ were diagnosed with OSA [23].

Demographic data were obtained by standard questionnaires completed during the overnight stay. Higher education was defined as having any college or university degree. The

variable of cohabitation was measured by a dichotomisation of different forms of cohabitation or living alone.

Excessive daytime sleepiness was defined as a score >10 on the Epworth Sleepiness Scale (ESS) [24]. An additional screening question for depression was included in the screening questionnaire: "Have you felt depressed or less interested in participating in activities you usually enjoy?". The response alternatives were: 1=almost every day, 2=three to four times per week, 3=one to two times per week, 4=one to two times per month, and 5=seldom or almost never. The variable "frequent depressive thoughts or loss of interest" in table 1 comprised response categories 1 and 2. Obesity was defined by a body mass index >30 kg·m⁻² calculated from self-reported height and weight.

The study protocol was approved by the Regional Committee for Medical Research Ethics in Eastern Norway, the National Data Inspectorate and the Norwegian Social Science Data Services. All participants provided written consent before participating.

Analysis

The Chi-squared test was used to assess bivariate differences between participants and non-participants and between participants with and without OSA. Crude odds ratios were calculated for associations between OSA, putative confounders and psychiatric disorders. Estimates were adjusted for one putative confounder at a time and were calculated using the Mantel-Haenszel common odds ratio. Effect modification was regarded as apparent when the Breslow-Day test of homogeneity of the odds ratio was significant. When effect

TABLE 1 Characteristics of the Berlin Questionnaire high-risk subjects

	Screening sample	Non-participants	Participants	p-value
Subjects n	3960	3670	290	
Age yrs	48.8±10.3	48.8±10.3	48.2±11.2	0.357
Females	44.5	44.5	44.1	0.899
Higher education			28.1	
Cohabitation [#]			83.3	
BMI kg·m ⁻²	29.1±5.2	29.1±5.2	29.0±4.9	0.951
Berlin Questionnaire				
Snoring category	92.3	92.4	91.0	0.412
Daytime somnolence category	63.1	62.5	70.7	0.005
Hypertension/obesity category	66.3	66.2	66.6	0.914
Epworth Sleepiness Scale	8.8±4.5	8.8±4.5	9.8±4.5	<0.001
EDS [†]	33.7	33.0	43.1	<0.001
Frequent depressive thoughts/loss of interest	15.3	15.5	12.9	0.253
Beck Depression Inventory			8.5±6.9	
Sleep latency min			11.0 (6.0–21.0)	
WASO min			55.2 (29.2–90.5)	
Mean total sleep time min			413.6±86.7	
Sleep efficiency			83.2±11.2	
AHI events·h ⁻¹			7.7 (2.4–22.2)	
Obstructive sleep apnoea			60.5	

Data are presented as mean±SD, % or median (interquartile range), unless otherwise stated. BMI: body mass index; EDS: excessive daytime sleepiness; WASO: wake after sleep onset; AHI: apnoea/hypopnoea index. [#]: married or living with partner; [†]: Epworth Sleepiness Scale >10.

modification was apparent, stratum-specific estimates were presented. Putative confounders significantly related to both OSA and the respective psychiatric disorder and interaction terms identified in stratified analyses were entered in logistic regression models. Finally, bivariate differences in BDI scores in the study sample and the auxiliary sample, with and without OSA, were calculated by unpaired t-tests. In all analyses, a two-tailed p-value of <0.05 was used as the cut-off for statistical significance.

RESULTS

Characteristics of the screening and clinical samples are displayed in table 1. A significantly higher proportion of participants were categorised as BQ somnolent (70.7%) compared with BQ high-risk responders who did not participate (62.5%). However, there were no significant differences with respect to age, sex, snoring, obesity or hypertension. OSA was diagnosed in 175 (60.6%) participants. When OSA was defined as $AHI \geq 15$ events·h⁻¹, 104 (35.9%) participants were diagnosed with OSA. In the auxiliary sample, mean $\pm$ SD BDI score was 4.4 ± 4.9 and median (interquartile range) AHI was 3.2 (0.7–10.9).

Frequencies of psychiatric disorders are displayed in table 2. The disorder diagnosed most frequently was somatoform pain disorder (19.3%). Of the 110 subjects with one or more psychiatric disorders, only 41 (37.3%) had an affective disorder (MDD or dysthymia). No participants reported psychosis, mania or hypomania.

No relationship was observed between OSA and any DSM-IV psychiatric disorder (table 2). However, the odds ratio of participants with OSA having at least one psychiatric disorder was 0.54 (95% CI 0.33–0.88) compared with participants without OSA. Psychiatric disorders by other definitions of OSA ($AHI \geq 15$ and ≥ 30 events·h⁻¹) are reported in the online supplement. Overall, no relationships were observed by alternative definitions of OSA. There were no significant differences in mean $\pm$ SD BDI score between participants with (7.9 ± 6.4) and without (9.1 ± 7.2) OSA. A similar lack of statistically significant differences between symptoms of depression and OSA were found among participants with BQ low risk in the auxiliary sample. In this sample, participants with OSA had a mean $\pm$ SD BDI score of 5.0 ± 5.3 , while participants without OSA had a mean $\pm$ SD BDI score of 4.0 ± 4.6 ($p=0.222$).

Crude odds ratios for associations between putative confounders of associations between MDD, anxiety, somatoform pain disorder and OSA are presented in table 3. Associations with having at least one psychiatric disorder followed the same pattern as the three individual disorders regarding all putative confounders (data not shown). Associations between OSA and individual psychiatric disorders stratified by these putative confounders identified effect modification by sex and cohabitation (table 4): Among males, the risk of having MDD was significantly lower among participants with OSA than among those without OSA. Moreover, the risk of having current anxiety in participants living alone was lower in participants with OSA than in those without OSA.

Adjusted Mantel-Haenszel common odds ratio estimates of the associations between OSA and individual psychiatric disorders were all nonsignificant (data not shown). Adjustment for

TABLE 2 Prevalence of current psychiatric disorders and differences between 290 participants with and without obstructive sleep apnoea (OSA) using the Chi-squared test[#]

	Total	OSA	No OSA	p-value
Affective disorders				
Current major depression [*]	36 (12.4)	16 (9.1)	19 (16.7)	0.055
Dysthymia	5 (1.7)	3 (1.7)	2 (1.8)	1.000 [§]
Current affective disorder	40 (13.8)	18 (10.3)	21 (18.4)	0.048
Anxiety disorders				
Current panic disorder	17 (5.9)	10 (5.7)	7 (6.1)	0.880
Agoraphobia without panic disorder	2 (0.7)	2 (1.1)	0 (0)	0.521 [§]
Social phobia	13 (4.5)	7 (4.0)	6 (5.3)	0.613
Obsessive compulsive disorder	5 (1.7)	2 (1.1)	3 (2.6)	0.386 [§]
Post-traumatic stress disorder	16 (5.5)	8 (4.6)	8 (7.0)	0.374
Generalised anxiety disorder	14 (4.8)	8 (4.6)	6 (5.3)	0.789
Current anxiety [*]	43 (14.8)	25 (14.3)	18 (15.8)	0.726
Alcohol and substance abuse				
Current alcohol abuse	5 (1.7)	3 (1.7)	2 (1.8)	1.000 [§]
Somatoform disorders				
Hypochondriasis	3 (1.0)	1 (0.6)	2 (1.8)	0.332 [§]
Somatoform pain disorder [*]	56 (19.3)	29 (16.6)	27 (23.7)	0.135
Somatisation disorder	9 (3.1)	4 (2.3)	5 (4.4)	0.324 [§]
Current somatoform disorder	58 (20.0)	30 (17.1)	28 (24.6)	0.124
Any psychiatric disorder [*]	110 (37.9)	56 (32.0)	53 (46.5)	0.013

Data are presented as n (%), unless otherwise stated. [#]: polysomnography recordings were not available for one participant with major depressive disorder, thus, the sum of current major depression, current affective disorder and any psychiatric disorder in participants with and without OSA differ from the total disorders diagnosed. ^{*}: inter-rater reliability was tested. [†]: any one or more of the psychiatric disorders listed. [§]: Fisher's exact test.

multiple covariates (putative confounders from table 3) only resulted in minor changes to these nonsignificant odds ratios (data not shown). Statistically significant Mantel-Haenszel common odds ratios for having at least one psychiatric diagnosis in participants with OSA compared with participants without OSA varied from 0.53 (95% CI 0.33–0.87) when adjusted for the BQ snoring category to 0.59 (95% CI 0.35–0.98) when adjusted for age. Adjustment for multiple covariates also only resulted in minor changes to the unadjusted odds ratio (data not shown).

DISCUSSION

The main findings of this study were that: 1) more than one-third of community-dwelling, middle-aged adults at risk for OSA, identified by the BQ, had one or more current DSM-IV psychiatric disorders; 2) somatoform pain disorder was the most prevalent individual psychiatric disorder; and 3) no individual psychiatric disorder was related to OSA but there was a significant negative association between OSA and having at least one psychiatric disorder when compared with BQ high-risk subjects without OSA.

TABLE 3 Crude odds ratios between putative confounders, major depressive disorder, anxiety, somatoform pain disorder and obstructive sleep apnoea

	Major depressive disorder	Current anxiety	Somatoform pain disorder	Obstructive sleep apnoea
Demographic factors				
Age yrs				
<50	2.01 (0.98–4.14)	1.38 (0.72–2.65)	1.37 (0.77–2.47)	1.00
≥50	1.00	1.00	1.00	3.30 (2.01–5.42)
Sex				
Female	2.51 (1.22–5.18)	3.51 (1.74–7.06)	4.15 (2.19–7.85)	1.00
Male	1.00	1.00	1.00	2.57 (1.58–4.17)
Education				
Low	4.75 (1.41–15.98)	1.85 (0.82–4.19)	1.76 (0.86–3.61)	1.16 (0.68–1.95)
High	1.00	1.00	1.00	1.00
Cohabiting [#]				
No	3.13 (1.43–6.84)	3.42 (1.66–7.08)	1.48 (0.71–3.07)	1.12 (0.60–2.12)
Yes	1.00	1.00	1.00	1.00
BQ categories				
Snoring				
No	1.00	1.00	1.00	1.00
Yes	1.77 (0.40–7.85)	0.95 (0.31–2.92)	0.78 (0.30–2.04)	2.26 (1.00–5.11)
Somnolence				
No	1.00	1.00	1.00	1.00
Yes	3.75 (1.28–10.95)	2.37 (1.01–5.57)	2.17 (1.04–4.53)	0.64 (0.38–1.10)
Hypertension/obesity				
No	1.00	1.00	1.00	1.00
Yes	0.76 (0.36–1.57)	0.65 (0.34–1.27)	0.61 (0.33–1.10)	2.00 (1.21–3.28)
Epworth Sleepiness Scale				
EDS [†]				
No	1.00	1.00	1.00	1.00
Yes	5.67 (2.48–12.93)	2.89 (1.47–5.68)	2.43 (1.34–4.41)	0.76 (0.47–1.22)

Data are presented as crude odds ratio (95% confidence interval) from eight bivariate logistic regression models for each disorder or group of disorders. BQ; Berlin Questionnaire; EDS: excessive daytime sleepiness. [#]: married or living with partner; [†]: Epworth Sleepiness Scale >10.

TABLE 4 Effect modifications by sex and cohabitation

	Major depressive disorder	Current anxiety
Females		
No OSA	1.00	
OSA	1.37 (0.55–3.45)	
Males		
No OSA	1.00	
OSA	0.16 (0.05–0.54)	
Living alone		
No OSA		1.00
OSA		0.25 (0.07–0.91)
Cohabiting[#]		
No OSA		1.00
OSA		1.33 (0.59–3.01)

Data are presented as stratum-specific crude odds ratios (95% confidence interval). OSA: obstructive sleep apnoea. [#]: married or living with partner.

Psychiatric disorders in a community-based BQ high-risk sample

Our finding of an accumulation of psychiatric disorders in a BQ high-risk sample representative of the general population is in line with two previous studies [17, 18]. The study by HIESTAND *et al.* [17] reported a prevalence of depression in 33% and anxiety in 18% of BQ high-risk respondents of the 2005 Sleep in America poll. The study by KAPSIMALIS *et al.* [18] reported a prevalence of depression in 41% and anxiety in 22% of BQ high-risk female respondents of the 2007 poll. These proportions were based on self-reported psychiatric diagnoses, which can explain the somewhat higher estimates than those reported in our study.

Properties of the BQ, in particular the items forming the BQ somnolence category [17, 18] or the selection of more somnolent/sleepy participants than non-participants in our study, might have contributed to the accumulation of psychiatric disorders. With respect to this potential sample selection, it is interesting that the proportion of participants reporting frequent depressive thoughts/loss of interest was not higher among the more sleepy participants than among the

less sleepy non-participants. Moreover, because pain symptoms are common in the general population [25] and are closely related to depression [26] and symptoms of OSA [8], associations between sleepiness, depression, somatoform pain and risk for OSA should be explored in future studies.

OSA and psychiatric disorders

The findings that MDD, current anxiety and somatoform pain disorder were not associated with OSA have important implications for the interpretation of previous studies that have reported positive associations between OSA and symptoms of psychiatric disorders [1–4]. Most community-based studies of this relationship have concluded that OSA seems to be an independent risk factor for depression [6–8]. In contrast, our data support community-based studies that have partly or completely failed to establish an independent association between OSA and depression [9, 10]. However, only two previous, community-based studies concerning the relationship between OSA and depression have assessed sleep with objective measures [7, 10]. In a sample with a median 4% oxygen desaturation index of 4.3 in females and 6.7 in males, KRIPKE *et al.* [10] found no association between symptoms of depression and OSA. In contrast, PEPPARD *et al.* [7], using a sample in which 6% of the females and 14% of the males showed an AHI ≥ 15 events·h⁻¹, found a positive dose-response association between SBD and depression. The severity of OSA in our BQ high-risk sample was higher than in these samples, but lower than most studies of clinical populations. Moreover, previous community-based studies investigated only depression, while our study also failed to establish associations between OSA and other psychiatric disorders.

The finding of a significant negative association between OSA and having at least one psychiatric disorder indicates that lack of statistical power is a potential explanation for the finding of no association between OSA and individual psychiatric disorders in our BQ high-risk sample. Thus, although mean BDI levels or prevalence of specific disorders did not differ between OSA and no OSA, participants in the study who had high symptom reports on the BQ but who were not subsequently found to have sleep apnoea had a significantly higher level of psychiatric morbidity than participants with sleep apnoea.

In the auxiliary sample, both the mean BDI sum and the median AHI were 50% lower than in the BQ high-risk sample. Moreover, also in this BQ low-risk sample, BDI scores did not differ significantly between those with OSA and those without OSA. Consequently these findings from the auxiliary sample imply that the high level of psychiatric comorbidity observed among BQ high-risk participants is probably related to properties of the BQ rather than being an effect of OSA as such. This interpretation is in line with the study by ANDREWS *et al.* [12] who hypothesised that shared co-factors between depression and OSA rather than apnoeas and hypopnoeas *per se* explain the association between OSA and symptoms of depression found in multiple studies of clinical samples. Nevertheless, PEPPARD *et al.* [7] found a dose-response association between OSA and symptoms of depression. However, this study also identified important effects of putative confounders on the said association. Therefore, we believe that our findings contribute to an elucidation of the

complex association between OSA, psychiatric disorders and predictors of OSA.

Among putative confounders of the association between OSA and psychiatric disorders, the odds ratios for having any of the three psychiatric disorders or having at least one psychiatric disorder were significantly higher in females than in males while the odds ratio for having OSA was the opposite. Stratified analysis by sex indicated that a significant negative association between OSA and MDD was persistent in males but not in females. However, we believe that this sex difference should be attributed to a lower severity of OSA in females than in males rather than a true interaction *per se*. Stratified analysis also identified effect modification by living alone on the association between current anxiety and OSA. To the best of our knowledge, we do not know of any previous studies that have reported an effect of living alone on the relationship between OSA and psychiatric disorders and this finding should be interpreted with caution.

Regarding the effect of other putative confounders, we anticipated that sleepiness and obesity would be related to both OSA and psychiatric disorders [12–14]. Sleepiness, as assessed by the ESS or the BQ somnolence category, was found to be related to individual psychiatric disorders, but not to OSA. Thus, sleepiness was not a confounder of the relationship observed between OSA and individual psychiatric disorders. On the contrary, the obesity/hypertension risk category of the BQ was related to OSA but not to individual psychiatric disorders and also could not be regarded as a confounder of the relationship.

In addition, the effect of risk stratification by the BQ probably had different effects on sleepy compared to non-sleepy OSA patients across age and sex strata. Unfortunately, the sample was too small for sub-analyses within single strata or groups of strata. In contrast to the study of PEPPARD *et al.* [7], utilising multivariate analyses did not strengthen the relationship between OSA and psychiatric disorders. However, studies of moderate-to-severe OSA have previously reported that fatigue [27] and sleepiness [28] can be up to eight times more strongly related to depression than to OSA. The results of our study are in line with these findings as psychiatric disorders seemed to be more strongly related to the BQ somnolence category or excessive sleepiness while OSA seemed to be more strongly related to the BQ snoring and obesity/hypertension categories. Thus, these apparently contradictory relationships between established features of OSA should stimulate increased attention to the contribution of anxiety, depression and somatoform pain in future studies of unsolved clinical problems, such as screening for OSA [29] and residual sleepiness in adequately treated OSA [30, 31].

Strengths and limitations

A strength of this study was the use of in-hospital polysomnography to diagnose OSA. Ideally, sleep should be measured twice by polysomnography [32], but in accordance with most previous studies that assessed the screening properties of the BQ or prevalence of OSA, we chose to rely on a single all-night recording of sleep. Moreover, the severity of OSA in the sample was mild and diagnosis was based on a simple cut-off value on the AHI. Thus, the results of the present study are

generalisable only to OSA in the general population. In addition, *post hoc* analyses with other cut-off values of the AHI affected our results to only a small degree, supporting our general conclusion that putative confounders show a greater impact on this association than on OSA severity *per se*.

Another strength is the use of the SCID-I, which, in the present study, was administered by one investigator who performed all interviews, and achieved excellent inter-rater reliability when compared to the scores of an experienced psychiatrist.

With a response rate of 55.7% and a participation rate of 44.3%, this study is susceptible to selection bias caused by help-seeking behaviour [5]. Therefore, as discussed previously, it is relevant to the findings of this study that selection by subjective sleep complaints occurred, but selection by screening question of depression did not. However, the potential selection bias caused by the limited response rate might have influenced the prevalence of other psychiatric disorders than depression. Consequently, the high prevalence of somatoform pain disorder should be interpreted with caution. Moreover, because no significant differences in sleepiness were found between participants with and without OSA, we have no reason to believe that any selection influenced the associations between psychiatric disorders and OSA.

Finally, it should be mentioned that because of the cross-sectional design of this study, we cannot draw any conclusions regarding causal or temporal relationships between OSA and psychiatric disorders.

In conclusion, more than one-third of participants in a community-based, BQ high-risk sample were diagnosed with a psychiatric disorder. A negative association between OSA and having psychiatric disorders was found. However, this negative association did not exist in an auxiliary sample consisting of persons with BQ low risk. Future community-based studies using the BQ should be aware of the large effect of sex, the caveat of selection bias and the difference between the BQ somnolence category and excessive daytime sleepiness defined by the ESS. Future community-based studies of screening instruments for OSA, associations between OSA and psychiatric disorders, and other clinical aspects of OSA should include assessment of somatoform pain disorder and anxiety, in addition to depression.

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STATEMENT OF INTEREST

A statement of interest for T. Omland can be found at www.erj.ersjournals.com/site/misc/statements.xhtml

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REFERENCES

- 1 Kales A, Caldwell AB, Cadieux RJ, *et al*. Severe obstructive sleep apnea—II: associated psychopathology and psychosocial consequences. *J Chronic Dis* 1985; 38: 427–434.
- 2 Bardwell WA, Berry CC, Ancoli-Israel S, *et al*. Psychological correlates of sleep apnea. *J Psychosom Res* 1999; 47: 583–596.
- 3 Aikens JE, Mendelson WB. A matched comparison of MMPI responses in patients with primary snoring or obstructive sleep apnea. *Sleep* 1999; 22: 355–359.
- 4 Sharafkhaneh A, Giray N, Richardson P, *et al*. Association of psychiatric disorders and sleep apnea in a large cohort. *Sleep* 2005; 28: 1405–1411.
- 5 Berkson J. Limitations of the application of fourfold table analysis to hospital data. *Biometrics Bulletin* 1946; 2: 47–53.
- 6 Ohayon MM. The effects of breathing-related sleep disorders on mood disturbances in the general population. *J Clin Psychiatry* 2003; 64: 1195–1200.
- 7 Peppard PE, Szklo-Coxe M, Hla KM, *et al*. Longitudinal association of sleep-related breathing disorder and depression. *Arch Intern Med* 2006; 166: 1709–1715.
- 8 Sivertsen B, Overland S, Glozier N, *et al*. The effect of OSAS on sick leave and work disability. *Eur Respir J* 2008; 32: 1497–1503.
- 9 Enright PL, Newman AB, Wahl PW, *et al*. Prevalence and correlates of snoring and observed apneas in 5,201 older adults. *Sleep* 1996; 19: 531–538.
- 10 Kripke DE, Ancoli-Israel S, Klauber MR, *et al*. Prevalence of sleep-disordered breathing in ages 40–64 years: a population-based survey. *Sleep* 1997; 20: 65–76.
- 11 Saunamäki T, Jehkonen M. Depression and anxiety in obstructive sleep apnea syndrome: a review. *Acta Neurol Scand* 2007; 116: 277–288.
- 12 Andrews JG, Oei TP. The roles of depression and anxiety in the understanding and treatment of obstructive sleep apnea syndrome. *Clin Psychol Rev* 2004; 24: 1031–1049.
- 13 Bixler EO, Vgontzas AN, Lin HM, *et al*. Excessive daytime sleepiness in a general population sample: the role of sleep apnea, age, obesity, diabetes, and depression. *J Clin Endocrinol Metab* 2005; 90: 4510–4515.
- 14 Scott KM, McGee MA, Wells JE, *et al*. Obesity and mental disorders in the adult general population. *J Psychosom Research* 2008; 64: 97–105.
- 15 Akhtar-Danesh N, Landeen J. Relation between depression and sociodemographic factors. *Int J Ment Health Syst* 2007; 1: 4.
- 16 Netzer NC, Stoohs RA, Netzer CM, *et al*. Using the Berlin Questionnaire to identify patients at risk for the sleep apnea syndrome. *Ann Intern Med* 1999; 131: 485–491.
- 17 Hiestand DM, Britz P, Goldman M, *et al*. Prevalence of symptoms and risk of sleep apnea in the US population: results from the national sleep foundation sleep in America 2005 poll. *Chest* 2006; 130: 780–786.
- 18 Kapsimalis F, Kryger M. Sleep breathing disorders in the U.S. female population. *J Womens Health* 2009; 18: 1211–1219.
- 19 Hrubos-Strom H, Randby A, Namtvedt SK, *et al*. A Norwegian population-based study on the risk and prevalence of obstructive sleep apnea. *J Sleep Res* 2010; 20: 162–170.
- 20 First MB, Spitzer RL, Gibbon M, Williams JBW. Structured Clinical Interview for DSM-IV Axis I Disorders, Patient Edn (SCID-I/P), version 2.0. Norwegian version. Biometrics Research Department, NY State Psychiatric Institute, New York, 1995.
- 21 Landis JR, Koch GG. The measurement of observer agreement for categorical data. *Biometrics* 1977; 33: 159–174.
- 22 Beck AT, Ward CH, Mendelson M, *et al*. An inventory for measuring depression. *Archives of General Psychiatry* 1961; 4: 561–571.
- 23 American Academy of Sleep Medicine. International Classification of Sleep Disorders: Diagnostic and Coding Manual. 2nd Edn. American Academy of Sleep Medicine, Westchester, IL, 2005.

- 24** Johns MW. A new method for measuring daytime sleepiness: the Epworth sleepiness scale. *Sleep* 1991; 14: 540–545.
- 25** Wittchen HU, Jacobi F. Size and burden of mental disorders in Europe—a critical review and appraisal of 27 studies. *Eur Neuropsychopharmacol* 2005; 15: 357–376.
- 26** Ohayon MM, Schatzberg AF. Using chronic pain to predict depressive morbidity in the general population. *Arch Gen Psychiatry* 2003; 60: 39–47.
- 27** Bardwell WA, Moore P, Ancoli-Israel S, *et al.* Fatigue in obstructive sleep apnea: driven by depressive symptoms instead of apnea severity? *Am J Psychiatry* 2003; 160: 350–355.
- 28** Sforza E, de Saint HZ, Pelissolo A, *et al.* Personality, anxiety and mood traits in patients with sleep-related breathing disorders: effect of reduced daytime alertness. *Sleep Med* 2002; 3: 139–145.
- 29** Jennum P, Riha RL. Epidemiology of sleep apnoea/hypopnoea syndrome and sleep-disordered breathing. *Eur Respir J* 2009; 33: 907–914.
- 30** Pepin JL, Viot-Blanc V, Escourrou P, *et al.* Prevalence of residual excessive sleepiness in CPAP-treated sleep apnoea patients: the French multicentre study. *Eur Respir J* 2009; 33: 1062–1067.
- 31** Koutsourelakis I, Perraki E, Economou NT, *et al.* Predictors of residual sleepiness in adequately treated obstructive sleep apnoea patients. *Eur Respir J* 2009; 34: 687–693.
- 32** Stepnowsky CJ Jr, Orr WC, Davidson TM. Nightly variability of sleep-disordered breathing measured over 3 nights. *Otolaryngol Head Neck Surg* 2004; 131: 837–843.