8 (1) | 2021

UMEDICAL REPORTS

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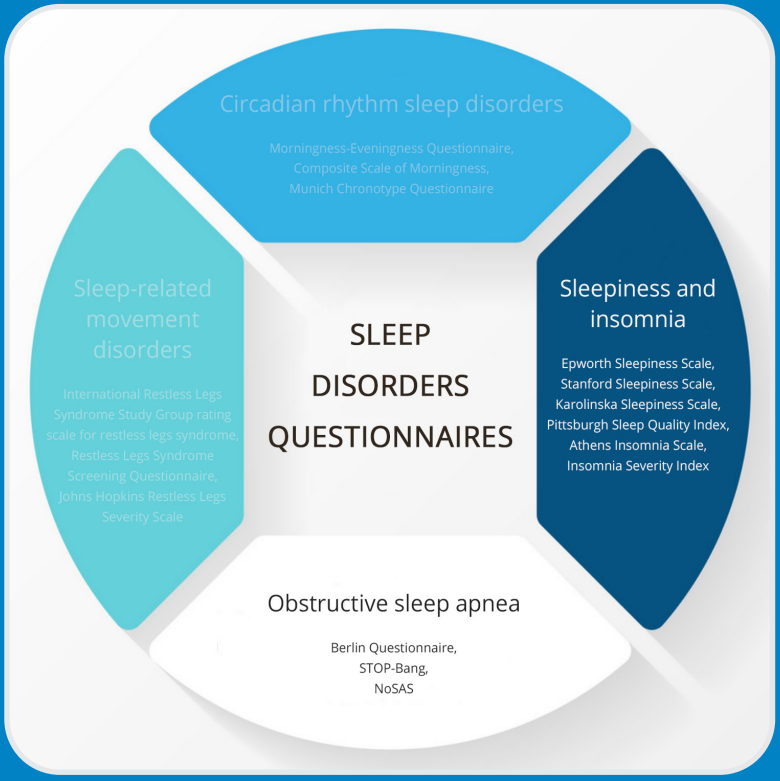


Wydawnictwo Uniwersytetu Medycznego w Łodzi

ŁÓDŹ 2021

8 (1) | 2021 UMR UMEDICAL REPORTS

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# QUESTIONNAIRES FOR SLEEP DISORDER ASSESSMENT. PART I: OBSTRUCTIVE SLEEP APNEA, SLEEPINESS AND INSOMNIA

## KWESTIONARIUSZE DO OCENY ZABURZEŃ SNU. CZĘŚĆ I: OBTURACYJNY BEZDECH SENNY, SENNOŚĆ I BEZSENNOŚĆ

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Wydawnictwo Uniwersytetu Medycznego w Łodzi ŁÓDŹ 2021

UMEDICAL REPORTS 8 (1) | 2021

Seria monografii naukowych dotyczących zagadnień z zakresu dyscyplin nauk farmaceutycznych, nauk medycznych i nauk o zdrowiu.

Wydawnictwo recenzowane i punktowane na zasadach zgodnych z Rozporządzeniem MNiSW z dnia 22 lutego 2019 r. w sprawie ewaluacji jakości działalności naukowej (Dz.U. 2019 poz. 392 z późn. zm.).



**QUESTIONNAIRES FOR SLEEP DISORDER ASSESSMENT PART I: OBSTRUCTIVE SLEEP APNEA, SLEEPINESS AND INSOMNIA***
Łódź 2021

* The contribution of the first and the last author is equivalent and accounts for 80% of the contribution to this research

**WYDAWNICTWO UNIWERSYTETU MEDYCZNEGO W ŁODZI**
http://wydawnictwo.umed.pl/
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**Unikatowy identyfikator Wydawnictwa: 60000**
(Komunikat Ministra Edukacji i Nauki z dnia 22 lipca 2021 r. w sprawie wykazu wydawnictw publikujących recenzowane monografie naukowe)

ISBN 978-83-963099-0-7

**WYDANIE PIERWSZE**

**Abstract:** Nowadays, sleep disorders are highly common in medical practice. Undiagnosed and untreated sleep disturbances have serious implications for our physiological, psychological and social functioning. Early detection and treatment of these diseases is of paramount importance. Over the last three decades, there has been increasing interest in the development of quick and inexpensive approaches for screening and assessing the severity of sleep disturbances, such as the use of questionnaires.

Depending on the detected disorder, these tools can be categorized into four groups:

1) Questionnaires used to assess sleepiness and insomnia (Epworth Sleepiness Scale, Stanford Sleepiness Scale, Karolinska Sleepiness Scale, Pittsburgh Sleep Quality Index, Athens Insomnia Scale, Insomnia Severity Index).
2) Questionnaires used to assess obstructive sleep apnea (STOP-Bang, NoSAS, Berlin Questionnaire, EuroSAS).
3) Questionnaires used to assess sleep-related movement disorders (International Restless Legs Syndrome Study Group rating scale for restless legs syndrome, Restless Legs Syndrome Screening Questionnaire, Johns Hopkins Restless Legs Severity Scale).
4) Questionnaires used to assess circadian rhythm sleep disorders (Morningness-Eveningness Questionnaire, Composite Scale of Morningness, Munich Chronotype Questionnaire).

The aim of this paper was to describe, evaluate and compare the most commonly-used questionnaires designed for sleepiness, insomnia and obstructive sleep apnea. Following a detailed literature review, it presents their advantages and disadvantages, and summarizes the available questionnaires.

**Keywords:** questionnaires, insomnia, sleepiness, obstructive sleep apnea, polysomnography, sleep-related movement disorders, restless legs syndrome, circadian rhythm sleep disorders, chronotype

**Streszczenie:** W obecnych czasach problemy ze snem są bardzo częste w praktyce lekarskiej. Niezdiagnozowane i nieleczone zaburzenia snu mają poważne konsekwencje dla naszego fizjologicznego, psychologicznego oraz społecznego funkcjonowania. Wczesne wykrycie i leczenie tych zaburzeń ma nadrzędne znaczenie. W ciągu ostatnich trzech dekad wzrosło zainteresowanie w kwestii opracowania niedrogich i szybkich sposobów wykrywania i oceny ciężkości zaburzeń snu, takich jak kwestionariusze.

W zależności od wykrywanego zaburzenia narzędzia te można podzielić na cztery grupy:

1) Kwestionariusze oceniające senność i bezsenność (Epworth Sleepiness Scale, Stanford Sleepiness Scale, Karolinska Sleepiness Scale, Pittsburgh Sleep Quality Index, Athens Insomnia Scale, Insomnia Severity Index).
2) Kwestionariusze do oceny obturacyjnego bezdechu sennego (STOP-Bang, NoSAS, Berlin Questionnaire, EuroSAS).
3) Ankiety oceniające zaburzenia ruchowe związane ze snem (International Restless Legs Syndrome Study Group rating scale for restless legs syndrome, Restless Legs Syndrome Screening Questionnaire, Johns Hopkins Restless Legs Severity Scale).
4) Ankiety do oceny zaburzeń rytmu okołodobowego (Morningness-Eveningness Questionnaire, Composite Scale of Morningness, Munich Chronotype Questionnaire).

Celem tej pracy była szczegółowa charakterystyka, porównanie i ocena przydatności klinicznej kwestionariuszy służących do oceny zaburzeń snu pod postacią bezdechu sennego oraz senności i bezsenności. Na podstawie przeglądu literatury zaprezentowano ich zalety i wady, a następnie podsumowano dostępne kwestionariusze.

**Słowa kluczowe:** kwestionariusze, bezsenność, senność, obturacyjny bezdech senny, polisomnografia, zaburzenia ruchowe w trakcie snu, zespół niespokojnych nóg, zaburzenia rytmu okołodobowego, chronotyp

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**Abbreviation list**

**AIS** – Athens Insomnia Scale
**AUC** – Area under the curve
**BQ** – Berlin questionnaire
**CRSD** – Circadian rhythm sleep disorders
**CSM** – Composite Scale of Morningness
**DSM-IV** – Diagnostic and Statistical Manual of Mental Disorders, 4th Edition
**ECG** – Electrocardiography
**EEG** – Electroencephalogram
**EOG** – Electrooculogram
**EOM** – Electromyogram
**ESS** – Epworth Sleepiness Scale
**EuroSAS** – European Sleep Apnea Syndrome
**IRLS** – International Restless Legs Syndrome Study Group rating scale for restless legs syndrome
**ICD** – International Classification of Diseases
**ICSD** – International Classification of Sleep Disorders
**ISI** – Insomnia Severity Index
**JHRLSS** – Johns Hopkins Restless Legs Severity Scale
**KSS** – Karolinska Sleepiness Scale
**MCTQ** – Munich Chronotype Questionnaire
**MEQ** – Morningness Eveningness Questionnaire
**NPV** – Negative Predictive Value
**OSA** – Obstructive Sleep Apnea
**PG** – Polygraphy
**PPV** – Positive Predictive Value
**PSG** – Polysomnography
**PSQI** – Pittsburgh Sleep Quality Index
**RDI** – The Respiratory Disturbance Index
**RLS** – Restless Legs Syndrome
**RLSSQ** – Restless Legs Syndrome Screening Questionnaire
**SBQ** – STOP-BANG questionnaire
**SRMD** – Sleep-Related Movement Disorders
**SSS** – Stanford Sleepiness Scale

**Number of tables:** 13

## 1. Sleep disorders

Humans spend approximately one-third of their lives asleep (Sleep Disorders and Sleep Deprivation, 2006). Sleep is a reversible state of unconsciousness and disconnection from the environment (Carley and Farabi, 2016; Feriante and Araujo, 2021) This physiological process is regulated by both cellular and molecular mechanisms and is crucial for health and many vital functions, including development, immune system response and cognition (Zielinski et al., 2016).

Sleep disorders include a wide spectrum of conditions which disturb the normal sleep patterns on a regular basis, and cause significant impairments of physical, mental and social functioning (Irwin, 2015; Karna and Gupta, 2021). They constitute a risk factor in the occurrence and progression of major diseases (Irwin, 2015). Early detection and treatment of sleep disorders is of paramount importance. They can be classified into five major categories: hypersomnia and insomnia, sleep-related breathing disorders (i.e. obstructive sleep apnea), sleep-related movement disorders (i.e. restless legs syndrome, periodic legs movement disorder), circadian rhythm sleep disorders (i.e. delayed sleep phase disorder, jet lag) and parasomnias. Sleep disorders are related to each other and represent a complex pathophysiological problem.

Subjective assessment of sleep quality is of significant importance in the clinical setting. Several sleep-rating measures have been developed to help clinicians in the early detection of sleep disturbances and to provide adequate intervention based on the type and severity of the problem. Depending on the detected disorder, these tools can be categorized into four groups (Table 1). Most of the questionnaires were translated into Polish, but not all of them were validated in Polish. Some of the questionnaires have limited availability, such as questionnaires used in restless leg syndrome.

**Table 1.** Types of sleep-disorders questionnaires.

| **Sleepiness and insomnia** | **Obstructive sleep apnea** | **Sleep-related movement disorders** | **Circadian rhythm sleep disorders** |
|---|---|---|---|
| Epworth Sleepiness Scale | NoSAS | International Restless Legs Syndrome Study Group rating scale for restless legs syndrome | Morningness-Eveningness Questionnaire |
| Stanford Sleepiness Scale | Berlin Questionnaire | Restless Legs Syndrome Screening Questionnaire | Composite Scale of Morningness |
| Karolinska Sleepiness Scale | EuroSAS | Johns Hopkins Restless Legs Severity Scale | Munich Chronotype Questionnaire |
| Pittsburgh Sleep Quality Index | | | |
| Athens Insomnia Scale | | | |
| Insomnia Severity Index | | | |

This monograph provides a concise overview of the most frequently-used sleep-disorder questionnaires designed for sleepiness, insomnia and obstructive sleep apnea. Based on a detailed review of the literature, it presents their advantages and disadvantages and summarizes the available questionnaires.

## 2. Questionnaires in determining the risk and severity of sleepiness and insomnia

### *2.1. Introduction*

Sleep disorders such as insomnia and sleepiness are common complaints among patients in ambulatory care.

Insomnia is the most common sleep disturbance in the general population (Schutte-Rodin et al., 2008). The frequency of chronic insomnia ranges from 10% to 15%, but the prevalence of insomnia symptoms is estimated at 30% (Roth, 2007; Schutte-Rodin et al., 2008). Furthermore, the prevalence of insomnia appears to be more common in recent decades (Garland et al., 2018; Kronholm et al., 2014). Insomnia is characterized by difficulty in initiating or maintaining sleep accompanied by impairment of daytime functioning, “despite adequate opportunity and circumstances for sleep” (Bollu and Kaur, 2019). It can be either a primary condition or comorbid disorder associated with underlying psychiatric and medical diseases (Mai and Buysse, 2008; Roth, 2007). Insomnia is also a risk factor for the development of several neurological and mental diseases (Buysse, 2013; Fernandez-Mendoza and Vgontzas, 2013; Hoshino, 2020; Sivertsen et al., 2014).

Another frequently-observed consequence of sleep disturbance is sleepiness. It affects about 20% of the population (Pagel, 2009). Sleepiness is a result of abnormal sleep quality and quantity (Slater and Steier, 2012). Sleepiness constitutes a common manifestation of sleep disorders (e.g. narcolepsy, hypersomnia, obstructive sleep apnea, restless legs syndrome, circadian rhythm sleep disorders); however, it is also related to a wide spectrum of psychiatric, neurological, cardiovascular and respiratory diseases (Roth, 2015; Slater and Steier, 2012).

The above mentioned conditions can significantly affect the patients’ health status, quality of life as well as academic and work performance and may have important economic consequences (Drake et al., 2003; Roth, 2015; Slater and Steier, 2012). Furthermore, patients affected by these disorders are at higher risk of being involved in road and industrial accidents (Kaur et al., 2020; Slater and Steier, 2012; Uehli, 2014). Therefore, proper diagnosis and treatment of insomnia and sleepiness is extremely important.

Both the self-administered questionnaires and physician-administered scales are helpful for evaluating sleep disturbances in the outpatient clinic [table 2]. They are very low cost, easy to use, and completion usually only takes a few minutes. They are also characterized by high validity and reliability. The most popular tools are the Epworth Sleepiness Scale (ESS) and the Pittsburgh Sleep Quality Index (PSQI) as well as short scales to evaluate sleepiness: the Stanford Sleepiness Scale (SSS) and the Karolinska Sleepiness Scale (KSS). In addition, the Athens Insomnia Scale (AIS) and the Insomnia Severity Index (ISI) can be used to evaluate insomnia.

**Table 2.** Self-assessment questionnaires in the assessment of risk and severity of sleepiness and insomnia.

| Questionnaire | Evaluated aspects | Disorder | Evaluated period | Scoring | Cut-off value | Advantages | Disadvantages | Reference |
|---|---|---|---|---|---|---|---|---|
| **Epworth Sleepiness Scale** (ESS) (Table 3) | Daytime sleepiness (propensity to fall asleep) | Hypersomnia, narcolepsy | Without a specified time range | 8 items rated on a scale from 0 to 3<br>Total score ranging from 0 to 24 | 10 points | 1. Helpful in diagnosing narcolepsy and idiopathic hypersomnia.<br>2. Helpful in evaluating the effectiveness of OSA treatment. | 1. Unreliable total score in view of the fact that some questions may not be applicable to some individual patients.<br>(subject may not perform one of the eight mentioned activities and cannot answer a question).<br>2. Not useful in evaluating the presence or severity of OSA.<br>3. Lack of consistent rules of the results interpretation – multiple studies suggest different optimal cut-off values. | Johns, 1991 |

**Table 2** (cont.)

| Questionnaire | Evaluated aspects | Disorder | Evaluated period | Scoring | Cut-off value | Advantages | Disadvantages | Reference |
|---|---|---|---|---|---|---|---|---|
| **Stanford Sleepiness Scale** (SSS) (Table 4) | Degree of sleepiness | Insomnia, narcolepsy | At the specific moment | One item rated on a scale from 1 to 7 | – | 1. Can be used to evaluate the sleepiness at the particular moment of the examination in contrast to many other tools.<br>2. Useful in evaluating changes in response to various factors (e.g. treatment).<br>3. Ratings correlate with performance on tasks which are sensitive to lack of sleep.<br>4. Sensitive to total sleep deprivation (24 hours). | 1. Not useful in evaluating sleepiness over a longer period of time.<br>2. Not sensitive to partial sleep deprivation. | Hoddes et al., 1972 |
| **Karolinska Sleepiness Scale** (KSS) (Table 5) | Degree of sleepiness | – | At the specific moment | One item rated on a scale from 1 to 9 | – | 1. Can be used to evaluate the degree of sleepiness at the particular moment of examination, in contrast to many other tools.<br>2. Useful in evaluating changes in response to various factors (e.g. treatment). | 1. Not useful in evaluating sleepiness over a longer period of time.<br>2. Ratings can vary according to e.g. time of day, earlier sleep. | Akerstedt and Gillberg, 1990 |

**Table 2** (cont.)

| Questionnaire | Evaluated aspects | Disorder | Evaluated period | Scoring | Cut-off value | Advantages | Disadvantages | Reference |
|---|---|---|---|---|---|---|---|---|
| **Pittsburgh Sleep Quality Index** (PSQI) (Table 6) | 1. Sleep quality.<br>2. Sleep latency.<br>3. Sleep duration.<br>4. Habitual sleep efficiency.<br>5. Sleep disturbances.<br>6. Use of sleeping medications.<br>7. Daytime dysfunction. | Insomnia | Previous month | 19 items grouped into 7 components, each scored from 0 to 3<br>Total score ranging between 0 and 21 | 5 points | 1. Useful for screening primary insomnia and identifying subjects with sleep difficulties. | 1. Not useful in evaluating the presence or severity of OSA.<br>2. Lack of consistent rules for interpreting results – multiple studies suggest different optimal cut-off values. | Buysse et al., 1989 |
| **Athens Insomnia Scale** (AIS) (Table 7) | 1. Sleep induction.<br>2. Awakenings during the night.<br>3. Final awakening earlier than desired.<br>4. Sleep duration.<br>5. Overall quality of sleep.<br>6. Daytime consequences of insomnia (sense of well-being, functioning and sleepiness during the day). | Insomnia | Previous month | 8 items rated on a scale from 0 to 3<br>Total score ranging from 0 to 24 | 6 points | 1. Based on worldwide-accepted criteria (ICD-10).<br>2. Appropriate to diagnose and evaluate insomnia severity.<br>3. Evaluates all major insomnia symptoms. | 1. Lack of consistent rules for interpreting results – multiple studies suggest different optimal cut-off values. | Soldatos et al., 2000 |

**Table 2** (cont.)

| Questionnaire | Evaluated aspects | Disorder | Evaluated period | Scoring | Cut-off value | Advantages | Disadvantages | Reference |
|---|---|---|---|---|---|---|---|---|
| **Insomnia Severity Index** (ISI) (Table 8) | 1. Daytime and nighttime symptoms of insomnia. 1. Severity of sleep onset.<br>2. Sleep maintenance and early morning waking problems.<br>3. Sleep dissatisfaction.<br>4. Impact of sleep difficulties on daytime functioning.<br>5. Noticeability of sleep difficulties by other people.<br>6. Distress caused by sleep difficulties. | Insomnia | Past 2 weeks | 7 items rated on a scale from 0 to 4<br>The total score ranging from 0 to 28 | 15 points | 1. Based on worldwide-accepted criteria (DSM-IV and ICSD).<br>2. Appropriate for diagnosing and evaluating insomnia severity.<br>3. Evaluates all major insomnia symptoms.<br>4. Satisfactory association with PSG variables.<br>5. 3 variants available: for patient, clinician and significant other (e.g. spouse, parent).<br>6. Sensitive to response to cognitive-behavioral therapy for insomnia. | 1. Lack of consistent rules of the results interpretation – multiple studies suggest different optimal cut-off values. | Bastien et al., 2001 |

*2.2. Epworth Sleepiness Scale*

The Epworth Sleepiness Scale (ESS) is a questionnaire used to measure a level of daytime sleepiness in adults (Johns, 1991). The ESS includes 8 items describing tendency to falling asleep in different situations during the day (Johns, 1994) with the 0–3 rating score, where '0' indicates no probability of falling asleep and '3' indicates a high probability of falling asleep (Table 3). The final score ranges between 0 and 24, and a score above 10 suggests excessive daytime sleepiness.

Numerous studies showed that the ESS is not useful in evaluating the presence or severity of obstructive sleep apnea (OSA) (Duarte et al., 2019; Osman, 1999; Ulasli et al., 2014). In an Ulasli et al. (2014) study, only 45.9% of 1,230 subjects with apnea-hypopnea index (AHI) > 5, which indicated presence of OSA, were classified as subjects with excessive daytime sleepiness using the ESS. The sensitivity and specificity were 46% and 60%, respectively. Duarte et al. (2019) conducted a study on 2,591 patients with a clinical diagnosis of insomnia. Although 76.3% of these subjects were diagnosed with OSA based on the AHI (score > 5), only 42.8% were classified as patients at high risk of OSA using the ESS cut-off score of 11 or above. Depending on the OSA severity indicated by AHI, the sensitivity of ESS score ranged from 45.4% to 53.2%, while its specificity ranged from 62.2% to 65.7%. These results suggest that the ESS cannot detect OSA or discriminate its severity. In addition, Osman et al. (1999) found no correlation between the AHI and the ESS-score among snorers. Many other studies also indicate that the ESS is not an accurate screening test for OSA (Goh et al., 2018; Guimarães et al., 2012; Kiciński et al., 2016; Laub et al., 2015). The low sensitivity and specificity of the ESS have been confirmed by Chiu et al. (2017) in a meta-analysis of 108 studies with a total of 47,989 patients. Detection sensitivity levels for mild, moderate and severe OSA were: 54%, 47%, 58% respectively, while the specificity levels were 65%, 62% and 60% respectively. These results demonstrate that although the ESS was designed to measure sleepiness, which is often associated with OSA, it cannot be used to detect OSA since not every patient with this syndrome demonstrates sleepiness. Furthermore, the ESS does not take into account other factors predisposing for OSA, such as age, sex, obesity and history of smoking (Desalu et al., 2017; Punjabi, 2008).

Although the ESS is not useful for OSA diagnosis, it can be used in some patients to evaluate and monitor the effectiveness of OSA treatment. Hardinge et al. (1995) measured the intensity of daytime sleepiness before and after continuous positive airway pressure (CPAP) treatment, and Yaremchuk et al. (2011) measured the intensity of this symptom before and after surgical treatment of OSA. Both studies demonstrated an improvement in the ESS score after CPAP therapy or surgery.

Moreover, numerous studies suggest that the ESS would be an effective screening tool for narcolepsy or hypersomnia (Johns, 2000; Oosterloo et al., 2006; Parkes et al., 1998; Vernet and Arnulf, 2009). Johns (2000) reported that the ESS score > 10 points, had 93.5% sensitivity and 100% specificity in narcoleptic patients. Similarly, Parkes et al. (1998) using a higher cut-off score (14 points), confirmed high specificity (100%) and high sensitivity (97%) of the ESS in patients with narcolepsy. Furthermore, Vernet et al. (2009) pointed out that patients with idiopathic hypersomnia had higher ESS scores than control subjects and 89% of patients with hypersomnia had scores > 10. Additionally, Oosterloo et al. (2006) revealed that 95.9% of patients with hypersomnia had scores ≥ 12. These results suggest that the ESS may effectively distinguish excessive daytime sleepiness (because of narcolepsy or idiopathic hypersomnia) from the daytime sleepiness of healthy subjects.

**Table 3.** Epworth Sleepiness Scale (Johns, 1994).

| Situation | Chance of falling asleep | | | |
|---|---|---|---|---|
| | **0** | **1** | **2** | **3** |
| 1. Watching TV | | | | |
| 2. Sitting inactive in a public place (e.g. a theater or a meeting) | | | | |
| 3. As a passenger in a car for an hour without a break | | | | |
| 4. Lying down to rest in the afternoon when circumstances permit | | | | |
| 5. Sitting and talking to someone | | | | |
| 6. Sitting quietly after a lunch without alcohol | | | | |
| 7. In a car, while stopped for a few minutes in traffic | | | | |

How likely are you to fall asleep in the following situations? This refers to your usual way of life in recent times. Use the following scale to indicate the most appropriate answer.
0 = would never fall asleep
1 = slight chance of falling asleep
2 = moderate chance of falling asleep
3 = high chance of falling asleep

### *2.3. Stanford Sleepiness Scale*

The Stanford Sleepiness Scale (SSS) measures sleepiness at a specific moment of time (Hoddes et al., 1972). It contains only one item rated from 1 (feeling alert, vital, wide-awake) to 7 (excessively sleepy, feeling that sleep onset is soon) (Table 4). A higher score suggests a higher level of sleepiness. Unlike other tools, which often measure sleepiness over a longer period of time, the SSS evaluates sleepiness at the particular time of examination (Shahid et al., 2012). Therefore, the SSS needs to be repeatedly administered to assess sleep treatment efficiency or level of intervention.

Hoddes et al. (1973) proved that the SSS scores increase following 24 hours of total sleep deprivation. The ratings closely correlate with patient's performance of tasks which are sensitive to lack of sleep. The authors also concluded that the SSS has a significant diagnostic value in the routine assessment of insomnia and narcolepsy. However, Broughton (1982) indicates that the SSS is unreliable in partial sleep deprivation.

**Table 4.** Stanford Sleepiness Scale (Hoddes et al., 1972)

Using the 7-point scale below, pick which best represents how you are feeling and note the corresponding number on the scale below.

| Degree of Sleepiness | Scale Rating |
|---|---|
| Feeling active, vital, alert, or wide awake | 1 |
| Functioning at high levels, but not fully alert | 2 |
| Awake, but relaxed; responsive but not fully alert | 3 |
| Somewhat foggy, let down | 4 |
| Foggy; losing interest in remaining awake; slowed down | 5 |
| Sleepy, woozy, fighting sleep; prefer to lie down | 6 |
| No longer fighting sleep, sleep onset soon; having dream-like thoughts | 7 |
| Asleep | X |

*2.4. Karolinska Sleepiness Scale*

The Karolinska Sleepiness Scale (KSS), like the SSS, evaluates the sleepiness level at a particular moment. It is a one-item scale ranked from 1 (extremely alert) to 9 (extremely sleepy) (Table 5) (Åkerstedt and Gillberg, 1990). The modified version of the KSS includes an additional point, i.e. 10, corresponding to feeling extremely sleepy and falling asleep all the time (Shahid et al., 2012).

The KSS has been used to measure current subjective drowsiness during driving (Kecklund and Åkerstedt, 1993; Kozak et al., 2005) or work shift (Geiger Brown et al., 2014; Kazemi et al., 2016) or to measure alertness and performance in experimental studies (Kazemi et al., 2018). The KSS is useful in evaluating changes in response to environmental factors or drugs (Shahid et al., 2012). Although KSS score highly correlates with electroencephalographic and behavioral variables (Kaida et al., 2006),its ratings can be affected by time of day, early sleep and other parameters (Shahid et al., 2012).

**Table 5.** Karolinska Sleepiness Scale (Åkerstedt and Gillberg, 1990).

| Rating | Verbal descriptions |
|---|---|
| 1 | Extremely alert |
| 2 | Very alert |
| 3 | Alert |
| 4 | Fairly alert |
| 5 | Neither alert nor sleepy |
| 6 | Some signs of sleepiness |
| 7 | Sleepy, but no effort to keep alert |
| 8 | Sleepy, some effort to keep alert |
| 9 | Very sleepy, great effort to keep alert, fighting sleep |

*2.5. Pittsburgh Sleep Quality Index*

The Pittsburgh Sleep Quality Index (PSQI) is a questionnaire used to measure sleep quality and disturbances during the previous month (Buysse et al., 1989). It was created as a standardized and reliable tool measuring different aspects of sleep and discriminating subjects with sleep disorders. The questionnaire comprises 19 items grouped into seven components (subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medication, and daytime dysfunction), each rated on a three-point scale, leading to a sum of up to 21 points (Table 6). Scores higher than 5 imply significant sleep problems.

A variety of studies indicate that the PSQI effectively differentiates between patients with good sleep quality and patients with relevant sleep disorders (Bertolazi et al., 2011; Carpenter and Andrykowski, 1998; Del Rio João et al., 2017). Buysse et al. (1989) report that the PSQI demonstrated 89.6% sensitivity and 86.5% specificity for indicating individuals with sleep difficulties, with a cut-off score of 5 points. Results of similar investigations also showed that the 5-point cut-off value provides satisfactory sensitivity, ranging from 80% to 94%, and specificity, between 72% and 86.5% (Farrahi Moghaddam et al., 2011; Grandner et al., 2006; Manzar et al., 2015). Backhaus et al. (2002) demonstrated that the PSQI is a valid and reliable tool to evaluate the presence of primary insomnia. The authors recommend 6 points, rather than 5, as a cut-off value to improve specificity (100% vs. 84.4%) with slight improvement of sensitivity (93.4% vs. 98.7%). Similarly, Tsai et al. (2005) demonstrated that a PSQI cut-off value of 6 had higher specificity (67% vs. 55%) and lower sensitivity (90% vs. 98) if measured in patients with insomnia and healthy individuals. Moreover, Mollayeva et al. (2016), in a meta-analysis of 37 studies, revealed that the PSQI strongly correlates with other sleep quality measures including: clinical diagnosis of insomnia by Diagnostic and Statistical Manual of Mental Disorders, 4th Edition, (DSM-IV), the ISI and ESS score, some actigraphy variables (sleep efficiency, total sleep time, wake after sleep onset, sleep latency), sleep diary variables (sleep efficiency, total sleep time, wake after sleep onset, sleep latency, sleep disturbance, sleep efficiency) and polysomnography variables (sleep latency, sleep efficiency, time spent asleep, %delta, %REM – Rapid eye movement, Mixed apnea index, the Respiratory Disturbance Index (RDI), $O_2$ desaturations < 85%). Manzar (2015) demonstrated that the PSQI component scores showed some considerable relationships with the related polysomnographic measures. On the contrary, Buysse (2008) and Grandner (2006) indicate that the PSQI score is not related to objective sleep measures, such as polysomnography and actigraphy, but it has weak correlation with sleep diary variables.

Furthermore, no association has been found between PSQI scores and AHI, which has been confirmed by Scarlata (2013) in a study on 254 patients with OSA, and Kezirian (2009) in a study on 2,849 subjects.

**Table 6.** Pittsburgh Sleep Quality Index (PSQI) (Buysse et al., 1989).

The following questions relate to your usual sleep habits during the past month only. Your answers should indicate the most accurate reply for the majority of days and nights in the past month. Please answer all questions.

1. During the past month, what time have you usually gone to bed at night? _____
2. During the past month, how long (in minutes) has it usually taken you to fall asleep each night? _____
3. During the past month, what time have you usually gotten up in the morning? _____
4. During the past month, how many hours of actual sleep did you get at night? (This may be different than the number of hours you spent in bed.) _____

| 5. During the past month, how often have you had trouble sleeping because you… | **Not during the past month** | **Less than once a week** | **Once or twice a week** | **Three or more times a week** |
|---|---|---|---|---|
| a. Cannot get to sleep within 30 minutes. | | | | |
| b. Wake up in the middle of the night or early morning | | | | |
| c. Have to get up to use the bathroom. | | | | |
| d. Cannot breathe comfortably. | | | | |
| e. Cough or snore loudly. | | | | |
| f. Feel too cold. | | | | |
| g. Feel too hot. | | | | |
| h. Have bad dreams. | | | | |
| i. Have pain. | | | | |
| j. Other reason(s), please describe: | | | | |
| 6. During the past month, how often have you taken medicine to help you sleep (prescribed or “over the counter”)? | | | | |
| 7. During the past month, how often have you had trouble staying awake while driving, eating meals, or engaging in social activity? | | | | |
| | **No problem at all** | **Only a very slight problem** | **Somewhat of a problem** | **A very big problem** |
| 8. During the past month, how much of a problem has it been for you to keep up enough enthusiasm to get things done? | | | | |
| | **Very good** | **Fairly good** | **Fairly bad** | **Very bad** |
| 9. During the past month, how would you rate your sleep quality overall? | | | | |

**Table 6** (cont.)

| | **No bed partner or room mate** | **Partner/ room-mate in other room** | **Partner in same room but not same bed** | **Partner in same bed** |
|---|---|---|---|---|
| 10. Do you have a bed partner or roommate? | | | | |
| | **Not during the past month** | **Less than once a week** | **Once or twice a week** | **Three or more times a week** |
| If you have a roommate or bed partner, ask him/her how often in the past month you have had: | | | | |
| a. Loud snoring | | | | |
| b. Long pauses between breaths while asleep | | | | |
| c. Legs twitching or jerking while you sleep | | | | |
| d. Episodes of disorientation or confusion during sleep | | | | |
| e. Other restlessness while you sleep, please describe: | | | | |

*2.6. Athens Insomnia Scale*

The Athens Insomnia Scale (AIS) is a questionnaire evaluating the severity of insomnia based on the international classification of diseases (ICD-10) (Table 7) (Soldatos et al., 2000). The first five items measure subjective sleep quality and quantity, while the last three items measure the daytime consequences of insomnia. There are two versions of the AIS: a full version (AIS-8) and a shorter version (AIS-5), which contains only the first five questions. Each item is rated from 0 to 3 points, with a higher score indicating more acute symptoms of insomnia. The AIS-8 provides a total score from 0 to 24 points, while the AIS-5 from 0 to 15 points. The AIS-8 is used more frequently.

The AIS is a simple and brief scale, developed to identify insomnia using globally-accepted criteria (Soldatos et al., 2000). Soldatos (2003) found the AIS to be characterized with 93% sensitivity and 85% specificity for diagnosing patients with insomnia, using 6 as a cut-off point. The authors also concluded that the AIS is an invaluable tool to evaluate perceived sleep-related difficulties in clinical practice and sleep research due to its satisfactory reliability, validity and consistency. In a study comprising 640 subjects by Okajima (2013), the AIS scores of all patients with insomnia were significantly higher than those in the control group. In this study, a cut-off score of 5.5 indicates an optimal value to distinguish subjects with insomnia with the sensitivity of 92% and specificity of 93%. The AIS has high validity and accuracy for detecting insomnia. In another study on 356 subjects, performed by Fornal-Pawłowska (2011), patients with insomnia had significantly higher AIS scores than self-defined good sleepers. In that study, the sensitivity and specificity suggested by the validation study were 99% and 67%, respectively, using a cut-off score of 6 points; the optimal cut-off value in this trial was estimated at 8 points, with sensitivity and specificity values of 94% and 84%.

Chiu (2016) conducted a meta-analysis of 19 studies including a total of 4,693 subjects to estimate the diagnostic accuracy of screening tools for insomnia. The pooled sensitivity and specificity of the AIS were 91% and 87%, respectively. Furthermore, by comparing the PSQI, AIS and ISI, it was demonstrated that the AIS and ISI are the strongest and the most appropriate tools for screening and

diagnosing insomnia (Chiu et al., 2016). Moreover, both AIS and ISI evaluate all major insomnia symptoms (early morning awakening and difficulties in initiating and maintaining sleep). Several other studies have confirmed that AIS is a validated and reliably screening tool for insomnia (Chung et al., 2011; Jeong et al., 2015; Sirajudeen et al., 2020).

Additionally, the AIS has been proved to be a very useful tool for assessing insomnia resulting from chronic pain or comorbid diseases, such as cancer (Enomoto et al., 2018; Lin et al., 2019; Sun et al., 2011). Studies with cancer patients suggest that the cut-off value of 7 points provides the best balance between sensitivity (86%) and specificity (81%) (Lin et al., 2019; Sun et al., 2011) while in patients with chronic pain, a cut-off score of 8 points gave satisfactory sensitivity (72%) and specificity (85%).

**Table 7.** Athens Insomnia Scale (Soldatos et al., 2000).

Please, indicate your estimate of any difficulty, provided that it occurred at least three times per week during the last month.

| | | | | |
|---|---|---|---|---|
| **Sleep induction** (Time it takes you to fall asleep after turning off the lights) | **0** No problem | **1** Slightly delayed | **2** Markedly delayed | **3** Very delayed or did not sleep at all |
| **Awakenings during the night** | **0** No problem | **1** Minor problem | **2** Considerable problem | **3** Serious problem or did not sleep at all |
| **Final awakening earlier than desired** | **0** Not earlier | **1** A little earlier | **2** Markedly earlier | **3** Much earlier or did not sleep at all |
| **Total sleep duration** | **0** Sufficient | **1** Slightly insufficient | **2** Markedly insufficient | **3** Very insufficient or did not sleep at all |
| **Overall quality of sleep** (no matter how long you slept) | **0** Satisfactory | **1** Slightly unsatisfactory | **2** Markedly unsatisfactory | **3** Very unsatisfactory or did not sleep at all |
| **Sense of well-being during the day** | **0** Normal | **1** Slightly decreased | **2** Markedly decreased | **3** Very decreased |
| **Functioning (physical and mental) during the day** | **0** Normal | **1** Slightly decreased | **2** Markedly decreased | **3** Very decreased |
| **Sleepiness during the day** | **0** None | **1** Mild | **2** Considerable | **3** Intense |

*2.7. Insomnia Severity Index*

The Insomnia Severity Index (ISI) is used to evaluate insomnia severity during the past two weeks (Bastien et al., 2001), based on the diagnostic criteria of DSM-V and the ICSD-3 (International Classification of Sleep Disorders). The ISI is composed of seven items concerning both daytime and nighttime symptoms of insomnia. These items are rated on a scale from 0 to 4 points, with the overall score between 0 and 28 points (Table 8). The result is stratified into four groups with increasing total score, reflecting the severity of sleep impairment as follows: no clinically-significant insomnia (0–7 points), sub-threshold insomnia (8–14 points), moderate insomnia (15–21 points) and severe insomnia (22–28 points) (Table 7) (Morin et al., 2011). Besides the self-administered version, two different variants are also available: one managed by a clinician and the other by a significant other person (e.g. spouse, parent).

Many studies have indicated that the ISS is a reliable and valid instrument to estimate the presence and severity of insomnia (Bastien et al., 2001; Blais et al., 1997; Gagnon et al., 2013; Gerber et al., 2016; Morin et al., 2011). An investigation conducted by Gagnon (2013) on 410 patients in primary care showed that for a cut-off value of 14 points, the ISI has a satisfactory sensitivity (82.4%) and specificity (82.1%) to distinguish patients with insomnia. Moreover, the positive predictive value (PPV) and negative predictive value (NPV) were 70% and 90.2%, respectively. Morin et al. (2011) confirmed usefulness of the ISI for detecting insomnia. The authors analyzed the results within the community group (959 subjects), clinical group (183 individuals with insomnia), and healthy controls (62 participants). A cut-off score of 10 points provided an optimal balance between sensitivity (86.1%) and specificity (87.7%) in a community-based sample, whereas the cut-off score of 11 corresponded to higher sensitivity (97.2%) and specificity (100%) in a clinical sample. The authors suggested that the cut-off value should depend on the type of population (Gagnon et al., 2013; Morin et al., 2011). The satisfactory psychometric properties of the ISI were also confirmed by Gerber (2016) with three independent groups: 1,475 adolescents, 862 university students and 533 police and emergency response service officers. These findings proved that the ISI is useful in identifying insomnia symptoms across various age groups and in both sexes. The reliability and validity of the ISI has been supported in a number of other studies (Castronovo et al., 2016; Cho et al., 2014; Fernandez-Mendoza et al., 2012; Lahan and Gupta, 2011; Park and Lee, 2019; Sierra et al., 2008; Veqar and Hussain, 2017).

The study carried out by Morin et al. (2011) revealed that the ISI is sensitive to cognitive-behavioral therapy response among clinical patients. A similar study performed by Castronovo et al. (2016) identified an important decrease in ISI scores after cognitive-behavioral therapy for insomnia. Bastien et al. (2001) also confirmed its sensitivity to changes in perceived sleep difficulties during treatment. Moreover, the changes in the ISI scores were followed by convergent changes in the polysomnography and in the sleep diary. Other studies also suggest that the ISI measurements are associated with PSG variables (Sadeghniiat-Haghighi et al., 2014; Yazdi et al., 2012).

The majority of studies focus on the utility of the ISI in diagnosing primary insomnia; however, several findings indicate that this questionnaire is equally helpful in the case of evaluating the secondary insomnia (Bastien et al., 2001; Lin et al., 2019; Savard et al., 2005). The outcomes of the research performed by Savard et al. (2005) on 1,670 cancer patients showed that the ISI is a valid and dependable tool for assessing the intensity of insomnia secondary to cancer. The appropriate cut-off value in this investigation was estimated at 8 points, which resulted in 94.7% sensitivity and 47.4% specificity, with PPV and NPV values equal to 67.7% and 88.5%, respectively.

Furthermore, the results indicate that in oncological patients, the ISI is also sensitive to changes related to the cognitive-behavioral therapy of insomnia. Another study conducted by Lin et al. (2019) on 573 patients with advanced cancer demonstrated that a cut-off value of 9 points optimally distinguishes subjects with sleep difficulties. This score was associated with 86% sensitivity and 83% specificity, where PPV and NPV values were 83% and 84%, consecutively.

**Table 8.** Insomnia Severity Index (Bastien et al., 2001).

For each question, please rate the current (i.e. last 2 weeks) severity of your insomnia problem(s).

| | **None** | **Mild** | **Moderate** | **Severe** | **Very severe** |
|---|---|---|---|---|---|
| **1. Difficulty falling asleep** | 0 | 1 | 2 | 3 | 4 |
| **2. Difficulty staying asleep** | 0 | 1 | 2 | 3 | 4 |
| **3. Problems waking up too early** | 0 | 1 | 2 | 3 | 4 |
| **4. How satisfied/dissatisfied are you with your current sleep pattern?** | Very satisfied 0 | Satisfied 1 | Moderately satisfied 2 | Dissatisfied 3 | Very dissatisfied 4 |
| **5. How noticeable to others do you think your sleep problem is in terms of impairing the quality of your life?** | Not at all noticeable 0 | A little 1 | Somewhat 2 | Much 3 | Very much noticeable 4 |
| **6. How worried/distressed are you about your current sleep problem?** | Not at all worried 0 | A little 1 | Somewhat 2 | Much 3 | Very much worried 4 |
| **7. To what extent do you consider your sleep problem to interfere with your daily functioning (e.g. daytime fatigue, mood, ability to function at work/daily chores, concentration, memory, mood, etc.) currently?** | Not at all interfering 0 | A little 1 | Somewhat 2 | Much 3 | Very much interfering 4 |

*2.8. Summary of overall clinical implications*

The primary limitation of the presented questionnaires is the fact that they are subjective. Therefore, the reported complaints may be understated or, on the contrary, exaggerated due to their individual perception. Moreover, there is a possibility that some patients may misunderstand the questions, answers or instructions for completing the questionnaire. Such difficulties can occur particularly in older patients. A study conducted by Onen et al. (2012) showed that the majority of older subjects without dementia were not able to answer all of the ESS questions. Although the whole study group complained about excessive daytime sleepiness, only 24% of them had abnormal ESS scores (> 10). The same problem may affect other subjective questionnaires. Furthermore, if patients are not proficient in the language used in some questionnaires, they may misunderstand questions. In this case, results could be inaccurate and not reflect the actual severity of the disorder. Furthermore, these scores may not correspond to the findings obtained with objective sleep measures.

Another limitation is associated with the optimal cut-off values of questionnaires such as ESS, PSQI, AIS and ISI. As a result, clinicians may experience difficulty in appropriate interpretation of their findings. An invalid analysis of results may affect further therapeutic decisions. Therefore, it is necessary to establish and validate the most optimal cut-off values of the presented tools. It is possible that having specific cut off points for different populations could be helpful.

Furthermore, results of the ESS are presented as the total value of ESS points. In order to achieve a reliable and valid score, the assessment of sleepiness should be preferably expressed as a percentage score of the obtained points. If the patient does not perform one of the eight mentioned activities (e.g. driving a car) and cannot answer a question, it should be answered "not applicable" instead of "0" and the total possible score should be reduced by 3 – the maximum score of the unanswered question. This way, the result can be compared with scores from other patients and excludes the possibility of false reduction of the score.

Unlike other tools which evaluate sleepiness over a longer period of time, the shortest, one-item scales (KSS and SSS) allow sleepiness to be measured at a particular moment of time. Both scales can be used to assess sleepiness throughout the day in response to various factors.

The aforementioned questionnaires are applicable for different sleep disorders. The ESS is the most accurate for hypersomnia or narcolepsy, whereas the PSQI is helpful for diagnosing insomnia. Although the ESS may be helpful in measuring the efficacy of OSA treatment, none of these tools can be used to identify individuals with a higher risk of OSA.

The AIS and the ISI are reliable and valid screening instruments for identifying primary and secondary insomnia. Moreover, both tools correspond to the worldwide-accepted criteria of insomnia. The ISI may also confirm the effectiveness of the cognitive behavioral therapy for insomnia.

Despite their limitations, self-assessment sleep questionnaires constitute essential tools for clinicians to evaluate the presence or severity of insomnia and sleepiness. They are easy to administer and inexpensive. They can be simply completed in a couple of minutes in an outpatient clinic. Furthermore, reviewed studies indicate that self-report questionnaires such as the ESS, PSQI, AIS and ISI are relatively accurate. They allow to identify patients with sleep difficulties and help to make decisions about additional diagnostic processes and treatment.

*2.9. Conclusions*

Self-administered sleep questionnaires constitute a crucial tool for the initial diagnosis of various sleep disorders such as insomnia, narcolepsy and hypersomnia in an outpatient clinic. Although some

of the questionnaires can be helpful in evaluating the effectiveness of OSA treatment, the presented questionnaires; however, cannot identify OSA patients. There is a great need to establish and validate the most optimal cut-off values of these tools.

## 3. Questionnaires in the assessment of risk and severity of obstructive sleep apnea

### 3.*1. Introduction*

Obstructive sleep apnea (OSA) is characterized by recurrent episodes of nocturnal breathing cessation (apnea) or breathing reduction (hypopnea), caused by upper airway collapses (Malhotra and White, 2002). It affects 3–7% of men and 2–5% of women (Chiu et al., 2017). In Poland, the number of OSA diagnoses ranges from 390 to 1,328/100,000 habitants depending on the region (Kuczyński et al., 2021). There is also a relationship between the age and the risk of OSA development, accounting for even greater disproportions among women (78%) and men (90%) (Franklin and Lindberg, 2015; Senaratna et al., 2017).

The Apnea-Hypopnea Index (AHI), measured with polysomnography (PSG), is extensively used to measure the severity of OSA symptoms (Malhotra and White, 2002; Thorpy, 2012). Depending on the mean number of apneas and hypopneas per hour of sleep, OSAs can be categorized into mild (AHI ≥ 5 to < 15), moderate (AHI ≥ 15 to < 30) or severe (AHI ≥ 30) (Martinez et al., 2011).

Several risk factors, including obesity, male sex, older age and neck circumference have been associated with an increased risk of OSA (Lurie, 2011; Lee et al., 2008). Numerous studies showed an association between OSA and arterial hypertension, highlighting that elevated morning diastolic blood pressure may be related to OSA (Lee et al., 2008; Mokros et al., 2017). OSA presents with a variety of other symptoms, including daytime sleepiness, snoring, morning headaches and breathing pauses noticed by a bed partner (Lee et al., 2008). All these parameters can be easily measured using questionnaires designed for evaluation of the probability of OSA.

Multiple population-based studies have reported that OSA increases the risk of cardiovascular events, hypertension, endocrine and metabolic disorders, highlighting the need for prompt OSA diagnosis and treatment (Peppard et al., 2000; Phillips and O'Driscoll, 2013; Punjabi and Polotsky, 2005; Yaggi et al., 2005). Additionally, OSA has a significant indirect impact on traffic accidents, industrial accidents and loss of productivity (Antonopoulos et al., 2011; Karimi et al., 2013; Phillips, 2007; Vennelle et al., 2009).

A variety of questionnaires are available for the evaluation of the pre-test likelihood and severity of OSA, such as: STOP-Bang, NoSAS, Berlin Questionnaire and EuroSAS (Table 9). The Polish Society of Occupational Medicine, the Polish Respiratory Society, the Nofer Institute of Occupational Medicine in Lodz and the Polish Sleep Research Society recommend using the EuroSAS tool – the extended version of STOP-Bang questionnaire. The EuroSAS is a recommended tool for OSA screening in drivers. Moreover, results of the EuroSAS provide information, whether the patient should be referred for PSG or PG (polygraphy). The questionnaires are brief, user-friendly and affordable. The major limitation results from their different sensitivity, specificity, PPV and NPV when being used in various populations.

**Table 9.** Questionnaires used to assess pre-test probability and severity of OSA.

| Questionnaire | Evaluated aspects | Scoring | Cut-off value | Advantages | Disadvantages | Reference |
|---|---|---|---|---|---|---|
| **STOP-Bang** (Table 10) | 1. Presence of loud snoring.<br>2. Tiredness during daytime.<br>3. Presence of breathing cessations.<br>4. History of hypertension.<br>5. BMI, age, neck circumference, gender. | From 0 to 8 points | 3 points | 1. Helpful as a screening tool for detection of OSA in the sleep clinic and surgical population.<br>2. A higher score indicates a greater probability of severe OSA. | 1. Composed of subjective and objective responses. | Chung et al., 2008 |
| **NoSAS** (Table 11) | 1. Neck circumference.<br>2. BMI.<br>3. Presence of snoring.<br>4. Age.<br>5. Gender. | From 0 to 17 points | 7 points | 1. Easy to use due to its small number of items.<br>2. Nearly all of the items are objective and can be easily measured.<br>3. It can be applied in demanding populations (e.g. those with major depression). | – | Marti-Soler et al., 2016 |
| **Berlin Questionnaire** (BQ) (Table 12) | 1. Snoring severity.<br>2. Excessive daytime sleepiness.<br>3 History of hypertension.<br>4. History of obesity. | – | High risk: if there are 2 or more categories with a positive score.<br>Low risk: if there is only 1 or no categories with positive score. | – | 1. Nearly all of the questions can be subjectively understood.<br>2. Can be time consuming due to a need to score the responses according to the answer key. | Netzer et al., 1999 |
| **EuroSAS** (Table 13) | 1. Gender, age, weight, height.<br>2. Presence of snoring.<br>3. Sleepiness while driving.<br>4. History of car accidents.<br>5. Presence of apneas.<br>6. Presence of non-restorative sleep.<br>7. Presence of hypertension.<br>8. The ESS score | From 3 to 25 points | – | 1. EuroSAS questionnaire attaches greater importance to the clinical parameters than STOP-Bang. | – | McNicholas, 2019 |

*3.2. STOP-BANG questionnaire*

The STOP-BANG questionnaire (SBQ) is a quick, concise and user-friendly questionnaire for OSA screening. It was originally developed for identification of OSA in surgical patients at preoperative clinics (Chung et al., 2008, 2012). It comprises eight questions: four subjective perception items and four clinical characteristics. The acronym STOP-BANG is based on the first letter of each feature evaluated in this questionnaire: Snoring, Tiredness, Observed apnea, Pressure (STOP), and Body Mass Index, Age, Neck circumference (≥ 41 in female and ≥ 43 in male), Gender (BANG). These questions have "yes/no" answers, which makes this scale quick and easy to complete. For each question, the answer "yes" scores 1 point and the answer "no" scores 0 points. Score 1 is obtained for age > 50 years old, neck circumference ≥ 41 cm in female, ≥ 43 cm in male and BMI > 35 kg/m$^2$. The total score ranges between 0 to 8 points (Table 10).

The use of the SBQ has been demonstrated in numerous studies (Chung et al., 2013; Firat et al., 2012; Tantrakul et al., 2015; Vasu et al., 2010) for identifying OSA in pregnant women (second trimester), bus drivers, obese and surgical patients (Chia et al., 2013; Chung et al., 2013; Firat et al., 2012; Tantrakul et al., 2015; Vasu et al., 2010). Furthermore, SBQ is believed to be an outstanding tool for screening moderate to severe OSA among adults with Down Syndrome (Carvalho et al., 2020). The SBQ has been validated in multiple different populations, but appears to be less helpful among patients with chronic kidney disease and those with end-stage renal disease (Nicholl et al., 2013). On the contrary, it has been found to demonstrate high sensitivity (89%), but low specificity (36%) in research among patients with atrial fibrillation (Abumuamar et al., 2018), with a PPV of 89% and NPV of 36%.

The SBQ is also frequently used in sleep clinics, where the prevalence of OSA is high. In a Reis et al. (2006) study, a score ≥ 3 points was associated with 93.4% sensitivity and 86.6% PPV for all severities of OSA. An increased SBQ score correlates with increased probability of OSA, up to 95% with a score of 6 points. Moreover, a higher SBQ score is associated with a greater probability of severe sleep apnea. Reis et al found that the score of 3 and 2 points corresponded to an NPV equal to 85.3% and 91.7% for moderate or severe OSA. Therefore, a score lower than 3 showed a high discriminative power to exclude moderate to severe OSA. Farney et al. (2011) obtained similar results (patients with ≥ 3 score had 85.1% probability of having OSA), and found the probability of detection of severe OSA to increase with any score greater than three points. Our own previous study on SBQ accuracy in positional OSA in adults (Kuczyński et al., 2019) found high sensitivity (96.9%), but low specificity (16.7%) using a cut-off score of 3 points, similarly to previous studies. For the probability of OSAS diagnosis with SBQ ≥ 3 points, the PPV and NPV were 79.2% and 62.0% respectively. In a Boyton (2013) study with a cut-off score of ≥ 3 points, the respective sensitivity levels for AHI levels of > 5, > 15, and > 30 were 82.2%, 93.2% and 96.8%, and the specificity values were 48.0%, 40.5% and 33.1%. The PPV and NPV were 79.2% and 28.3% for AHI > 5, 52.2% and 66.7% for AHI > 15 and 36.4% and 96.3%, respectively, for AHI > 30.

In a Tan et al. (2016) study with subjects selected from the population-based cohort, the sensitivity of a STOP-Bang score of ≥ 3 points were 66.2% for detecting AHI ≥ 15 and 69.2% for detecting AHI≥30. The specificities were 74.7% and 67.1%, respectively. The NPVs were 85% for moderate-to-severe OSA and 94.8% for severe OSA, while PPVs were 50.6% and 20.2%, respectively. Silva et al. (2011) revealed that the sensitivity of SBQ score ≥ 3 points was 87% for moderate-to-severe OSA detection and 70.4% for severe OSA. The specificity levels were 43.3% and 59.5%, respectively.

Nagappa et al. (2015) performed a meta-analysis of 17 studies including 9,206 patients, in which the accuracy of the STOP-Bang questionnaire was validated by PSG. The pooled sensitivity of a STOP-Bang score ≥3 points to predict any OSA, moderate-to-severe and severe OSA in the sleep clinic population was 90%, 94% and 96% respectively, while the pooled specificity was relatively low: 49%, 34% and 25%, respectively. For any OSA, moderate-to-severe and severe OSA the PPVs were 91%, 72% and 48%, whereas the NPVs were 46%, 75% and 90%, respectively. The sensitivity of SBQ in detecting OSA was relatively high in the surgical population (91%), but the specificity at the same cut-off was modest and ranged from 32% in the surgical population to 34% in the sleep clinic. In another meta-analysis performed by Chiu et al. (2017), the specificity of the STOP-BANG was a major limitation.

The SBQ is better than other questionnaires for identifying mild, moderate and severe OSA, especially for specific populations such as subjects in a sleep clinic as well as in the surgical population.

**Table 10.** STOP-BANG questionnaire (Chung et al., 2008).

| | | | |
|---|---|---|---|
| **STOP** | Do you **S**NORE loudly (louder than talking or loud enough to be heard through closed doors)? | Yes | No |
| | Do you often feel **T**IRED, fatigued, or sleepy during daytime? | Yes | No |
| | Has anyone **O**BSERVED you stop breathing during your sleep? | Yes | No |
| | Do you have or are you being treated for high blood **P**RESSURE? | Yes | No |
| **BANG** | **B**MI more than 35kg/$m^2$? | Yes | No |
| | **A**GE over 50 years old? | Yes | No |
| | **N**ECK circumference >16 inches (40cm)? | Yes | No |
| | **G**ENDER: Male? | Yes | No |

*3.3. NoSAS*

NoSAS is a screening tool for identification of individuals with an increased risk for sleep-disordered breathing (Marti-Soler et al., 2016). The NoSAS score (Table 11) consists of five items: neck circumference (> 40 cm is rated at 4 points), body mass index (BMI; between 25 and <30 kg/$m^2$ – 3 points, BMI ≥ 30 kg/$m^2$ – 5 points), age (> 55 years is rated at 4 points) and gender (2 points for male sex). The total score ranges between 0 and 17 points.

In the HypnoLaus study on 2,168 subjects (Marti-Soler et al., 2016), a cut-off score of 8 had an AUC (Area under the curve) of 0.74, a PPV of 0.47 and NPV of 0.90. Similar results were obtained from the EPISONO cohort, where the NoSAS score corresponded to the AUC value of 0.81 and PPV and NPV values were respectively 33% and 98%. Moreover, the authors compared NoSAS with the STOP-BANG questionnaire and Berlin questionnaire, and found out that NOSAS has a significantly better outcome. Peng et al. (2018) used the same threshold in their study, and the sensitivity and specificity to predict AHI ≥ 5, AHI ≥ 15 and AHI > 30 were 59.0% and 70.7%, 64.9% and 62.6%, as well as 64.4% and 56.2%, respectively. The NoSAS score had the largest AUC value compared to other questionnaires in the study (the Berlin questionnaire), if the AHI ≥ 5 was used for diagnosing

sleep-disordered breathing. A study performed by Coutinho Costa et al. (2019) in patients referred by primary care physicians to the sleep unit found the sensitivity, PPV and NPV to be respectively 94.3%, 87.6% and 50% for all OSA severities, using a cut-off value of 7 points. Duarte et al. (2018) revealed that the sensitivity of NoSAS for detecting OSA in the group of patients suspected for sleep-disordered breathing was 71.6%, while the specificity was 68.7%, PPV was 89.0% and NPV was 40.7%.

Tan et al. (2017) performed a multi-ethnic Asian cohort study, where the sensitivity, specificity, NPV and PPV of the NoSAS score to predict severe SRBM were 69.2%, 73.1%, 95.2% and 23.7%, respectively. Consequently, the authors demonstrated that NoSAS score performed comparably to the STOP-Bang and Berlin questionnaires. However, portable monitors used in this study without electroencephalography signals, did not allow sleep times to be identified and could affect AHI values.

Due to its small number of items, the NoSAS questionnaire can be effortlessly and objectively assessed. Moreover, it can be applied in demanding populations, such as patients with major depression (Guichard et al., 2018).

**Table 11.** NoSAS questionnaire (Marti-Soler et al., 2016).

| Feature | Points |
|---|---|
| Neck circumference | 4 |
| BMI 25 to < 30 kg/m2 | 3 |
| BMI ≥ 30 kg/m2 | 5 |
| Snoring | 2 |
| Age > 55 years | 4 |
| Sex (male) | 2 |

*3.4. BERLIN questionnaire*

The Berlin questionnaire (BQ) was developed to identify patients at high risk for OSA in primary care (Netzer et al., 1999). It consists of 11 items divided into three categories (Table 12), which concern snoring, sleepiness or fatigue and the presence of high blood pressure or obesity. In category 1, high risk was defined as persistent symptoms described by two or more questions about snoring. In category 2, high risk was defined as persistent drowsy driving, wake time sleepiness or both. In category 3, high risk was defined as a history of hypertension or BMI higher than 30kg/m$^2$. Patients are considered to be at increased risk for OSA, if they are at high risk in at least two of these categories.

Many studies have evaluated the validity of BQ for OSA risk in sleep clinic populations (Amra et al., 2013; El-Sayed, 2012; Khaledi-Paveh et al., 2016; Sagaspe et al., 2010; Saleh et al., 2011). Saleh et al. (2011) found the sensitivity, specificity, PPV and NPV for AHI > 5 to be 97%, 90%, 96% and 93%, respectively. El-Sayed (2012) observed a similar sensitivity for predicting OSA (95%) but also revealed low specificity (23%), with a PPV and NPV of 92% and 33%, respectively. The BQ had high sensitivity for identifying moderate-to-severe (95% for AHI > 15) and severe OSA (97% for AHI > 30), but very low specificity for identifying moderate-to-severe (7%) and severe OSA (10%). In a study conducted by Amra et al. (2013), the sensitivity, specificity, PPV and NPV of the BQ for OSA diagnosis with AHI > 5 were as follows: 84%, 62%, 96%, 25%. On the contrary, the values at AHI ≥ 15 were 87.9%, 36.7%, 75.3%, 58.0% and at AHI ≥ 30 – 87.8%, 26.5%, 51.5%, 70.9%, respectively. Ng et al. (2019)

demonstrated that the BQ was undependable among patients in predicting OSA by PSG-AHI. A different study showed that the BQ has high sensitivity (87.2%), but low specificity (11.8%) with PPV and NPV equal to 73.2% and 25.0%, respectively (Stelmach-Mardas et al., 2017).

Kang et al. (2012) performed a study on the general population, which showed that the high-risk group based on the BQ predicted an AHI ≥ 5 with a sensitivity and specificity of 69% and 83%, respectively. On the contrary, they revealed that BQ is not a satisfactory tool for predicting OSA in healthy elders (Sforza et al., 2011). BQ is also believed to be a poor predictor of OSA in a random group of patients undergoing pulmonary rehabilitation (Weinreich et al., 2006).

It is worth noting that there is an association has been identified between OSA and idiopathic intracranial hypertension (IIH) (Marcus et al., 2001). The BQ demonstrated 83.3% sensitivity and 58.3% specificity for OSA in IIH patients, with a PPV of 75% and NPV of 70% (Thurtell et al., 2011).

A meta-analysis by Senaratna et al. (2017) found BQ to have good sensitivity in the sleep clinic population for identifying clinically relevant OSA (≥ 15 AHI). In other populations, the sensitivity for identifying clinically relevant OSA is modest-to-high. Moreover, in all populations, the BQ had a low specificity. Another meta-analysis revealed that neither the BQ nor the Sleep Disorders Questionnaire was perfect, although both evaluated tools were the most accurate for preoperative assessment (Ramachandran and Josephs, 2009).

**Table 12.** Berlin questionnaire (Netzer et al., 1999).

| **Category 1** | | | | | |
|---|---|---|---|---|---|
| **Do you snore?** | Yes | No | Don't know | | |
| **Your snoring is...** | Slightly louder than breathing | As loud as talking | Louder than talking | Very loud, can be heard in adjacent rooms | |
| **How often do you snore?** | Nearly every day | 3-4 times a week | 1-2 times a week | 1-2 times a month | Never or nearly never |
| **Has your snoring ever bothered other people?** | Yes | No | | | |
| **Has anyone noticed that you quit breathing during your sleep?** | Nearly every day | 3-4 times a week | 1-2 times a week | 1-2 times a month | Never or nearly never |

**Table 12** (cont.)

| **Category 2** | | | | | |
|---|---|---|---|---|---|
| **How often do you feel tired or fatigued after your sleep?** | Nearly every day | 3-4 times a week | 1-2 times a week | 1-2 times a month | Never or nearly never |
| **During your wake time, do you feel tired, fatigued, or not up to par?** | Nearly every day | 3-4 times a week | 1-2 times a week | 1-2 times a month | Never or nearly never |
| **Have you ever nodded off or fallen asleep while driving a vehicle?** | Yes | No | | | |
| **If yes, how often does it occur?** | Nearly every day | 3-4 times a week | 1-2 times a week | 1-2 times a month | Never or nearly never |
| **Category 3** | | | | | |
| **Do you have high blood pressure?** | Yes | No | Don't know | | |

*3.5. EuroSAS Questionnaire*

The European Sleep Apnea Syndrome Questionnaire (EuroSAS) has been developed for OSA screening in drivers (McNicholas, 2019). The EuroSAS is composed of 11 features (Table 13): the first four items refer to demographic characteristics (gender, age, weight and height), whereas the next six refer to a history of snoring, sleepiness while driving, car accidents, apneas, non-restorative sleep and hypertension (Peker et al., 2020). The last item refers to the total score of the ESS (Johns, 1991). The total score ranges between 3 and 25, with a score ≥ 10 points suggesting the occurrence of OSA.

Due to the low number of studies, it is impossible to assess the sensitivity, specificity or predictive values of this test. Studies evaluated with the use of this questionnaire seem to be justified, because it is the extended version of the STOP-Bang questionnaire. In comparison to STOP-Bang, the EuroSAS is more focused on clinical parameters, such as BMI (Mokros et al., 2018).

**Table 13.** European Sleep Apnea Syndrome (EuroSAS) Questionnaire (McNicholas, 2019).

| | | |
|---|---|---|
| **1.** | Gender | |
| **2.** | Age | |
| **3.** | Weight | |
| **4.** | Height | |

**Table 13** (cont.)

| | | |
|---|---|---|
| **5.** | Have you dozed off while driving? | Yes |
| | | no |
| | | don't know |
| **6.** | Have you had a serious accident (with personal injuries or property damage) due to sleepiness in the last 3 years? | yes |
| | | no |
| | | don't know |
| **7.** | Do you snore loudly almost every night? | yes |
| | | no |
| | | don't know |
| **8.** | Have you been told your breathing stops during your sleep? | yes |
| | | no |
| | | don't know |
| **9.** | Do you usually wake up refreshed after a full-night sleep? | yes |
| | | no |
| | | don't know |
| **10.** | Do you suffer from, or are you being treated for, arterial hypertension? | yes |
| | | no |
| | | don't know |
| **11.** | Please complete the questionnaire on usual daytime sleepiness, called the Epworth Sleepiness Scale | |

*3.6. Discussion*

A screening questionnaire for OSA should be precise, available and suitable for many different populations. Most of the presented studies have concentrated on the validation of questionnaires in sleep clinic patients, where the prevalence of OSA is high. In order to precisely diagnose patients with OSA, sleep clinics may demand questionnaires characterized with high sensitivity, like the SBQ. As a higher score is associated with a greater probability of severe OSA, an SBQ score of 5 points or higher may be an indication for earlier PSG. In contrast, the use of a questionnaire with high specificity may prevent unnecessary referral for PSG in the general population.

Furthermore, sometimes urgent screening for OSA may be important in some populations, especially in surgical units. The SBQ is a clinically convenient, quick and verified tool for predicting SRBM, and may be used in such situations.

One of the mentioned studies (Chiu et al., 2017), performed on a substantial population, showed that NoSAS had greater diagnostic accuracy than the BQ or SBQ. This questionnaire consists of only five items and practically all of them are objective. It seems to be a very simple, quick and accurate tool for screening of OSA. It is worth emphasizing that the objectivity of the answers depends on questionnaires. Only 2 of 17 points in the NoSAS, and 3 of 8 points of the STOP-Bang are subjective responses, whereas the BQ is predominantly subjective, despite the occurrence of hypertension. Consequently, this creates a difficulty in understanding or subjective perception of a certain ailment.

None of the presented questionnaires were sensitive or specific enough to discontinue further examination. PSG is a gold standard in the diagnosis of OSA. If this high-priced and time-consuming examination is unavailable, PSG should be applied as a faster and easier option.

In one of the mentioned studies (Mokros et al., 2018), the researchers noted that a symptomatic patient with BMI lower than 25.0 kg/m$^2$ has a very low chance (less than 3%) of AHI ≥ 15 events/h in the lateral sleep position. Consequently, in this group of patients, positional treatment is an alternative method, which can be applied prior to conducting PSG.

### *3.7. Conclusions*

SBQ appears to be a valuable screening tool for OSA in populations from sleep clinics and surgical populations. Nonetheless, a literature review indicates that studies suggesting which questionnaire can be useful in the general population are of limited value. Consequently, further investigation in this field is very important. The mentioned questionnaires may have some value in assessing the probability of OSA, despite the fact that they do not provide an acceptable and satisfactory level of certainty in the detection or exclusion of this SRBD. PSG is a gold standard for OSA diagnosis, and PG should be used only if the PSG is not available.

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