



Original Article

Sleep perception in insomniacs, sleep-disordered breathing patients, and healthy volunteers – An important biologic parameter of sleep

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ABSTRACT

Background: The mechanisms involved in sleep perception are not widely known. Therefore, we believe that investigating this phenomenon is the best way to understand some of the mechanisms involved in several sleep disturbances, particularly insomnias.

Objective: The objective of our study was to evaluate sleep perception in insomniacs, sleep-disordered breathing (SDB) patients, and healthy volunteers. Our hypothesis was that insomniacs have less sleep perception than healthy individuals and patients with sleep respiratory disorders.

Methods: We studied 199 individuals who were divided into the following four groups: (1) insomnia group; (2) patients with sleep-disordered breathing; (3) patients with insomnia complaints and an associated sleep respiratory disorder; and (4) healthy individuals with no sleep complaints. All patients were subjected to polysomnography (PSG) followed by a questionnaire addressing their perception about the previous night's sleep. In addition to analysis of all sleep parameters, we determined sleep perception as the percentage of the ratio between total sleep time perceived by the patient and the total sleep time obtained by PSG.

Results: Sleep perception was significantly lower in insomnia patients than in sleep-disordered breathing patients or the normal group. In addition, no significant differences across the four groups were observed in sleep efficiency and total sleep time.

Conclusions: The results showed that the reported sleep perception of insomniacs is lower than that of sleep-disordered breathing patients or normal individuals. We believe that sleep perception is as important as other commonly measured parameters, such as sleep efficiency.

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1. Introduction

The mechanisms involved in sleep perception are not widely known. Some sleep disorders, particularly insomnia, drastically alter sleep perception and this often explains the difficulty in treating such patients. However, the sleep pattern in obstructive sleep apnea syndrome is extremely altered (in its architecture and continuity), with many night arousals. Nevertheless, these patients often have good sleep perception.

Based on these findings, we believe that investigating sleep perception is the best way to understand the mechanisms involved in several sleep disturbances, particularly the insomnias. Therefore, we have used an objective parameter to measure the degree of sleep perception called the objective sleep time estimated. This parameter was used by Edinger and Fins in 1994 [1], and it is de-

defined as the percentage obtained by dividing the patient's estimated minutes of sleep by the minutes of sleep obtained by PSG.

Our study aimed to compare sleep perception among insomniacs, individuals suffering from sleep-disordered breathing, and normal individuals. We believe that comparing the number of hours perceived by the patient with the actual sleep duration recorded by polysomnography may be as important as other parameters, such as sleep efficiency. Sleep efficiency is defined as the percentage of total sleep time over the total recording time.

2. Material and methods

The objective of the present study was to evaluate sleep perception of insomniacs, patients with sleep-breathing disorders, and healthy individuals. Patients were selected from the Sleep Laboratory at the Sao Paulo Federal University, Sao Paulo, Brazil. Subjects were asked to respond to a questionnaire before the examination. The results provided us with necessary information regarding the

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patients' clinical category. Three groups of patients were formed. The first group (group insomnia) was formed by patients with primary insomnia according to the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV) [2] and the International Classification of Sleep Disorders (2005) [3]. This group excluded insomnias associated with neurological diseases and mental disorders, ones caused by inadequate sleep hygiene, use of psychotropic agents, and if the PSG showed an apnea/hypopnea index (AHI) higher than 5/h. The second group (SDB group) was formed by patients with sleep-disordered breathing, including patients with complaints of snoring, episodes of suffocation, or reported night apnea with or without daytime sleepiness, and a PSG that showed an AHI higher than 5/h. The third group (group insomnia + SDB) were patients who presented with complaints of insomnia together with SDB. The fourth group (healthy group) was formed by healthy volunteers. These individuals did not present with complaints of sleep, possessed an AHI limit of 5/h during PSG, did not use medicines or any other substances that could interfere with their sleep, and had no neurological diseases or mental disorders.

The polysomnograms were recorded during one night of observation with digital equipment. The following measurements were registered: two channels of electroencephalogram (C3-A2 and C4-A1), two channels of electrooculogram (OD-A1 and OE-A2), one channel of electromyogram of the chin, nasal and oral air flow, thoracic and abdominal movements and oxyhemoglobin saturation. We considered sleep architecture (total sleep time, sleep efficiency and latency) and apnea/hypopnea and arousal indexes. After obtaining the reports, the records were assessed by the technical and medical team of the referred laboratory [4]. Immediately after the conclusion of the PSG, patients were asked to respond to a questionnaire in which they indicated the hours of sleep perceived.

In addition to performing the analysis of all sleep parameters, we determined sleep perception (SP) as the percentage of the ratio between the total sleep time perceived by the patient and the total sleep time obtained by PSG. In addition to SP, we compared all other sleep parameters among the four groups.

Once the age factor was lower in the healthy individuals, the groups were compared by an analysis of covariance. When significant results were obtained, the analysis was followed by Duncan's multiple range test. Differences were considered significant at $p < .05$. Prior approval was obtained from the Ethics Committee of the Sao Paulo Federal University, Sao Paulo, Brazil.

Table 1

Number (N), age and gender of the four groups studied: insomnia, sleep-disordered breathing (SDB), insomnia + SDB, and healthy volunteers.

	N	Age	Gender
Insomnia	36	44.1 (± 14.2)	M 12; F 24
SDB	60	49.6 (± 12.4)	M 46; F 14
Insomnia + SDB	75	50.1 (± 13.9)	M 48; F 27
Healthy	28	35.5 (± 7.9)	M 13; F 15

Table 2

Sleep parameters: total sleep time (TTS) in minutes, sleep efficiency (SE) in%, sleep latency (SL) in minutes, and sleep perception (SP) in the four following groups: healthy volunteers, insomnia, sleep-disordered breathing (SDB) and insomniac + SDB.

	Healthy	Insomnia	SDB	Insomnia + SDB	ANCOVA
TST (min)	347.0 (± 48.9)	335.0 (± 48.7)	344.6 (± 50.6)	335.0 (± 57.7)	NS
SE (%)	85.0 (± 9.1)	83.2 (± 10.9)	84.2 (± 9.2)	81.9 (± 12.7)	NS
SL (min)	15.2 (± 15.3)	13.0 (± 7.4)	12.9 (± 19.8)	18.9 (± 28.9)	NS
SP	124.2 (± 39.9) ^a	77.2 (± 33.6) ^a	97.6 (± 26.3)	88.4 (± 30.0)	$p < .01$

Statistical significance – Duncan's multiple range tests.

^a SP: healthy volunteers group is different from the other groups ($p < .01$); insomniac group is different from the SDB group ($p < .01$).

3. Results

The insomnia group was formed by 36 individuals with an average age of 44.1 (± 14.2), the SDB group contained 60 patients with an average age of 49.6 (± 12.4), the insomnia + SDB group was formed by 75 individuals with an average age of 50.1 (± 13.9) years, and the healthy volunteers group comprised 28 individuals with an average age of 35.5 (± 7.9) (Table 1).

The SP was distributed as follows: insomnia group, 77.2 (± 33.6); SDB group, 97.6 (± 26.3); insomnia + SDB group, 88.4 (± 30.0); and healthy group, 124.2 (± 39.9) (Table 2 and Fig. 1). An SP higher than 100.0 was observed in eight patients of the insomnia group (22.2%), in 21 patients in the SDB group (35.0%), in 20 patients in the insomnia + SDB group (26.6%), and in 19 volunteers of the healthy group (67.8%). Comparison of the total sleep times demonstrated that the difference between insomniacs and normal individuals was 12.0 min and that the difference in sleep efficiency was 1.8% (Table 2).

Considering sleep architecture, no significant differences across the four groups were observed in total sleep time, sleep efficiency, and sleep latency. However, the percentage of stage 2 sleep was lower in the healthy group compared to the other groups ($p < .01$), while REM sleep in the healthy group was higher than the insomnia + SDB group ($p < .01$) (Table 3).

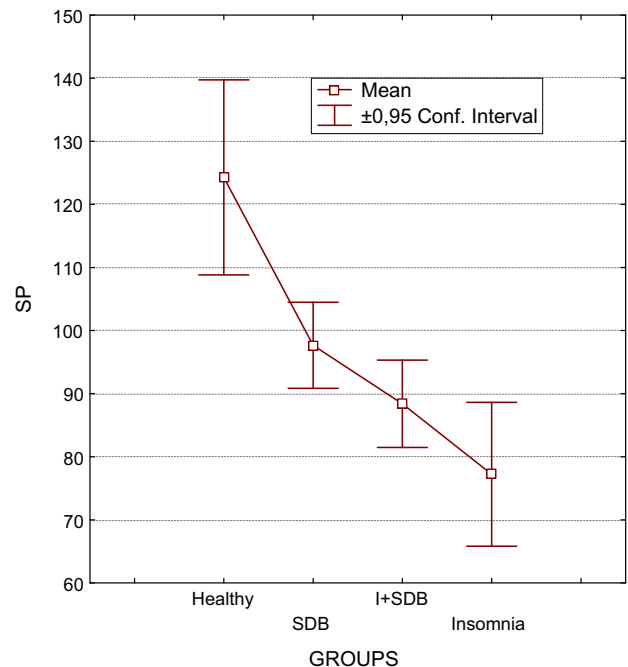


Fig. 1. Sleep perception of the four groups studied: healthy volunteers, sleep-disordered breathing (SDB), insomnia + SDB, and insomnia group.

Table 3

Sleep stages in percentage (stage 1, 2, slow wave and REM sleep) in the four groups: healthy volunteers, insomniacs, sleep-disordered breathing (SDB) and insomnia + SDB.

	Healthy	Insomnia	SDB	Insomnia + SDB	ANCOVA
S1	4.1 (±2.5)	4.3 (±2.7)	5.5 (±4.5)	5.9 (±4.3)	NS
S2	53.4 (±7.0) ^a	59.9 (±11.4)	59.6 (±10.5)	60.1 (±10.1)	<i>p</i> < .01
SWS	22.5 (±6.3)	18.6 (±8.2)	16.6 (±8.8)	16.7 (±8.3)	NS
REM	19.4 (±4.2) ^b	17.2 (±7.4)	18.1 (±6.5)	17.7 (±6.5)	<i>p</i> = .02

Statistical significance – Duncan's multiple range tests.

^a Stage 2: healthy group is different from the other groups (*p* < .01).

^b REM sleep: healthy group is different from the insomnia + SDB group (*p* < .01).

Table 4

Sleep parameters (arousals index, apnea/hypopnea index and O₂ minimal saturation) in the four groups: healthy volunteers, insomniacs, sleep-disordered breathing (SDB), and insomnia + SDB.

	Healthy	Insomnia	SDB	Insomnia + SDB	ANCOVA
Arousals	9.9 (±1.1) ^a	7.5 (±5.5) ^a	15.5 (±12.8)	15.5 (±16.2)	<i>p</i> < .01
AHI	3.3 (±1.8) ^b	3.1 (±1.6) ^b	28.4 (±24.7)	27.0 (±21.0)	<i>p</i> < .01
O ₂	89.7 (±2.9) ^c	89.1 (±3.6) ^c	80.7 (±7.6)	79.9 (±11.1)	<i>p</i> < .01

Statistical significant comparison – Duncan's multiple range tests.

^a Arousal index: healthy group is different from the insomnia + SDB group (*p* = .04); insomnia group is different from the SDB and insomnia + SDB groups (*p* < .01).

^b AHI: healthy group and insomnia group are different from the SDB and insomnia + SDB groups (*p* < .01).

^c O₂ minimal saturation: healthy and insomnia groups are different from the SDB and insomnia + SDB groups (*p* < .01).

Healthy volunteers presented with an arousal index lower than the insomnia + SDB group, and insomniacs had a lower arousal index than the SDB and insomnia + SDB groups (*p* = .04). The healthy group and insomnia group showed a lower AHI than the SDB and insomnia + SDB groups (*p* < .01), and the healthy and insomnia groups presented with a lower oxyhemoglobin saturation than in the SDB and insomnia + SDB groups (*p* < .01) (Table 4).

The covariance analysis showed that the age factor interfered with slow wave sleep (*p* < .01) and the AHI (*p* = .04). However, the ANOVA multifactor analysis indicated that gender did not affect the results.

4. Discussion

After analysis of the four groups, it was observed that sleep perception varied from a higher to a lower value, depending on the group studied. Healthy volunteers presented an SP higher than 100.0 in 67.8% of the individuals, which was significantly different from the other groups. However, insomniacs presented with lower indexes, which were different from the healthy volunteers and SDB group. Intermediate values were found in the SDB and insomnia + SDB groups.

Insomniacs showed a reduced SP, with an index lower than 100.0 in 77.8% of the patients. However, the difference in the total sleep time relative to normal individuals was only 12.0 min, and the difference in sleep efficiency was only 1.8%. So insomniacs have a low SP and tend to underestimate the total sleep time. As for the total sleep time, similar results were found by Chambers and Keller [5], who reported differences of only 30 min between normal individuals and insomniacs.

In contrast to the insomniacs, patients with SDB tended to present an SP closer to what is considered normal (value of 100.0). This means that the occurrence of respiratory events, the decrease in the oxyhemoglobin saturation and other factors, such as microarousals, defined by the AASM as introduction of fast rhythms that

last until 15 s, do not seem to interfere with the SP. Attarian et al. [6] published a case study of a woman with SDB who reported longer sleep duration than the time shown by PSG. This work defined reverse sleep misperception as the subjective overestimation of sleep.

The presence of obstructive sleep apnea is an important comorbidity that reduces the sleep quality of insomniac patients. Approximately one-half of patients with SDB also experience insomnia. The relationship between these two common sleep disorders is complex and unclear, but patients with both SDB and insomnia have poorer sleep quality, and the incidence of comorbid insomnia is greater in women with SDB than in men [7–11]. Therefore, the analysis of the decreased SP in the insomnia + SDB group has clinical relevance. The association of insomnia and sleep apnea also reduced sleep perception, which made the two groups of insomnia + SDB and insomnia have similar results.

Understanding sleep perception or recognizing the sleep state is very difficult. The SP in insomniac patients is very complex since it involves biologic and psychologic factors. From the biologic point of view, neurophysiology findings demonstrate that the insomniacs' hypervigilant state could be associated with high frequencies of brain electric activity. Reports examining primary insomniacs showed increased fast activity (beta and gamma rhythms) on electroencephalograms. This high frequency activity was at the expense of delta bands during NREM sleep, and it posed detrimental effects on sleep/arousal perception [12–14]. This may explain why insomniacs present with somatic awakening (higher heart rate, blood pressure and galvanic skin resistance), cortical arousal (higher frequency of cerebral electrical activity), cognitive arousal, and probably a fourth type of arousal, which may explain the feeling of non-restorative sleep reported by patients.

Maybe the biggest challenge in the characterization of this hypervigilant state will be to find an underlying anatomic substratum in the central nervous system. Single photon emission computed tomography (SPECT) of primary insomnia cases has shown hypoperfusion in the frontal, parietal and occipital lobes, thalamus, pons, and particularly in base ganglions, thus indicating dysfunction of these regions [15,16]. Some authors have suggested that the amygdale is involved in the origin of insomnia and, consequently, in the different states of consciousness during sleep [17]. The state of arousal is influenced by emotions and external stimuli. There are a number of different states of arousal and the amygdalar structure relates sensory afferents from the cerebral stem, limbic system and cerebral cortex, with different states of perception of both external and internal environments [12].

However, what would be the neuropsychologic mechanisms involved in the insomniacs? Perception of sleep duration is related to the state of consciousness at that moment; hence it involves complex cognitive processes. Semler and Harvey [18] demonstrated that patients with a misperception of sleep duration also presented with a distorted perception of reality when awake. This misperception was due to a cascade of cognitive processes leading to distorted perception of sleep and reality during waking states. The same phenomena occurred with other mental disorders, such as panic syndrome, hypochondria and certain eating disorders, such as anorexia or bulimia. These are all situations where there is a high level of rumination as substratum.

Sleep perception is influenced not only by intrinsic factors, but also by extrinsic ones. However, understanding the influence of other factors will require more investigations. In accordance with Means et al. [19], we believe that in addition to physiological and probably structural differences proposed by the literature, individual characteristics and other factors such as psychosocial, environmental, constitutional features, or personality disorders, may affect sleep duration perception. It is known that sleep perception is

modified by several factors such as age, gender, place, time, and the patient's conditions, which can be either physical or emotional [19]. Perhaps, the presence of the insomnia is a result of emotional situations that provoke distortions in the patient's perception of reality.

In addition, the knowledge of a patient's sleep perception has therapeutic implications. Downey and Bonnet [20] obtained improvements in insomnia by training patients with paradoxical insomnia to improve their sleep perception. These findings suggest a lot can be achieved by simply showing patients that, although they feel they are not sleeping, the PSG indicates they are getting a much longer or even normal sleep. Although PSG indications in all cases of insomnia contradicted the proposed norms [21], we suggest the use of PSG in all insomnia cases. This measurement would be for both diagnostic purposes and for the therapeutic process as part of a broad based cognitive-behavioral treatment.

Cognitive and behavior therapy, which is the main therapeutic technique for insomnia, consists of modifications in the knowledge and thoughts acquired along many years. The simple fact that the patient's understanding of their insomnia is caused, many times, by a distortion of perception can be of great importance in their treatment, thus bringing improvements for the insomnia.

5. Conclusions

Maybe we are addressing a new facet of sleep perception that involves sleep state perception. Trajanovic et al. [22] identified a condition opposite of the underestimation of sleep and they named it positive sleep state misperception, which was characterized by a sleep overestimation. These authors observed that people who overestimated their sleep had more objective daytime sleepiness than patients who underestimated it. They propose that this new condition, named positive sleep state, could be one end of a spectrum, having in the other end the negative sleep state misperception. However, it seems that sleep perception depends fundamentally on the individual's psychologic structure and that to understand sleep state perception means that one must understand the cognitive factors involved in the state of consciousness that happens during sleep.

We believe that examining the patient's sleep perception is as important as knowing the other sleep parameters. In order to obtain this degree of perception, the implementation of an objective examination, such as PSG, is fundamental. Although, considering that doing a PSG in all insomniac patients means higher costs, this measurement has to be systematically done, not only in the diagnosis of SDB but also in cases of insomnia.

It is important to emphasize that our study showed that the analysis of total sleep time, sleep efficiency and sleep latency did not show differences among the four groups; however, the percentage of stage 2 sleep was lower in the healthy group compared to the other groups. It is important to emphasize that gender did not interfere in the results of sleep perception analysis; however, future studies must be done aiming to standardize samples, as it was observed that age influenced sleep architecture and AHI in the groups studied. The SP must be evaluated in individual situations without the interference of so many other confounding factors. These studies should be conducted in more homogeneous groups of the general population and in specific segments, such

as children, old people or men and women. The contribution of anxiety on sleep perception has been a specific aim of our research.

Comparing the number of sleep hours perceived by the patient with the number of hours actually slept, as recorded by PSG, may be as important as other parameters. Thus, SP may be used as a biologic parameter of sleep that could be as important as sleep efficiency, and it may be a marker for sleep disorder evolution and the effectiveness of the therapy adopted.

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