ORIGINAL ARTICLE

Sleepiness in patients with obstructive sleep apnoea – daytime course and impact of nocturnal respiratory events

Simona Dostálová [1], Marek Šusta [2,3], Tereza Vorlová [1], Karel Šonka [1]

1 Department of Neurology and Centre of Clinical Neurosciences, Charles University 1st Medical Faculty and General University Hospital in Prague, Czech Republic
2 Department of Psychiatry, Charles University 1st Medical Faculty and General Teaching Hospital in Prague, Czech Republic
3 St. Elisabeth University of Health and Social Sciences, Bratislava, Slovakia

Correspondence to: Marek Šusta
Department of Psychiatry, Charles University 1st Medical Faculty and General University Hospital in Prague,
Ke Karlovu 11, 120 00 Praha 2, Czech Republic.
E-MAIL: marek.susta@lf1.cuni.cz

Abstract

BACKGROUND: Obstructive sleep apnoea (OSA) is a condition leading to excessive daytime sleepiness. The aim of the study was a) to study course of daytime sleepiness in patients with OSA and b) to find the most important nocturnal polysomnography parameters influencing daytime sleepiness in OSA.
METHODS: The cohort consisted of forty-five patients (6 women, 39 men) diagnosed with OSA. All patients underwent polysomnography, Multiple Sleep Latency Test (MSLT) and rated subjectively their daytime tendency to sleep with the Epworth Sleepiness Scale.
RESULTS: Sleep latency was significantly longer at 15:00 and at 17:00 hours compared to previous tests. A significant negative correlation was found between the mean of the MSLT sleep latency and a number of awakenings, the apnoea/hypopnoea index and oxygen desaturation index values.
CONCLUSIONS: The study showed the sleep latency prolongation at 15:00 and 17:00 hours respectively and confirmed connection of excessive daytime sleepiness to fragmentation of nocturnal sleep and OSA severity.

INTRODUCTION

Obstructive sleep apnoea (OSA) is characterized by repetitive episodes of upper airway obstruction in sleep mostly accompanied by decreased haemoglobin oxygen saturation. The severity of OSA is expressed in the apnoea/hypopnoea index – AHI (apnoea and hypopnoea episodes ratio per hour of sleep). The criteria for the diagnosis of OSA in adults are AHI ≥5 in the presence of other concurrent clinical symptoms such as excessive daytime sleepiness, insomnia or others, or AHI ≥15 unless those symptoms are expressed (American Academy of Sleep Medicine 2005). Apnoea and hypopnea terminate with arousal or awakening. Repeated arousals and awakenings lead to sleep fragmentation with reduced slow wave sleep (SWS) and REM sleep. Excessive daytime sleepiness is the

most prominent daytime symptom of OSA (Sonka & Slonkova 2008), but limited information on daytime variations of sleep propensity in OSA is available.

The aim of the study was to assess the course of daytime tendency to sleep and to find the most important nocturnal sleep parameters influencing daytime sleepiness in OSA.

METHODS

Cohort

Data of 45 consecutive patients diagnosed with OSA previously examined in the sleep laboratory of the Department of Neurology were enrolled in the study. Study exclusion criteria included circadian rhythm disorders/abnormalities, narcolepsy and other central hypersomnias as well as the intake of drugs affecting sleep or vigilance or sleep breathing.

The cohort consisted of 6 women aged from 46 to 69 years (mean 61.2) and 39 men aged from 19 to 67 years (mean 48.3). The following comorbid sleep disorders were present in the cohort: three cases of restless leg syndrome, three cases of periodic leg movements in sleep (PLMS) and one patient suffered from REM sleep behavior disorder. As for cardiovascular and metabolic diseases, twenty-four patients had a history of arterial hypertension, twelve hyperlipidaemia, six type 2 diabetes mellitus, four stroke in the past and two coronary heart disease. Ten patients suffered from pulmonary involvement – two from chronic obstructive pulmonary disease, seven from bronchial asthma, and one from restrictive pulmonary disease. Four were treated with antidepressants and, at the time of examination, showed no signs of mood disorder. No other comorbidity interfering with sleep and sleep breathing was present.

EXAMINATION

Somatometric examination

The body mass index (BMI – kg/m^2) was calculated from the body weight and height.

Epworth sleepiness scale (ESS)

ESS (Johns 1991) uses subjective estimate of the likelihood of dozing off during the day in eight everyday situations over the past week. Resulting score ranges from 0 to 24. The scale was used in its Czech mutation (Horinek *et al.* 2004).

Polysomnography (PSG)

The diagnosis of OSA was based on standard overnight PSG. PSG included four electroencephalographic leads (C3-A2, C4-A1, O1-A2, O2-A1), two electro-oculographic leads (E1-M2, E2-M2) and chin and bilateral anterior tibialis surface electromyograms, one electrocardiographic lead, respiratory sounds, nasal airflow (thermistors), thoracic and abdominal movements (piezoelectric belts), finger probe oxymetry and the patient's body position record. Sleep was scored according to Rechtschaffen and Kales criteria (Rechtschaffen & Kales 1968). Apnoea was defined as complete airflow cessation ≥10 seconds and hypopnoea as 50% or greater reduction of air inflow leading to 3% or greater oxyhemoglobin desaturation.

All patients were allowed to sleep (polysomnography duration – Time In Bed) from 22.00 to 6.00. For statistical purposes, following parameters were processed: Total Sleep Time (duration of all 30 sec epochs scored as sleep), Sleep Efficiency (SE – Total Sleep Time/Time In Bed), number of awakenings (an awakening was defined as at least one 30-sec epoch containing a minimum of 50% wakefulness), sleep onset latency (SOL) – from lights-off to the first epoch scored as 2 NREM, REM sleep duration, SWS duration, REM sleep onset latency, SWS onset latency, oxygen desaturation index (ODI – number of saturation drops by 3% and more per hour), AHI and mean oxygen saturation.

Multiple Sleep Latency Test (MSLT)

This is a neurophysiological test for standard confirmation and quantification of daytime sleepiness by repeated measurements of sleep latencies during the day (Carskadon *et al.* 1986). For MSLT, electroencephalogram, electro-oculogram and chin electromyogram are recorded and analysis of sleep stages is performed according to the same rules as nocturnal sleep (Rechtschaffen & Kales 1968). MSLT consists of 5 measurements made in 2-hour intervals. The first examination starts at 9 a.m. A patient lies in a quiet darkened room. He/she is asked to assume an optimal position in bed, and to lay still with eyes closed and refrain from resisting sleep. If he/she falls asleep within 20 minutes, the recording continues for another 15 minutes from the actual sleep onset until the technician wakes him/her up and the measurement is terminated. If the subject fails to fall asleep within 20 minutes, the measurement is terminated. As part of MSLT, the sleep latency (SL-MSLT) is measured – the time between the lights off and the beginning of the first epoch scored as sleep. The mean SL-MSLT is then calculated (the mean of sleep latencies ascertained of all five consecutive measurements).

Statistics

The test readings were processed to obtain basic statistical characteristics: mean values and standard deviations. The data were tested for normality. Since the MSLT-related parameters are acceptable with respect to normality, the course of daytime sleepiness was examined using parametric method (paired samples – tests – Pearson). As some parameters of the nocturnal sleep data fail to meet all the criteria of normality, the effect of the quality of nocturnal sleep on daytime sleepiness was tested with a non-parametric method – Spearman´s rho correlation – even though the number of tested subjects (N) was sufficient. *p*-values <0.05 were considered significant.

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Tab. 1. Results of night polysomnography.

	Mean	SD
SE (%)	82.8	9.5
Number of awakenings	49.5	46.9
SOL (min)	19.4	20.0
REM sleep duration (min)	82.7	37.1
REM sleep latency (min)	84.2	48.1
SWS duration (min)	69.2	44.1
SWS latency (min)	46.8	78.5
ODI	33.7	32.6
AHI	31.5	32.2
Mean saturation (%)	92.6	1.9

SD – standard deviation, SE – sleep efficiency, SOL – sleep onset latency, SWS – slow-wave sleep, ODI – oxygen desaturation index, AHI – apnoea/hypopnoea index

Tab. 2. Comparison of MSLT sleep latencies.

	Mean of Differences		*p*-value
	Mean	SD	
SL 1 – SL 2	−0.5	5.0	0.512
SL 1 – SL 3	0.3	5.7	0.726
SL 1 – SL 4	−1.8	5.6	**0.035**
SL 1 – SL 5	−5.1	6.6	**0.001**
SL 2 – SL 3	0.8	5.7	0.356
SL 2 – SL 4	−1.3	3.7	**0.019**
SL 2 – SL 5	−4.6	7.0	**0.001**
SL 3 – SL 4	−2.1	5.2	**0.009**
SL 3 – SL 5	−5.4	7.0	**0.001**
SL 4 – SL 5	−3.3	6.6	**0.002**

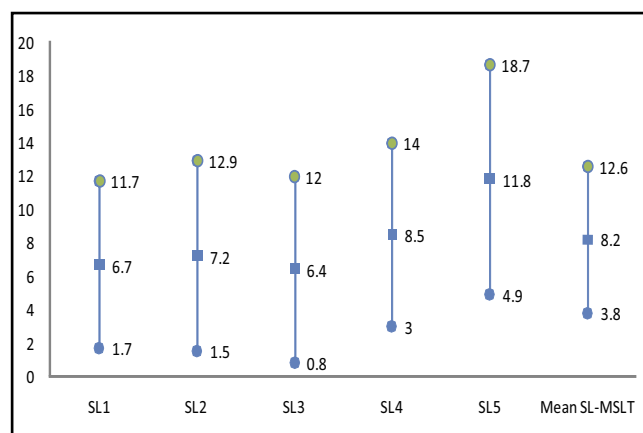SD – standard deviation, SL – sleep latency

Fig. 1. SL-MSLT for each measurement (minutes). SL – sleep latency

RESULTS

The BMI values varied from 21 to 46 (mean 31.2, SD 5.5). No BMI correlation was found with the mean of SL-MSLT) neither with ESS. As for the subjects questioned with ESS, their subjective assessment varied from 3 to 24 points (mean 14.1, SD=5.2). Night polysomnography revealed OSA of mild intensity (AHI 5–14) in 17 patients, moderate intensity (AHI 15–29) in 13, and severe intensity (AHI over 30) in 15 patients. Table 1 shows the PSG results found in patients with OSA.

Figure 1 presents SL-MSLT for each measurement. The mean SL-MSLT was 8.2 min (SD = 4.4). No epoch was scored as REM sleep. To assess the course of daytime sleepiness, SL-MSLT in each MSLT measurement was compared. As results in Table 2 show, sleep latencies become significantly longer in the fourth and the fifth measurement.

A significant negative correlation was found between the mean of SL-MSLT and ODI (Table 3) and AHI (Table 4). As the results indicate, subjectively perceived sleepiness expressed by ESS does not exhibit any significant correlation.

In order to ascertain the effect of nocturnal sleep quality on daytime sleepiness we looked for correlations between mean of SL-MSLT, ESS and PSG results. The only one significant finding was a negative correlation between the mean of SL-MSLT and the number of awakenings (Table 5). The study fell short of proving an SE effect on daytime sleepiness. No significant correlation exists between the mean of SL-MSLT and REM sleep duration, SWS duration, SOL, SWS latency or REM sleep latency.

DISCUSSION

Markedly increased BMI values found in patients with sleep apnoea compared to Czech standards for the same age categories are in line with previous studies showing that obesity is an important disposition factor for sleep apnoea (Komenda & Blaha 1988; Schwab & Gefter 2002). According to Cao *et al.* (2011), the degree of obesity is significant not only for the development of OSA but also for occurrence of excessive daytime sleepiness. However this was not confirmed by this study as no correlation between BMI and excessive daytime sleepiness intensity expressed was found by means of MSLT or ESS.

In 1980, Roth *et al.* (1980) were clearly the first research group to use repetitive daytime 15-minute naps (at 10, 12, 14 and 16 hours) in patients with OSA. The Guidelines for the use of the MSLT as used to this day were devised by Carskadon and her co-workers (Carskadon *et al.* 1986). Data confirming MSLT reliability and validity for the assessment of excessive daytime sleepiness and normal range of latencies in the MSLT were published by Roehrs and Roth (Roehrs & Roth

1992). There are many relevant studies rating sleepiness in OSA patients by the SL-MSLT mean and quite a number of studies describing the course of daytime sleepiness in the normal population. On the other hand, evidence of the daytime sleepiness intensity variability in patients with OSA is lacking. In the OSA patients nonsignificant peak of daytime sleepiness comes in early afternoon (at 13 hours) similarly as in the healthy population (Clodore *et al.* 1990). Sleep onset latency shortening at this time of the day is caused by circadian changes in wakefulness together with body temperature and efficiency known as the „midafternoon dip" (Monk *et al.* 1996). This phenomenon is independent of any previous food intake; not to be confused for a sign of the postprandial slump that in some cases follows high-starch meal. As the results of the study show, the patients' tendency to doze off declines later in the afternoon (at 15 and 17 hours).

Significant negative correlation between the mean SL-MSLT, ODI and AHI parameters supports the hypothesis that the greater the sleep apnoea intensity, the greater the objective tendency to fall asleep during the day. Similar results were obtained by Sun *et al.* [14], who divided OSA patients into subgroups with excessive daytime sleepiness (ESS >10 and SL-MSLT<10 min) and those without excessive daytime sleepiness (ESS <10 and SL-MSLT >10 min) and found that the first group showed a higher AHI. But they did not performed correlation analysis of AHI and sleep latency in MSLT as we did in our study. Likewise, a study by Basta *et al.* (2008) proved logarithm-transformed AHI to be a significant predictor of excessive daytime sleepiness. But again, their study rated excessive daytime sleepiness solely by ESS, i.e., by subjective assessment of the tendency to doze off in everyday situations and not in terms of MSLT.

The negative effect of sleep fragmentation in healthy subjects is documented by Martin *et al.* (1996) proving that artificial fragmentation of nocturnal sleep with auditory stimuli results in a significant shortening of sleep latency at 10, 14 and 16 hours in the course of MSLT compared to the controls. In another piece of proof, one of the parameters of sleep fragmentation – the arousal index indicating a number of arousals – was found to be an independent predictor of excessive daytime sleepiness (Sun *et al.* 2011). Our study confirms negative impact of sleep fragmentation on objective daytime sleepiness in patients with OSA – there is a negative correlation between the number of awakenings (another of the parameters of sleep fragmentation) and the average SL-MSLT.

According to relevant literature, the percentage of SWS in healthy individuals exposed to sleep-fragmenting stimuli is a predictor of sleep latency in the Maintenance of Wakefulness Test (Martin *et al.* 1996). However, our own results do not confirm significance of SWS duration for daytime wakefulness in OSA patients as well as the influence of sleep efficiency on

Tab. 3. Spearman correlation coefficient rho of subjective quantification of sleepiness (ESS), MSLT sleep latency and oxygen desaturation index (ODI).

		ESS	Mean of SL-MSLT	ODI
ESS	Correlation Coefficient	1.000	–0.123	0.056
	p-value		0.420	0.713
Mean of SL-MSLT	Correlation Coefficient	–0.123	1.000	–0.442
	p-value	0.420		**0.002**
ODI	Correlation Coefficient	0.056	–0.442	1.000
	p-value	0.713	**0.002**	

ESS – Epworth Sleepiness Scale, SL- MSLT – sleep latency on the Multiple Sleep Latency Test, ODI – oxygen desaturation index

Tab. 4. Spearman correlation coefficient rho of subjective quantification of sleepiness (ESS), MSLT sleep latency and apnoea-hypopnoea index (AHI).

		ESS	Mean of SL-MSLT	ODI
ESS	Correlation Coefficient	1.000	–0.123	0.109
	p-value		0.420	0.476
Mean of SL-MSLT	Correlation Coefficient	–0.123	1.000	–0.425
	p-value	0.420		0.004
ODI	Correlation Coefficient	0.109	–0.425	1.000
	p-value	0.476	0.004	

ESS – Epworth Sleepiness Scale, SL- MSLT – sleep latency on the Multiple Sleep Latency Test, AHI – apnoea-hypopnoea index

Tab. 5. Spearman correlation coefficient rho of subjective quantification of sleepiness (ESS), MSLT sleep latency and number of awakenings.

		ESS	SL-MSLT (mean)	Nr. of awakenings
ESS	Correlation Coefficient	1.000	–0.123	0.231
	p-value		0.420	0.131
SL-MSLT (mean)	Correlation Coefficient	–0.123	1.000	–0.336
	p-value	0.420		0.026
Nr. of awakenings	Correlation Coefficient	0.231	–0.336	1.000
	p-value	0.131	0.026	

ESS – Epworth Sleepiness Scale, SL- MSLT – sleep latency on the Multiple Sleep Latency Test, N of awakenings – number of awakenings

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daytime sleepiness. Available sources fail to deliver consistent results: some authors confirm higher sleep efficiency in patients with excessive daytime sleepiness, while others found no significant correlation between mean SL-MSLT and sleep efficiency (Chervin *et al.* 1995). Since no correlation has been found between the mean SL-MSLT and sleep onset latency, SWS latency, REM sleep latency, SWS duration and REM sleep duration, we believe that these parameters prove to be of little importance in terms of OSA patients' daytime sleepiness.

However, different conclusions were reached by Kayumov *et al.* (2000) in their study showing a positive correlation between the mean SL-MSLT and the sleep onset latency during PSG examination. In their opinion fragmented nocturnal sleep results in latency shortening in daytime as much as in nighttime. Other authors stress the importance of other parameters indirectly related to sleep that may play an important role in the OSA patients' sleepiness, such as the measure of obesity and anxiety (Ye 2011).

Subjectively perceived or reported sleepiness assessed by ESS varied from 3 to 24 with the average reaching the value of 14.1, indicating subjectively perceived increased daytime sleepiness in this particular cohort. The results do not reveal any of the anticipated correlation between the mean SL-MSLT and the ESS values. This is in accord with findings of Chervin and Aldrich (1999), who found in patients with OSA no statistically significant association between the ESS score and the average sleep latency in MSLT or the severity of OSA expressed in the AHI. The difference between subjective and objective estimation of sleepiness points to the patient's inability to estimate the degree of sleepiness. Among other factors, this explains the fact that less busy people are less aware of their sleepiness, and that daytime sleepiness can be dissimulated for a number of reasons. This lack of correlation can also suggest that one or both used tests (ESS, MSLT) are inappropriate for daytime sleepiness assessment in OSA patients.

CONCLUSION

Our study showed similar sleep latencies at 9:00, 11:00 and 13:00 hours and a significant sleep latency prolongation at 15:00 and 17:00 hours respectively when compared to previous latencies. The study also confirmed the effect of the nocturnal sleep discontinuity and the parameters of OSA severity on daytime sleepiness.

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Confilct of interest statement
The authors declare that they have no conflict of interest.

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