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Definition of excessive daytime sleepiness in the general population: Feeling sleepy relates better to sleep-related symptoms and quality of life than the Epworth Sleepiness Scale score. Results from an epidemiological study

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Abstract

Many different subjective tools are being used to measure excessive daytime sleepiness (EDS) but the most widely used is the Epworth Sleepiness Scale (ESS). However, it is unclear if using the ESS is adequate on its own when assessing EDS. The aim of this study was to estimate the characteristics and prevalence of EDS using the ESS and the Basic Nordic Sleep Questionnaire (BNSQ) in general population samples. Participants aged 40 years and older answered questions about sleepiness, health, sleep-related symptoms and quality of life. Two groups were defined as suffering from EDS: those who scored >10 on the ESS (with increased risk of dozing off) and those reporting feeling sleepy during the day ≥3 times per week on the BNSQ. In total, 1,338 subjects (53% male, 74.1% response rate) participated, 13.1% reported an increased risk of dozing off, 23.2% reported feeling sleepy and 6.4% reported both. The prevalence of restless leg syndrome, nocturnal gastroesophageal reflux, difficulties initiating and maintaining sleep and nocturnal sweating was higher among subjects reporting feeling sleepy compared to non-sleepy subjects. Also, subjects reporting feeling sleepy had poorer quality of life and reported more often feeling unrested during the day than non-sleepy subjects. However, subjects reporting increased risk of dozing off (ESS > 10) without feeling sleepy had a similar symptom profile as the non-sleepy subjects. Therefore, reporting only risk of dozing off

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without feeling sleepy may not reflect problematic sleepiness and more instruments in addition to ESS are needed when evaluating daytime sleepiness.

KEYWORDS
Basic Nordic Sleep Questionnaire, subjective sleepiness

1 | INTRODUCTION

Excessive daytime sleepiness (EDS) is a significant public health problem as it affects tasks that require vigilance, memory and executive function (Jackson, Howard, & Barnes, 2011). It interferes with daily activities and impairs quality of life (Engleman & Douglas, 2004). EDS can be a sign of insufficient sleep and poor sleeping habits and diseases such as sleep-related breathing disorders, restless leg syndrome (RLS), circadian rhythm disorders and narcolepsy (Murray, 2016). EDS is also associated with obesity (Bixler et al., 2005; Panossian & Veasey, 2012), chronic obstructive pulmonary disease (COPD) (Ali Zohal, Yazdi, & Kazemifar, 2013), asthma (Kallin et al., 2016) and stroke (Ding, Whittemore, & Redeker, 2016). Of conditions causing EDS, obstructive sleep apnea (OSA) is the most frequently made diagnosis (Jackson et al., 2011).

Excessive daytime sleepiness includes both an inability to stay alert and awake during the day and a more general feeling of sleepiness. The varying definitions and usage of many different instruments, both subjective and objective, to measure EDS is a well-known problem in epidemiological studies on EDS. As a result, prevalence rates range from 4% to 21% depending on the definition and method of assessment (Ohayon, 2008). The most commonly used questionnaire to assess EDS is the Epworth Sleepiness Scale (ESS), where subjects are asked to rate their likelihood of dozing off or falling asleep in eight different situations most people encounter in their daily lives (Johns, 1991). The higher the score, the higher the person's risk of dozing off during the day and a score higher than 10 is usually used to define EDS (Johns, 2016). However, the ESS has some limitations. For example, an individual suffering from insomnia and having difficulties falling asleep will probably rate his or her chance of dozing off in the different situations low and therefore have a low ESS score despite possibly feeling excessively sleepy during the day. Also, the ESS measures the tendency to doze off during some soporific conditions, which does not necessarily reflect problematic EDS, for example lying down to rest in the afternoon when circumstances permit. Furthermore, activities of daily life mentioned in the ESS might differ in different groups of subjects and may therefore affect a subject's answer regardless of how sleepy they are, for example depending on gender and age (Baldwin, Kapur, Holberg, Rosen, & Nieto, 2004; Ulander, Arestedt, Svanborg, Johansson, & Broström, 2013). Consequently, the ESS may not be a meaningful measure of EDS in many patients. Other questionnaires assess the more general feeling of sleepiness rather than the risk of dozing off. The Basic Nordic Sleepiness Questionnaire (BNSQ) assesses EDS by asking how often per week subjects feel sleepy (Partinen & Gislason, 1995). This question is widely used and has been shown to correlate with variables that contribute to EDS, including snoring (Young et al., 1993), nasal congestion (Young, Finn, & Kim, 1997) and OSA severity categories (Young, Hutton, Finn, Badr, & Palta, 1996; Young et al., 1993). EDS is usually defined when subjects experience daytime sleepiness at least 3 days per week and the prevalence of EDS in the general population has been found to be 17%–28.5% using that definition (Hara, Lopes Rocha, & Lima-Costa, 2004; Janson et al., 1995; Kallin et al., 2016).

The association between the different subjective measurement tools used to measure EDS has not been the topic of many papers. In the few studies on this matter, only a weak correlation between feelings of sleepiness and self-estimated sleep behaviour has been reported (Adams et al., 2016; Baldwin et al., 2004; Kim & Young, 2005; Pilcher, Pury, & Muth, 2003; Pilcher, Schoeling, & Prosansky, 2000). Also, studies have shown that the ESS is more likely to detect EDS among men than women and women more often report feeling unrested (Baldwin et al., 2004; Kim & Young, 2005). The ESS may therefore not be an adequate measure of sleepiness in women. Thus, there is a need for a better screening tool for EDS in order to improve the evaluation of the magnitude and aetiological factors of this highly prevalent condition in the general population.

The aim of this study was to determine the prevalence and characteristics of EDS in the general population in Iceland and Sweden using two frequently used questionnaires. EDS was defined both as the risk of dozing off assessed by the ESS and the general feeling of sleepiness using the BNSQ sleepiness question. Subjects were divided into three sleepiness categories based on a standard cut-off level for sleepiness in both questionnaires. Sleepiness categories were compared with different outcome measures: sleep-related symptoms, comorbidities and quality of life. The hypothesis was that the risk of dozing off and the general feeling of sleepiness describe different components of sleepiness. Using the more expansive definition of sleepiness using the BNSQ question will identify subjects with EDS who do not have a risk of dozing off during the day but might nevertheless have increased risk of sleep-related symptoms, comorbidities and reduced quality of life. Reporting only dozing off during the day without feeling sleepy may not reflect problematic EDS.

2 | METHODS

2.1 | Participants

The study population for this research was primarily individuals in the general population invited to participate in The Burden of

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Obstructive Lung Disease (BOLD, www.boldstudy.org) initiative in Reykjavik, Iceland, and Uppsala, Sweden, a multicentre international study aiming to estimate the burden of COPD worldwide (Buist et al., 2007). Using the national registries of inhabitants in both countries, a random sample of adults aged 40 years and older was contacted and invited to participate in this general population-based study. The design and rationale for the BOLD study have been reported elsewhere (Benediktsdottir et al., 2010). In total, 1,366 (52% male) participated, 765 in Reykjavik and 601 in Uppsala. Response rates were 81.8% and 62.2%, respectively. Of those, 28 participants were excluded as information on risk of dozing off (ESS scores) or feeling sleepy (BNSQ) was missing.

2.2 | Questionnaires and measurements

As a part of the BOLD study protocol, all participants came to the outpatient clinic of the respective hospitals in Reykjavik and Uppsala, where they answered the same questionnaires on respiratory symptoms, risk factors for COPD, health status, medication use, healthcare utilization, comorbidities, respiratory diagnoses, limitation of activity and quality of life. Lung function (including forced expiratory volume in 1 s [FEV_1] and forced vital capacity [FVC]) was measured using the ndd EasyOne Spirometer (ndd Medizintechnik AG, Zurich, Switzerland), before and 15 min after inhaling salbutamol (200 μg). In addition to the BOLD protocol, the participants were asked to answer questions about sleepiness (Johns, 1991; Partinen & Gislason, 1995), RLS (Allen et al., 2003) and sleep-related symptoms, such as snoring, nocturnal sweating, difficulties initiating and maintaining sleep and nocturnal gastroesophageal reflux (nGER) (Emilsson, Janson, Benediktsdóttir, Júlíusson, & Gíslason, 2012). Each site obtained ethical approval from the local ethical committee (National Bioethics Committee of Iceland: 04-080; Swedish Research Council: 2006/146) and written informed consent was obtained from every participant.

2.3 | Assessment of EDS

Two aspects of EDS were evaluated: the risk of dozing off and a more general feeling of sleepiness. The participants were defined as having a risk of dozing off if they scored >10 on the ESS (Johns, 2016). As part of the BNSQ they were also asked a specific question 'Do you feel sleepy during the day?' and rated their answers on a five-point scale: never/almost never (1); less than once a week (2); once or twice a week (3); three to five times a week (4); every day or almost every day of the week (5). Those who answered three times or more often per week (scores 4 and 5) were considered to have subjective daytime sleepiness (Hara et al., 2004; Janson et al., 1995; Kallin et al., 2016).

These two definitions of EDS were evaluated separately and subsequently merged, and four different groups were identified.

1. Non-sleepy; ESS score ≤10 and reporting feeling sleepy <3 times per week on the BNSQ.
2. Risk of dozing off; ESS score >10 but reporting feeling sleepy <3 times per week on the BNSQ.
3. Feeling sleepy; ESS score ≤10 but reporting feeling sleepy ≥3 times per week on the BNSQ.
4. Both risk of dozing off and feeling sleepy; ESS score >10 and reporting feeling sleepy ≥3 times per week on the BNSQ.

2.4 | Assessment of body mass index, smoking history and previous health

Standardized methods were used to measure height and weight. Body mass index (BMI) was calculated as kg/m^2. Current smokers were defined as those who smoked tobacco regularly during the month preceding the examination. Former smokers were defined as those smokers who had denied having smoked regularly for a month prior to the examination. Those who reported no regular smoking at or prior to the examination were defined as never smokers.

The participants were defined as having diabetes if they reported doctor-diagnosed diabetes and were using medication for diabetes. Similarly, participants were considered to have hypertension if they reported a doctor's diagnosis and were on antihypertensive medication. Cardiovascular disease was defined if subjects reported doctor-diagnosed myocardial infarction, stroke and/or heart failure. Those with post-bronchodilatory FEV1/FVC ratio <0.70 were defined as having COPD (GOLD, 2018). Asthma was defined as when subjects reported ever having a doctor tell them they had asthma, asthmatic bronchitis or allergic bronchitis and reported still having this condition.

2.5 | Sleep-related symptoms and quality of life

As in our previous papers, nGER was defined as reporting heartburn after going to bed ≥ 1 time per week (Emilsson et al., 2012). Insomnia symptoms were defined as difficulties initiating sleep or maintaining sleep ≥3 times per week (Björnsdóttir et al., 2013). Habitual snoring was defined as snoring ≥3 times per week (Janson et al., 1995). Frequent nocturnal sweating was defined as subjects reporting heavy perspiration during the night ≥3 times per week (Arnardottir et al., 2013). Additionally, we used the multivariable apnea prediction (MAP) index to define subjects at high or low risk of OSA (Maislin et al., 1995). The MAP index is based on a self-reported frequency of occurrence of sleep apnea symptoms (snoring or gasping, breathing stops, choking or struggling for breath during the night) as well as BMI, age and gender. The MAP score ranges from 0 to 1, where subjects scoring 0 are least likely to have OSA. A cut-off of 0.5 has been used to define those subjects at high risk of OSA. The estimated sensitivity and specificity of this cut-point are 0.88 and 0.55, respectively (Maislin et al., 1995). Participants also answered the 12-item Short-Form Health Survey (SF-12) for physical and mental quality of life (Ware, Kosinski, & Keller, 1996) and questions on symptoms of RLS based on recommendations from the International Restless Legs Syndrome Study Group (Allen et al., 2003).

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2.6 | Statistical analyses

All statistics were calculated using STATA software, Version 13.0 (Stata Corporation, College Station, Texas). Differences in categorical and continuous variables between the four groups identified were first compared using the Pearsons's chi-squared test and one-way analysis of variance, respectively. This was also used when comparing the characteristics of individuals in the two study centres. Independent association of health status (e.g. hypertension) and sleep-related symptoms (e.g. snoring) in relation to the three different groups of subjects with EDS was calculated using multiple linear regression controlling for age, sex, BMI, smoking history and study centre. A sensitivity analysis was subsequently performed with different cut-off values for ESS scores to determine whether lower or higher values could impact our results. Four different cut-off values for ESS score were tested (>8, >9, >11 and >12).

3 | RESULTS

3.1 | Participation and characteristics

The baseline characteristics of the study population are shown in Table 1. Participants in Reykjavik were on average 2 years younger, had a higher BMI and more years of education and a higher prevalence of RLS than participants in Uppsala. No significant difference was found between the centres in gender distribution, smoking history or in the prevalence of hypertension, cardiovascular disease, diabetes, asthma and COPD.

3.2 | Prevalence of sleepiness

Participants from Uppsala more often reported feeling sleepy ≥3 times a week using the BNSQ than those from Reykjavik (26.3% versus 20.7%, respectively, $p = 0.015$) but no significant difference was found in the risk of dozing off (ESS > 10) between the two centres (Table 1). Altogether, 175 subjects (13.1%) reported an increased risk of dozing off, 310 subjects (23.2%) reported feeling sleepy and 86 subjects (6.4%) reported both (Figure 1). Of those at risk of dozing off, 49.1% also reported feeling sleepy, but only 27.7% of those reporting feeling sleepy also had significant risk of dozing off.

3.3 | Characteristics of the different sleepiness groups

There was a significant difference in age between the four groups identified, with the youngest being those reporting increased risk of dozing off only (Table 2). However, no differences in gender distribution or BMI were found between the four groups. After adjusting for age, sex, BMI, education, smoking history and study centre, those reporting only feeling sleepy were more likely to have a history of hypertension, cardiovascular disease and diabetes compared to non-sleepy subjects (Table 3). This was not found for the other sleepiness groups. However, reporting both risk of dozing off and feeling sleepy

TABLE 1 Baseline characteristics of the study population in the two centres

	Total (n = 1,338)	Reykjavik (n = 741)	Uppsala (n = 597)	p value*
Male gender (%)	52.7	53.3	51.9	0.619
Age (years)	57.4 ± 11.5	56.4 ± 11.7	58.7 ± 11.2	**<0.001**
Body mass index (kg/m^2)	27.5 ± 4.7	27.9 ± 4.9	27.0 ± 4.3	**<0.001**
Education (years)	13.2 ± 4.2	13.4 ± 4.3	12.9 ± 4.0	**0.038**
Smoking history (%)				0.055
Never	40.8	38.5	43.8	
Past	42.7	43.2	42.0	
Current	16.5	18.3	14.2	
COPD (%)	16.8	17.4	15.8	0.449
Asthma (%)	8.6	8.2	9.3	0.482
Hypertension (%)	30.5	32.1	28.6	0.174
Cardiovascular disease (%)	12.5	13.7	11.0	0.132
Diabetes (%)	4.3	4.6	3.9	0.545
Restless legs syndrome (%)	15.2	18.4	11.2	**<0.001**
ESS, total score	6.1 ± 3.9	6.1 ± 3.9	6.1 ± 3.9	0.884
Risk of dozing off, ESS > 10 (%)	13.1	12.7	13.6	0.634
Feeling sleepy ≥ 3 × week, BNSQ (%)	23.2	20.7	26.3	**0.015**

Data are presented as $M \pm SD$ or % where indicated. Significant differences are in bold ($p < 0.05$). *p-value from Pearson's chi-squared test (numerical variables) and unpaired t test (continuous variables).
BNSQ: Basic Nordic Sleep Questionnaire; COPD: chronic obstructive pulmonary disease; ESS: Epworth Sleepiness Scale.

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was associated with increased odds of asthma. Subjects reporting feeling sleepy, both those with and without dozing off, had on average worse mental and physical quality of life than non-sleepy subjects, whereas no association was found with isolated risk of dozing off (Table 3).

3.4 | Sleep-related symptoms in the four sleepiness categories

Firstly, comparisons of characteristics between the two definitions of EDS were made separately (Supporting Information, Tables S1 and S2). In general, differences in sleep-related symptoms (snoring, sweating, nGER, apneas, not feeling rested, difficulties initiating and maintaining sleep and MAP index >0.5) were more significant between feeling sleepy and not feeling sleepy on the BNSQ ($p < 0.001$ for every sleep-related symptom) than when comparing those at risk of dozing off versus those not at risk of dozing off in the ESS.

After merging the two definitions, subjects within all three groups with EDS had a higher prevalence of snoring and reported apneas than non-sleepy subjects (Table 4) and this association remained significant after adjusting for age, sex, smoking history, BMI, education and study centre (Table 5). Interestingly, those both at risk of dozing off and feeling sleepy had the far highest odds of apneas, with an odds ratio of 7.79 (95% confidence interval, 3.71–16.4) when compared with the non-sleepy population (Table 5). Similarly, the MAP index was highest among those who were both at risk of dozing off and feeling sleepy (Table 4). After adjusting for age, sex, BMI, education, smoking history and study centre, the odds of having a MAP index >0.5 was significantly higher in all three sleepiness groups compared to the non-sleepy population but by far highest in those both at risk of dozing and feeling sleepy, with an OR of 13.52 (95% confidence interval, 4.30–42.55). These results are, however, limited because the MAP index was only available for 760 of 1,338 subjects. The prevalence of RLS, nocturnal sweating, nGER and not feeling rested was higher among those reporting feeling sleepy (with or without risk of dozing off) but not related to isolated risk of dozing off (Tables 4 and 5). Also, difficulties in initiating and maintaining sleep were related to feeling sleepy (with and without the risk of dozing off) but not to isolated risk of dozing off during the day (Table 5).

3.5 | Using other cut-off values for ESS scores: Results from the sensitivity analysis

When using lower cut-off values (>8 and >9) for the ESS score, the change primarily impacted results for those defined only at risk of dozing off, but not other sleepiness groups. When using >9 those only at risk of dozing off had increased odds of reporting cardiovascular disease and when using >8 they also had increased odds of diabetes. When using a cut-off value of >11, we found that those only at risk of dozing off during the day more often reported cardiovascular disease and diabetes but did not report apneas. When using a cut-off value of >12, those feeling sleepy only and both dozing off and feeling sleepy more often reported asthma compared to the non-sleepy group. In general, using different cut-off values for ESS scores had minimal impact on our results.

4 | DISCUSSION

This present study shows that reporting feeling sleepy is better correlated with many variables that contribute to EDS, such as RLS, nGER and difficulties initiating and maintaining sleep, than the risk of dozing off as measured with the ESS. Also, sleepy subjects complain more often of not feeling rested during the day and have a significantly poorer quality of life. However, those with risk of dozing off during the day but no subjective sleepiness had a similar symptom profile

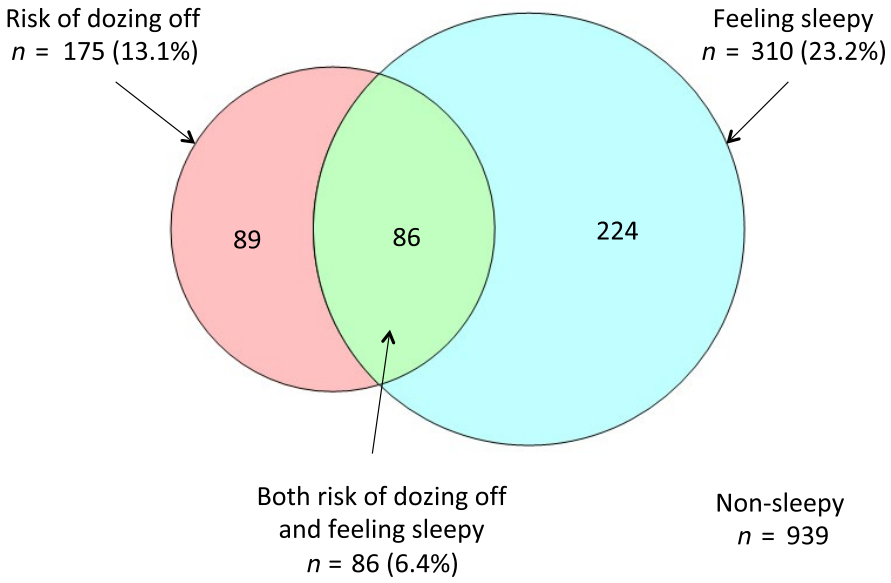


FIGURE 1 Prevalence and overlap of different categories of excessive daytime sleepiness in the general population sample. Pink: subjects at risk of dozing off (Epworth sleepiness scale score >10); blue: subjects reporting feeling sleepy during the day ≥3 times per week (Basic Nordic Sleep Questionnaire question); green: subjects reporting feeling sleepy ≥3 times per week and at risk of dozing off

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TABLE 2 Characteristics of subjects in the four sleepiness categories

	Non-sleepy[a] (*n* = 939)	Dozing off only[b] (*n* = 89)	Feeling sleepy only[c] (*n* = 224)	Dozing off and feeling sleepy[d] (*n* = 86)	*p* value[e]
Male gender (%)	52.8	58.0	48.2	57.0	0.333
Age (years)	57.4 ± 11.6	54.56 ± 8.2	59.0 ± 12.4	56.1 ± 10.1	**0.015**
Body mass index (kg/m^2)	27.4 ± 4.6	26.7 ± 3.7	27.9 ± 5.0	28.2 ± 5.3	0.094
Education (years)	13.0 ± 4.0	14.0 ± 4.0	12.0 ± 4.0	14.0 ± 4.0	**0.020**
Smoking history (%)					0.633
Never	41.1	47.7	38.6	36.1	
Past	43.0	34.1	43.6	45.4	
Current	15.9	18.2	17.7	18.6	
COPD (%)	16.8	9.1	19.9	17.1	0.159
Asthma (%)	7.6	5.7	10.5	18.6	**0.003**
Hypertension (%)	28.5	21.6	41.8	32.6	**<0.001**
Cardiovascular disease (%)	11.5	5.7	19.6	12.8	**0.002**
Diabetes (%)	3.4	4.6	7.3	7.0	**0.041**
Quality of life (SF-12)					
MCS (total score)	50.3 ± 9.4	49.3 ± 8.4	45.8 ± 10.2	45.2 ± 10.0	**<0.001**
PCS (total score)	49.6 ± 9.0	51.2 ± 6.5	44.7 ± 11.4	45.6 ± 9.7	**<0.001**

Data are presented as *M* ± *SD* or % where indicated. Significant differences are in bold ($p < 0.05$). [a]ESS score ≤10 and reporting feeling sleepy <3 times per week on the BNSQ. [b]ESS score >10 but reporting feeling sleepy <3 times per week on the BNSQ. [c]ESS score ≤10 but reporting feeling sleepy ≥3 times per week on the BNSQ. [d]ESS score >10 and feeling sleepy ≥3 times per week on the BNSQ. [e]*p*-value from Pearson's chi-squared test (numerical variables) and one-way analysis of variance (continuous variables).
BNSQ: Basic Nordic Sleep Questionnaire; COPD: chronic obstructive pulmonary disease; MCS: mental health composite score; PCS: physical health composite score; SF-12: Short Form (12) Health Survey.

TABLE 3 Independent association between comorbidities and quality of life in relation to different categories of excessive daytime sleepiness expressed as adjusted (adjusted for age, sex, body mass index, education, smoking history and study centre) odds ratios or beta-coefficients (95% CI) with the non-sleepy[a] group as reference

	Dozing off only[b] (*n* = 89)	Feeling sleepy only[c] (*n* = 224)	Dozing off and feeling sleepy[d] (*n* = 86)
COPD (OR)	0.68 (0.31, 1.48)	1.12 (0.73, 1.73)	1.36 (0.71, 2.60)
Asthma (OR)	0.83 (0.32, 2.14)	1.28 (0.77, 2.13)	**2.94 (1.60, 5.40)**
Hypertension (OR)	0.90 (0.52, 1.56)	**1.70 (1.22, 2.36)**	1.32 (0.80, 2.18)
Cardiovascular disease (OR)	0.74 (0.28, 1.93)	**1.86 (1.20, 2.89)**	1.50 (0.72, 3.12)
Diabetes (OR)	1.92 (0.65, 5.70)	**1.96 (1.03, 3.73)**	2.03 (0.80, 5.18)
Quality of life (SF-12)			
MCS (β)	−0.49 (−2.22, 1.24)	**−3.74 (−4919, −2.58)**	**−4.14 (−5.89, −2.40)**
PCS (β)	0.71 (−1.17, 2.60)	**−3.84 (−5.11, −2.58)**	**−3.95 (−5.85, −2.05)**

Significant differences are in bold. [a]ESS score ≤10 and reporting feeling sleepy <3 times per week on the BNSQ. [b]ESS score >10 but reporting feeling sleepy <3 times per week on the BNSQ. [c]ESS score ≤10 but reporting feeling sleepy ≥3 times per week on the BNSQ. [d]ESS score >10 and feeling sleepy ≥3 times per week on the BNSQ.
B: beta-coefficient; BNSQ: Basic Nordic Sleep Questionnaire; CI: confidence interval; COPD: chronic obstructive pulmonary disease; MCS: mental health composite score; OR: odds ratio; PCS: physical health composite score; SF-12: Short Form (12) Health Survey.

as the non-sleepy population, except for snoring and self-reported apneas, where a higher prevalence was found in all three groups with EDS compared to non-sleepy subjects. This study therefore supports previous research that indicates that the ESS and self-reported EDS measure distinct aspects of sleepiness (Adams et al., 2016; Baldwin et al., 2004; Kim & Young, 2005; Pilcher et al., 2000, 2003).

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Although there was some overlap, many subjects were characterized differently when using the two different methods to evaluate sleepiness. Similar to previous studies, 13.1% were at risk of dozing off during the day using the ESS (Adams et al., 2016; Stradling, Barbour, Glennon, Langford, & Crosby, 2000) and 23.2% reported feeling sleepy most days of the week (Hara et al., 2004; Kallin et al., 2016). As the ESS only measures the propensity to doze off during the day, our study shows that many subjects with EDS will go undiagnosed. This is in line with previous studies that have compared the ESS to questionnaires measuring the more general feeling of sleepiness rather than the propensity to doze off (Sangal, 2012). Also, the ESS measures the tendency to fall asleep in various situations, including some soporific circumstances that do not necessarily increase the risk of any adverse effect, for example when lying down to rest in the afternoon when circumstances permit. This may lead to overdiagnosing of subjects who do not have problematic EDS. This is supported by our results that show that subjects at risk of dozing off without feeling sleepy as measured by the BNSQ do not report poorer quality of life and have a similar symptoms profile as the non-sleepy population. Our study therefore supports previous studies that have found EDS to be a multidimensional symptom that needs more than one method of assessment when making a diagnosis (Kim & Young, 2005; Ohayon, Dauvilliers, & Reynolds, 2012). Designing

TABLE 4 Unadjusted analysis of sleep-related symptoms in the four sleepiness categories

	Non-sleepy[a] (*n* = 939)	Dozing off only[b] (*n* = 89)	Feeling sleepy only[c] (*n* = 224)	Dozing off and feeling sleepy[d] (*n* = 86)	*p*[e]
Restless legs syndrome (%)	12.3	14.5	25.0	23.3	**<0.001**
Snoring ≥ 3 n/w (%)	41.6	57.1	51.8	66.2	**<0.001**
Sweating ≥ 3 n/w (%)	10.5	9.0	18.1	26.8	**<0.001**
nGER ≥ 1 n/w (%)	5.6	6.7	13.6	16.3	**<0.001**
Apneas ≥ 1 n/w (%)	5.4	13.0	14.3	31.3	**<0.001**
Not feeling rested ≥ 1/w (%)	9.5	13.5	28.8	27.9	**<0.001**
Difficulties initiating sleep ≥ 3 n/w (%)	10.8	5.6	30.9	19.1	**<0.001**
Difficulties maintaining sleep ≥ 3 n/w (%)	25.4	28.4	47.8	48.8	**<0.001**
MAP index > 0.5 (%)	15.8	20.3	25.4	41.7	**<0.001**

Data are presented as %. Significant differences are in bold ($p < 0.05$). [a]ESS score ≤10 and reporting feeling sleepy <3 times per week on the BNSQ. [b]ESS score >10 but reporting feeling sleepy <3 times per week on the BNSQ. [c]ESS score ≤10 but reporting feeling sleepy ≥3 times per week on the BNSQ. [d]ESS score >10 and feeling sleepy ≥3 times per week on the BNSQ. [e]*p*-values from Pearson's chi-squared test.
BNSQ: Basic Nordic Sleep Questionnaire; MAP index: Multivariable Apnea Prediction index; nGER: nocturnal gastroesophageal reflux; n/w: nights per week.

TABLE 5 Independent association between sleep-related symptoms in relation to different categories of daytime sleepiness expressed as adjusted (adjusted for age, sex, body mass index, education, smoking history and study centre) odds ratios (95% CI) with the non-sleepy group[a] as reference

	Dozing off only[b] (*n* = 89)	Feeling sleepy only[c] (*n* = 224)	Dozing off and feeling sleepy[d] (*n* = 86)
Restless leg syndrome	1.23 (0.64–2.37)	**2.37 (1.62–3.46)**	**2.39 (1.37–4.19)**
Snoring ≥ 3 n/w	**1.96 (1.19–3.24)**	**1.55 (1.08–2.21)**	**2.42 (1.39–4.22)**
Sweating ≥ 3 n/w	0.91 (0.42–1.95)	**1.78 (1.18–2.68)**	**2.97 (1.73–5.12)**
nGERT ≥ 3 n/w	1.28 (0.53–3.09)	**2.63 (1.62–4.28)**	**3.19 (1.67–6.10)**
Apneas ≥ 1 n/w	**2.55 (1.14–5.71)**	**3.20(1.77–5.79)**	**7.79 (3.71–16.4)**
Not feeling rested ≥ 1/w	1.50 (0.78–2.88)	**3.82 (2.63–5.53)**	**3.57 (2.11–6.04)**
Difficulties initiating sleep ≥ 3 n/w	0.57 (0.22–1.44)	**3.49 (2.42–5.01)**	**2.11 (1.16–3.83)**
Difficulties maintaining sleep ≥ 3 n/w	1.52 (0.90–2.58)	**2.62 (1.87–3.68)**	**3.31 (2.03–5.42)**
MAP index > 0.5	**5.49 (2.03–14.86)**	**3.44 (1.65–7.18)**	**13.52 (4.30–42.55)**

Significant differences are in bold. [a]ESS score ≤10 and reporting feeling sleepy <3 times per week on the BNSQ. [b]ESS score >10 but reporting feeling sleepy <3 times per week on the BNSQ. [c]ESS score ≤10 but reporting feeling sleepy ≥3 times per week on the BNSQ. [d]ESS score >10 and feeling sleepy ≥3 times per week on the BNSQ.
BNSQ: Basic Nordic Sleep Questionnaire; CI: confidence interval; MAP index: Multivariable Apnea Prediction index; nGER: nocturnal gastroesophageal reflux; n/w: nights per week.

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new questionnaires that capture different aspects of sleepiness will provide better diagnosis of the individual level of EDS (Guaita et al., 2015).

It is important to acknowledge that although a large portion of the population is defined as sleepy using the BNSQ question, these subjects have poorer quality of life and have increased frequency of sleep-related symptoms that could be worth diagnosing. Improvement in the diagnostic techniques can provide a more accurate picture of those really in need of specialized treatments that could potentially increase their quality of life.

In our study, we found that subjects with RLS expressed significantly more sleepiness than those without RLS. However, our RLS sufferers did not report significant risk of dozing off during the day compared with those without RLS. This is contradictory to some previous studies that have found that subjects with RLS have higher scores on the ESS (Benediktsdottir et al., 2010; Cuellar, Strumpf, & Ratcliffe, 2007). A possible explanation is that our RLS sufferers come from the general population and might be less symptomatic than those seeking help primarily for RLS complains. Also, in our data, we separated those with only risk of dozing off, those only reporting sleepiness and those reporting both, which could affect our results.

Our study showed that subjects reporting snoring and apneas during sleep also had an increased risk of dozing off during the day and reported sleepiness more often than subjects without snoring or apneas. Similarly, our study showed that subjects reporting nocturnal sweating and nGER, which are symptoms that have been associated with OSA (Arnardottir et al., 2013; Demeter, Visy, & Magyar, 2005) and insomnia (Hartz, Ross, Noyes, & Williams, 2013), also reported more often daytime sleepiness and a tendency to doze off during the day.

As in previous studies (Ford, Cunningham, Giles, & Croft, 2015; Janson et al., 1996; Kallin et al., 2016), we found that subjects reporting both risk of dozing off and feeling sleepy more often reported asthma. We also found that subjects with hypertension and cardiovascular disease more often reported feeling sleepy during the day, which is in line with previous studies (Gislason & Almqvist, 1987). However, having those previously mentioned diseases was only related to feeling sleepy and not to risk of dozing off. Subjects in all three sleepiness groups had almost twice as high odds of diabetes compared to the non-sleepy group. However, this was only statistically significant for the largest group (sleepy only). In our study, neither the risk of dozing off nor feeling sleepy was significantly related to BMI, in contrast to previous studies (Bixler et al., 2005; Panossian & Veasey, 2012; Resta et al., 2001).

The strengths of this study include the simultaneously analyzed various aspects of EDS in a well-defined target population recruited from the general population in two countries. Because of the high participation rate and the lack of differences between the responders and the non-responders (Buist et al., 2007), we believe the responders accurately reflected the general populations of the two countries. The study was based on a well-standardized protocol with excellent staff training, but the age distribution of the participants was a limitation as they were all over 40 years of age, as well as the fact that the diagnosis of cardiovascular disease, hypertension and diabetes was only based on self-report of a doctor's diagnosis and appropriate pharmacological treatment. We did not perform a sleep study on the participants to assess the prevalence of OSA and other sleep disorders. Therefore, we do not know how many subjects in the cohort had treated or untreated OSA and how much effect undiagnosed OSA had on the prevalence of EDS. We used the MAP index, a widely used and validated tool for OSA risk assessment, to minimize this effect on our results. However, because many subjects in our cohort answered questions on OSA symptoms (snoring, snorting and apneas during sleep) with 'I don't know', we were only able to calculate the MAP index for 760 out of 1,338 subjects (57%). Another limitation is the lack of information about sleep time as insufficient sleep is a common cause of EDS. Also, the current study was based entirely on subjective measures of sleepiness and no objective assessment was carried out, such as the multiple sleep latency test, which is considered today the 'reference standard' when measuring EDS (Littner et al., 2005); however, this is costly for large epidemiological studies. Also, no psychometric tests were performed, such as the psychomotor vigilance test, which is a limitation of the study. However, in a recent epidemiological study from our group (Arnardottir, Bjornsdottir, Olafsdottir, Benediktsdottir, & Gislason, 2016) we only found a significant relationship between OSA severity (measured by the apnea hypopnea index [AHI]) and psychomotor vigilance test in those with severe OSA (AHI ≥ 30) and not in those with less severe disease.

In conclusion, the current findings suggest that measuring both the feeling of sleepiness and the risk of dozing off is important when assessing patients with potential EDS. Also, our data suggest that the risk of dozing off without feeling sleepy does not necessarily have consequences on health and quality of life. As the ESS measures only one aspect of sleepiness it is not adequate, on its own, when assessing subjects with EDS. Future research on the definition and measurement of EDS is important so we can better evaluate the magnitude and aetiological factors of EDS.

AUTHOR CONTRIBUTIONS

All the authors have made substantial contributions to design, and acquisition and analysis of data for this article. Calculations were performed by the first author with help from Christer Janson and Thor Aspelund. The first author was mainly responsible for drafting the paper and the co-authors revised the article for important intellectual content. All the authors have approved this version to be published.

CONFLICT OF INTEREST

No conflicts of interest declared.

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