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Mandibular advancement device for the treatment of snoring-induced noise exposure: an objective assessment of the therapeutic effect

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Abstract

Purpose: The mandibular advancement device (MAD) is now an internationally recognized treatment option for snoring and obstructive sleep apnea. However, the extent to which this treatment method reduces snoring-induced noise exposure for bed partners has only been investigated subjectively to date. The purpose of this study is to carry out an objective assessment using acoustic methods.

Methods: 19 subjects (15 males aged 28 – 71, mean 52.9 years) participated in a non-randomized crossover on-off/off-on controlled observational study (with/without MAD) involving two full-night extended polygraphy sessions and acoustic measurements.

Results: A significant improvement in sleep apnea (Apnea-Hypopnea Index [AHI] from 24.1/h to 14.5/h, $p<0.001$) was recorded in subjects using an MAD. A highly significant reduction was observed in all physical and acoustic measurements across all parameters assessed [mean sound pressure level (35db[A] to 32.3db[A], $p<0.001$); mean sound energy LAeq (27.5db[A] to 25.6db[A], $p<0.001$); Snoring Index (455 to 293, $p<0.001$); percentage snoring time (12.6% to 8.1%, $p<0.001$)]. Snoring-induced noise exposure, assessed as per the Psycho-acoustic Snore Score, also fell from 23.1 to 12.7 ($p<0.001$).

Conclusion: This study is the first to show through objective (psycho-)acoustic measurements that, in addition to treating obstructive sleep apnea, an MAD has a significant positive effect on snoring and therefore on noise exposure for the bed partner.

Declaration of the study:

German Clinical Trials Register (DRKS): Effect of the Mandibular Advancement Device on snoring: An evaluation based on objective acoustic Parameters, DRKS-ID: DRKS00040349

Key words: Snoring, OSA, mandibular advancement device, bed partner, annoyance, objective assessment

Statements and Declarations

Author statement:

All authors have seen and approved the manuscript.

Disclosure statement:

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Data availability statement:

The authors confirm that the data supporting the findings of this study are available within the article.

Purpose

The mandibular advancement device (MAD) is an internationally recognized alternative to CPAP (*continuous positive airway pressure*) mask treatment for the guided treatment of obstructive sleep apnea (OSA) [1, 2]. The prevalence of OSA fluctuates considerably and appears to be substantially under-diagnosed [3]. Recently collated representative national data from Germany indicate a prevalence of 46% (59% men, 33% women) [4]. Nocturnal exposure to snoring is a common accompanying symptom in patients presenting OSA and also one of the main reasons why patients actually seek treatment [5]. From this perspective and taking habitual rhonchopathy into consideration, the “snoring” phenomenon seems to be significantly more prevalent that the clinical picture of OSA.

Apart from the burden on the snorer *per se*, a major problem is the adverse effect on the bed partner who has difficulty falling asleep and staying asleep due to the noise, not to mention the ensuing daytime fatigue. This can lead to relationship problems and separate bedrooms [6-8].

The partner is usually asked to complete a questionnaire in order to assess snoring and therapeutic success. In studies, this often involves the use of Visual Analogue Scales (VAS) or simply questions about improvements in terms of noise exposure [8-10]. It is not uncommon for the psychometric information provided by the bed partner to contradict objectively measurable and thus comparable acoustic parameters regarding snoring-induced noise exposure [10, 11]. The Snoring Index (SI) is one such objective acoustic parameter. Percentage snoring time (ST) can be derived from the resulting number of snoring sounds or episodes per hour [10, 11]. Psycho-acoustic methods can be used to obtain additional information separately from the bed partner. The Psycho-acoustic Snore Score (PSS) is used to objectively estimate the extent of snoring-induced noise exposure and critically review the effectiveness of treatment methods [12, 13].

Guidelines advocating the use of a mandibular advancement device (MAD), albeit with evidence based on studies focusing solely on the bed partner’s assessment of snoring or, at best, analyzing physical parameters such as the sound pressure level, are available for the treatment of sleep-related respiratory disturbance (including snoring) [1, 14]. No data on the analysis of (psycho-)acoustic effects using objective parameters have been published to date.

Taking these approaches into consideration, the purpose of this study is to investigate the effect of an MAD on snoring-induced nocturnal noise exposure for the first time using objective (psycho-) acoustic techniques.

Patients and methods

The study was approved by the local Ethics Committee (24-3622-104) and was performed in accordance with the ethical standards laid down in the Declaration of Helsinki.

Conduct of the study

The investigation was conducted as a non-randomized crossover on-off/off-on controlled observational study between 2018 and 2025.

The study cohort comprised participants who were all ≥ 18 years old with a history of socially debilitating rhonchopathy and/or presenting obstructive sleep apnea.

All participants gave their written consent to take part in the study. Participation was voluntary. Willingness or refusal to participate in the study did not influence the choice of treatment for the patients.

As part of the study, all subjects were given a custom MAD (TAP®-T-Reverse, Thornton Adjustable Positioner, Airway Management, Carrolton, USA). Patient treatment was standardized and delivered by the same orthodontist and the same dental laboratory (Department of Orthodontics, University of Regensburg, Regensburg, Germany) to ensure comparable, consistent care.

All patients were monitored overnight by extended polygraphy (PG) (WatchPat300, Itamar Medical Ltd., Caesarea/Israel). This uses a PAT-technology (peripheral arterial tonometry) for measuring sleep stages and provides results comparable to normal polysomnography [15]. In addition, snoring was digitally recorded using an audio and acoustic analyzer equipped with a Class 1 microphone (XL2 with M2210, NTi Audio AG, Schaan, Liechtenstein) to assess the success of the treatment. All recordings were made in the clinic under standardized acoustic conditions (structurally identical single room with identical furnishings, identical measurements, microphone positioned precisely 50 centimeters above the tip of the subject's nose) [13]. Patient blinding (examination with or without MAD for the first night) was performed by an independent investigator. Second night measurements were recorded under identical test conditions but with a crossover design amended accordingly from the measurements taken on the first night. The evaluating physician was blinded in terms of the study protocol.

Assessment of the respiratory parameters and acoustic measurement

Respiratory parameters recorded by PG, with and without an MAD, were analyzed on one hand together with (depending on the effective sleep time), the nocturnal noise recordings or the hour during which most snoring sounds were recorded [hour with the highest Snoring Index (SI)]. To this end, the SI and percentage snoring time (ST) were calculated from the acoustic parameters documented on a second-by-second basis. In light of a preliminary study (manual evaluation), sounds ≥ 38dB LAeq (mean sound energy, A-weighted) were defined as snoring sounds. The mean sound pressure level ([dB], A-weighted) and mean sound energy (LAeq) were calculated over the entire sleep time.

Objective calculations were done with dBSONIC Version 4.13 software (01dB-Metravib technologies, Limonest cedex/France) based on the audio files recorded in WAV format.

Mean and maximum sound pressure levels ([dB], A-weighted), the 5th percentile of psycho-acoustic loudness (N_5) and mean roughness (R_{mean}) could be determined using this analysis software. In addition, the Psycho-acoustic Snore Score (PSS) was calculated according to Fischer *et al.*, which objectively indicates the annoyance of a snoring sound [12].

Questionnaire

In addition to the objectively collected data, the Epworth Sleepiness Scale (ESS) was used in the study to assess daytime fatigue in the treated patients [16, 17].

Statistics

Statistical analysis and graphical representation were carried out using Microsoft Excel 365 for Windows (Microsoft Corporation) and SPSS Statistics 28 (IBM Corporation, Armonk/USA) software.

The Wilcoxon test was used for dependent variables for non-normally distributed data. Values below 0.05 and 0.01 were deemed significant and highly significant, respectively.

The respective effect size was also calculated according to Cohen *et al*. ($r < 0.3$ = weak; 0.3 – 0.5 = moderate; ≥ 0.5 = strong) [18].

Results

Nineteen subjects (15 males) with a mean age of 52.9 years (±11.4; 28 – 71) were enrolled in the study between 2018 and 2025. All of the study subjects presented at least socially debilitating rhonchopathy with 16 participants demonstrating obstructive sleep apnea. The mean apnea-hypopnea index (AHI) across the entire cohort was 24.1/h (±11.3/h; 2.3 – 40.7).

The individual data for all subjects are presented in Table 1 with the summarized data for all participants in Table 2.

						Complete night							Hour with the highest SI						
Patient	Age	BMI kg/m²	AHI /h	ODI /h	ESS	Mean SI n	Snoring time %	Mean sound pressure level dB[A]	Mean sound energy LAeq dB[A]	N5 sone	Rmean asper	PSS	Mean SI n	Snoring time %	Mean sound pressure level dB[A]	Mean sound energy LAeq dB[A]	N5 sone	Rmean asper	PSS
1	28 28	24,4 24,4	15,1 2,2	3,7 0,3	15 7	334,6 97,4	9,3 2,7	33,9 28,6	23,7 23,9	3 1,3	3,5 1,6	16,9 3,3	1071 327	29,8 9,1	44 33,7	31,7 24,6	7,6 2,9	6,1 2,4	54,3 16,4
2	35 35	30 30	26,5 26,3	9,8 13,5	11 6	1064,3 442,3	29,6 12,3	41,3 34,7	32,4 28	6,5 3,3	10 5	53,3 26,2	1837 777	51 21,6	43,4 34,1	36,9 30,4	7,2 3,6	13,2 5,2	61,5 31,3
3	66 66	29 29	32 14,3	18,6 10,1	9 6	168 60	6,1 1,6	32,8 32,8	26,5 23,5	2 1,3	3,6 1,4	11,4 0,7	488 1777	13,6 4,9	35 33,1	30 23,8	4,1 1,5	6,9 1,6	38,2 0
4	55 55	26 26	2,3 1,3	0,2 0,2	8 3	76,4 31,8	2,3 0,9	27 26	22,2 21,2	1,1 0,4	1 0,4	4,4 0	296 80	8,2 2,2	24,4 24,2	24,6 21,4	0,5 0,6	0,3 0,4	0 0
5	50 51	34,7 34,7	14,7 7,5	3,2 1,2	6 4	1639 1415,7	46,5 39,3	47,1 41,1	36,6 36,3	9,4 5,3	17 13,8	71 53	2426 2263	67,4 62,9	50,2 43,5	43,9 39,8	12,3 6,3	16,1 13,4	79 57,9
6	49 50	29,8 29,8	33,5 24,7	24,3 16,8	15 13	528,4 509,5	14,7 13,8	37,3 36,6	27,2 28,5	5 4,2	6,5 6,6	38,4 35,4	1121 1093	31,1 30,4	39,5 39,6	31,7 33,2	6,6 5,4	11,3 8,2	57,3 48
7	52 52	35,9 35,9	29,5 16,3	18,1 15,6	12 6	79,7 75,3	2,2 2,1	29,7 28	25,8 23,1	1,4 1,1	2,4 1,3	2,5 1,8	153 253	4,3 7	29 33	26,9 25,1	1,4 2,4	2,1 2,7	0 12,3
8	37 37	22,6 22,6	13 3,3	1,6 0,1	14 9	186,3 6	5,2 0,1	31,7 26,1	27,8 25,1	2,6 0,9	4,4 1,5	13,7 0	855 17	23,8 0,5	43,1 24,1	32 25,6	8,1 0,7	9 0,8	60,6 0
9	53 53	30,1 30,1	36,3 15,8	17,8 7,2	11 7	235,8 153,5	6,6 3,1	31,3 30,4	25,9 25,5	2,2 1,6	4,9 3,6	16 6,9	394 305	10,8 8,5	28,4 29,8	26,9 27,8	1,7 1,5	3,6 3,4	5,8 1,5
10	71 71	23,8 23,8	20,5 8,5	10,9 4,9	6 3	238,6 55,5	5,9 1,5	31,7 29,9	25,4 24,2	2,1 1,4	3,4 2,2	12 1,6	486 119	13,5 3,3	31,9 30,2	28,1 24,6	2,2 1,8	2,8 2,6	10,2 3,7
11	69 69	30,5 30,5	23 17,1	12,1 5,9	7 6	579,5 275,4	16,1 8,1	37,9 35,7	28,6 24,3	4,8 2,5	6 2,7	39,4 14,3	1047 603	29,1 16,8	39,7 41,4	32,2 27,7	6,1 4	6,5 3,9	48,8 31
12	53 52	40,2 40,2	40,7 29,9	23 11,8	10 4	886,3 460,2	24,6 12,8	40 38,8	30,2 27	5,3 4,1	7 5,1	45,1 30,5	1177 1006	32,7 27,9	39,3 41,9	32 30,7	5,7 5,7	5,5 8,8	45 50,3

13	60 60	27,2 27,2	37,6 41	19,9 25,2	2 1	1691 1662,8	43,7 46,2	46,9 45,4	37,2 36,6	8,9 8,8	17 14,6	68,5 67,6	2098 2047	58,3 56,9	48,4 49,1	40,7 40	9,8 11,7	18,7 21,2	74,3 80,7
14	52 52	29,5 29,5	35,9 6,9	19,7 1,3	9 6	360,2 40	10 1,2	37,2 27,9	28,2 23,6	2,7 1,1	4,9 1,3	22,4 0	807 83	22,4 2,3	36,5 34,4	31,5 23,7	3,3 1,4	5,3 1,4	29 0
15	41 41	28 28	9,6 8,1	3,9 4,6	9 1	293,2 71,8	8,1 2	36,5 32	26,8 22,7	3 1	4,6 1,2	21,8 0	498 131	13,8 3,6	40 33,5	29,1 22,9	4,8 1,5	7,2 1,6	43,1 0
16	56 56	29 29	19,2 19,4	5,8 6,2	19 14	109,8 71,4	3,1 2,1	36,1 31,3	25,1 23,1	1,6 1	2,2 1,1	1,6 0	210 200	5,8 5,6	34,3 34	25,6 23,6	1,7 1,8	1,9 1,5	0 0
17	56 56	28,1 28,1	31,7 14,3	10,4 3	3 3	87,2 84,5	2,4 2,3	30,4 33,8	23,6 23,7	1,1 1	1,4 1,5	0 0	154 180	4,3 5	30,2 32,2	24 23,7	1,2 1,3	1,7 1,6	0 0
18	64 64	29,7 29,7	29,4 16,4	16,4 8,6	11 3	46,8 17	1,3 0,5	28,9 26	24,4 23,6	1 0,9	1,6 1,3	0 0	117 33	3,3 0,9	30,6 25,5	24,4 23,1	1,1 0,7	1,2 0,9	0 0
19	58 58	24,7 24,7	7,5 2,8	1,7 0,4	7 3	34,4 34,2	0,9 0,9	27 28,1	24,1 23,4	1 0,8	1,5 1,1	0 0	68 106	1,9 2,9	25,5 33,8	24,3 24,5	0,8 1,2	1,1 2	0 0

Table 1: Data table of all subjects and investigated parameters. In each cell, the first upper number represents the measured values without a MAD. The latter lower values with MAD.

Parameter	Without MAD (Control) (n=19)	With MAD (n=19)	p-value / effect (d/r) Cohen (1988)
Descriptive data			
Age (years)	52.9 ± 11.4 (28 – 71)	53 ± 11.4 (28 – 71)	
Sex (male). n (%)	15 (78.9)	15 (78.9)	
BMI. (kg/m²)	29.1 ± 4.3 (22.6 – 40.2)	29.1 ± 4.3 (22.6 – 40.2)	
Respiratory parameters			
AHI (/h)	24.1 ± 11.3 (2.3 – 40.7)	14.5 ± 10.5 (1.3 – 41)	.001 / 1.17
ODI (/h)	11.6 ± 8.0 (0.2 – 24.3)	7.2 ± 6.9 (0.1 – 25.2)	.004 / 0.65
Questionnaire			
Epworth Sleepiness Scale	9.7 ± 4.2 (2 – 19)	5.5 ± 3.5 (1 – 14)	.001 / 0.87
Acoustic analysis			
Entire night			
Mean SI (n)	454.7 ± 510.4 (34.4 – 1691)	292.9 ± 468.4 (6 – 1662.8)	.001 / 0.88
Percentage snoring time (%)	12.6 ± 13.9 (0.9 – 46.5)	8.1 ± 13 (0.1 – 46.2)	.001 / 0.78
Mean sound pressure level (dB[A])	35 ± 5.9 (27 – 47.1)	32.3 ± 5.4 (26 – 45.4)	.001 / 0.89
Mean sound energy LAeq (dB[A])	27.5 ± 4.1 (22.2 – 37.2)	25.6 ± 4.2 (21.2 – 36.6)	.001 / 0.76
N_5 (sone)	3.4 ± 2.6 (1 – 9.4)	2.2 ± 2.1 (0.4 – 8.8)	.001 / 0.88

R_{mean} (asper)	5.4 ± 4.7 (1 – 17)	3.5 ± 4.1 (0.4 – 14.6)	.001 / 0.85
PSS	23.1 ± 23 (0 – 71)	12.7 ± 20.3 (0 – 67.6)	.001 / 0.81
Hour with the highest SI			
Mean SI (n)	805.4 ± 694.4 (68 – 2426)	600 ± 714.8 (17 – 2263)	.013 / 0.57
Percentage snoring time (%)	22.4 ± 19.3 (1.9 – 67.4)	14.3 ± 18.4 (0.5 – 62.9)	.001 / 0.75
Mean sound pressure level (dB[A])	36.5 ± 7.5 (24.4 – 50.2)	34.3 ± 6.5 (24.1 – 49.1)	.005 / 0.36
Mean sound energy LAeq (dB[A])	30.3 ± 5.5 (24 – 43.9)	27.2 ± 5.4 (21.4 – 40)	.001 / 0.77
N_5 (sone)	4.5 ± 3.4 (0.5 – 12.3)	2.9 ± 2.7 (0.6 – 11.7)	.016 / 0.55
R_{mean} (asper)	6.3 ± 5.3 (0.3 – 18.7)	4.4 ± 5.3 (0.4 – 21.2)	.023 / 0.52
PSS	32 ± 28.6 (0 – 79)	17.5 ± 25 (0 – 80.7)	.009 / 0.60

Table 2: Patients profiles

The subjects were divided into two groups in the non-randomized crossover on-off/off-on controlled observational study (*Figure 1*).

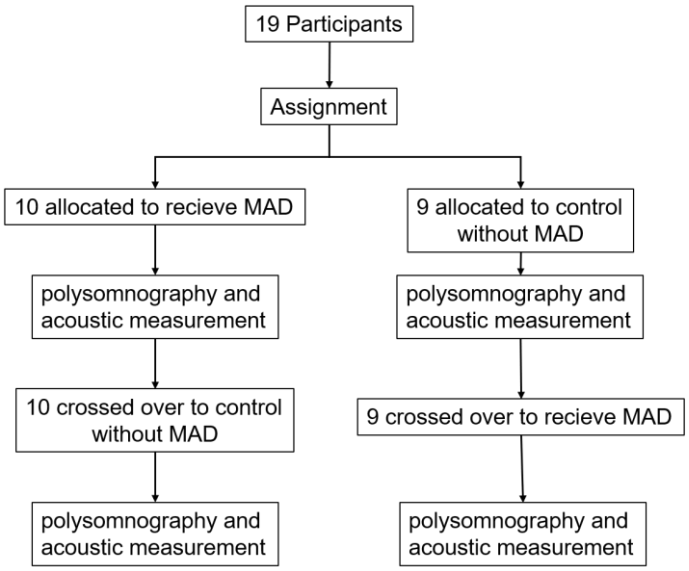


Fig. 1 The study flow with participants divided into two groups using an on/off–off/on design.

Nine participants spent the first night without an MAD (group 1, 7 males, mean age 48.5 years (± 10.4; 28 – 64), mean baseline AHI 27.5/h ± 10.9/h). Ten subjects (group 2, 8 males, mean age 57.8 years (±11.0; 35 – 71), mean baseline AHI 20.4/h ± 11.2/h) were examined on the first night with an MAD.

No significant difference in the proportion of REM (Rapid Eye Movement) sleep was highlighted on analyzing the sleep stages during treatment (p=0.327). The proportion of light sleep decreased (p=0.002) while that of deep sleep increased due to treatment (p=0.016).

Respiratory parameters

In all subjects, the use of an MAD reduced AHI (24.1/h ± 11.3/h to 14.5/h ± 10.5/h) and the Oxygen Desaturation Index (ODI) (11.6/h ± 8.0/h to 7.2/h ± 6.9/h) (*Figure 2)*. A similar effect was observed in the supine position with a reduction in respiratory disturbance (AHI from 30.5/h ± 17.0/h to 21.9/h ± 18.7/h) whereas sleep time in the supine position increased significantly during therapy (48.1% vs. 52.3%, p=0.018). The reduction in AHI (p<0.001) and ODI (p=0.004) was highly significant with a significant reduction in AHI in the supine position (p=0.027). The effect size according to Cohen highlighted a large effect for the test parameters amounting to 1.17 for AHI, 0.65 for ODI and 0.5 for AHI in the supine position for each treatment method.

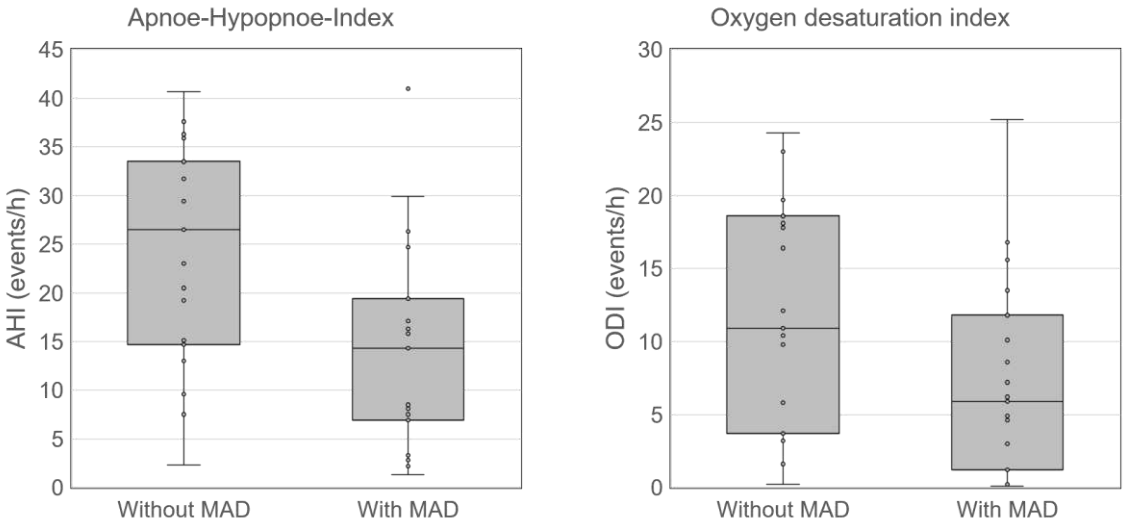


Fig. 2 Respiratory parameters (AHI and ODI) presented as box plots, comparing results with and without the use of a MAD.

Acoustic parameters

Acoustic parameters were calculated overnight and for the hour with the highest SI.

Calculations throughout the entire night

Treatment resulted in a highly significant reduction in physical (mean sound pressure level (35.0db[A] to 32.3db[A], p<0.001)) and acoustic (mean sound energy LAeq (27.5db[A] to 25.6db[A], p<0.001)) parameters with a correspondingly large effect size (see *Figure 3*).

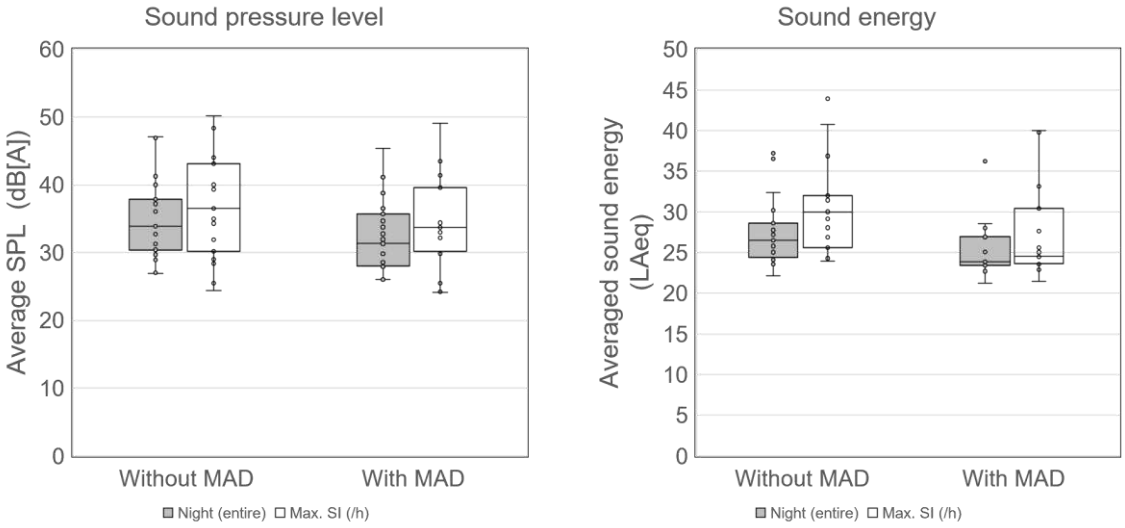


Fig. 3 Physical parameters, shown in box plots for all participants studied, over the entire night (grey) and in the hour with the highest SI (white), compared with and without MAD.

SI decreased from 454.7 to 292.9 using an MAD and the percentage snoring time therefore also decreased from 12.6% to 8.1%. The difference was highly significant in each case ($p<0.001$) and the effect size according to Cohen was marked (r=0.88/0.78) (see *Figure 4*).

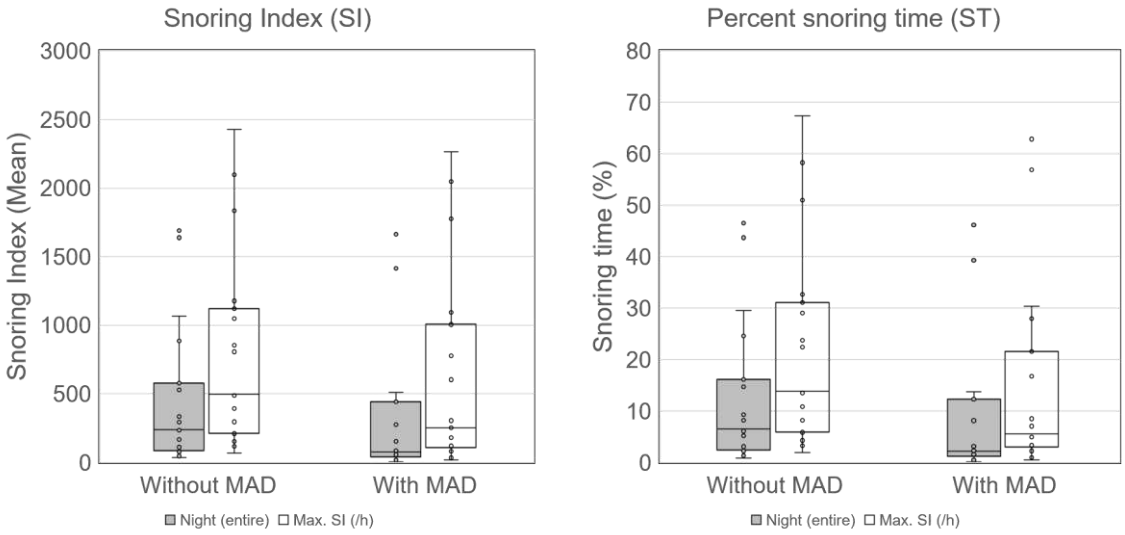


Fig. 4 Acoustic parameters, with SI and the calculated ST shown as absolute values (y-axis), for the entire night and for the hour with the highest SI.

In addition to the physical and acoustic parameters, an equally highly significant effect was also observed for the psycho-acoustic measurement (r=0.81 – 0.89, $p<0.001$). The 5th percentile of loudness (N_5) fell on average from 3.4 sone to 2.2 sone, mean roughness (R_{mean}) from 5.4 asper to 3.5 asper and PSS, as a measure of snoring exposure, from 23.1 to 12.7 (see *Figure 5*). A PSS of 0 was recorded without therapy in 3 subjects out of the overall group. There was no change in the psycho-acoustic algorithm under therapy.

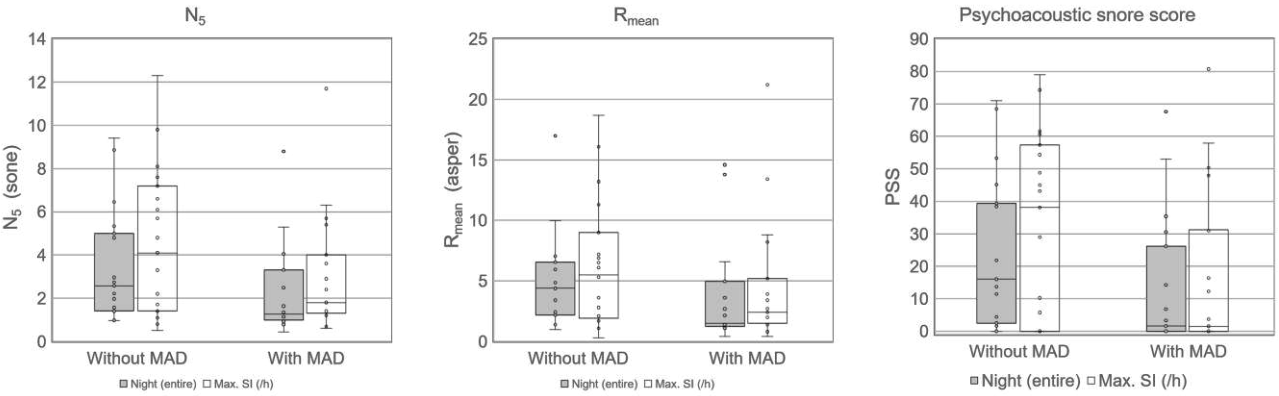


Fig. 5 Box plots of psychoacoustic parameters (N_5, R_{mean}, and the resulting objective snoring exposure – PSS) with and without MAD, shown for the entire night and for the hour with the highest SI.

Calculations in the hour with the highest SI

Similar effects to those observed overnight were also recorded on analyzing the hour with the highest Snoring Index (SI). All parameters decreased significantly, mainly with a high effect size. For instance, the SI fell from 805 to 600 with a reduction in percentage snoring time from 22.4% to 14.3% ($p=0.013$ / $p<0.001$). The PSS, as a measure of annoyance, also fell significantly (32 to 17.5, $p=0.009$). Only a moderate effect according to Cohen was recorded solely on measuring the mean sound pressure level (36.5.0db[A] to 34.3db[A], $p<0.005$, $r=0.36$).

The data are presented in Tables 1 and 2 and Figures 2 to 4.

Questionnaire

A significant improvement in subjective parameters was also recorded in the study cohort after introducing MAD *(Table 1 / 2)*. Daily fatigue (ESS) fell from 9.7 to 5.5 out of a possible 24 points.

Discussion

According to international guidelines, MAD therapy has long since been recommended for the treatment of sleep-related respiratory disturbance including obstructive sleep apnea [1, 2]. These literatures sources also contain convincing evidence-based recommendations in favor of MAD with regard to the snoring phenomenon [19, 20]. As previously mentioned, however, these are base especially on subjective assessments using questionnaires and do not feature standardized snoring scales.

Notwithstanding, there are also guidelines and recommendations on the topic of “Snoring treatment” that primarily cite objective studies focusing on MAD therapy [14, 21, 22].

These studies are based partly on subjective reports but also on objective physical measurements involving sound pressure levels [20, 23, 24]. A type of snoring index can be generated using pre-defined threshold values by adding up every sound that exceeds the corresponding sound pressure level.

In the studies cited, various sound levels (45 – 55 dB[A]) are defined as snoring. This issue is also evident in the general literature on snoring where the thresholds used to distinguish snoring from respiratory sounds wide range [6, 11, 25-27]. The lack of consensus acoustic definition for snoring is certainly the main reason behind this issue of inadequate standardization.

It has also been shown that not only the sound pressure level but also the specific acoustic nature of the sounds in addition to their progression over time, play a key role in assessing snoring annoyance [28-30].

The purpose of this study was, therefore, to conduct an initial objective assessment of the effect of MAD on snoring-induced nocturnal noise exposure. To this end, established physical and psycho-acoustic parameters were used, based on well-established preliminary studies such as those featuring hypoglossal nerve stimulation [13].

The observational study cohort comprised 19 subjects for whom MAD therapy was introduced in accordance with current guidelines [1, 2, 14, 21, 22].

Comparative studies making a significant statement included a similar-sized cohort (tending towards slightly fewer participants), thus indicating a sufficiently large sample [13, 20, 23, 24].

A significant improvement in respiratory disturbance (AHI from 24.1/h to 14.5/h, $p<0.001$) was recorded using an MAD. The improvement in respiratory parameters is reflected in the improvement in the ESS, thereby emphasizing its effectiveness in the treatment of obstructive sleep apnea.

Taking physical and acoustic parameters into account, a significant decrease with a marked effect size in terms of sound energy as well as SI and ST were recorded with an MAD, both throughout the entire night and in the hour in which the heaviest snoring was recorded. Only the sound pressure level fell to a highly significant extent in the hour with the most snoring, but only with moderate effect according to Cohen.

This appears to be due to a milder degree of snoring in the study cohort. Comparison of the physico-acoustic parameters with the hypoglossal nerve stimulation study reveals a significant difference not only in the extent of sleep-related respiratory disturbance (24.1/h vs. 35.8/h), but also in the mean sound level (35db[A] vs. 42.9db[A]), mean sound energy LAeq (27.5db[A] vs. 33.1db[A]) and mean SI (454.7 vs. 1068) parameters [13]. The extent of OSA in patients undergoing hypoglossal nerve stimulation is, however, more often in the severe range compared to patients treated with an MAD [2].

Psycho-acoustic parameters were used in this study to investigate snoring-induced noise exposure for bed partners. Based on these values, the extent of the exposure was calculated using the Psycho-acoustic Snore Score [12]. Therapy led to a significant reduction in the 5th percentile of loudness and roughness both throughout the entire night and in the hour during which the heaviest snoring was recorded. This resulted in an almost 50% decrease in the psycho-physical algorithm, PSS, over the entire night and in the hour with the highest SI, namely from 23.1 to 12.7 and from 32 to 17.5, respectively.

Last but not least, 3 patients showed no snoring-related disturbance even without treatment, with a PSS score of 0, which once again highlights the difference in the intensity of snoring-related noise exposure compared to the group in the previous study by *Fischer et al.,* in which patients received therapy via hypoglossal nerve stimulation.

Nevertheless, psychoacoustics appears to be a suitable method, particularly for detecting treatment differences even in cases of mild snoring. The psychophysical algorithm (PSS) reveals more distinct differences in the assessment of snoring than any of the physical or acoustic parameters used.

A key limitation of this study is its relatively small sample size. However, despite being a non-randomized crossover observational study, it yields results for standard guideline parameters (such as AHI, ODI, and ESS) that are comparable to those of frequently cited literature [1]. Additionally, measurements were recorded using an on-off/off-on design to avoid a potential 'first-night effect'.

To summarize, a well-founded conclusion can be drawn, taking earlier subjective studies [19, 20], studies with physical measurements, the sound pressure level [20, 23, 24] and this study into consideration. MAD treatment not only positively impacts respiratory disturbance by stabilizing the patient's upper airway but also reduces snoring-induced nocturnal noise exposure for bed partners at the same time. This information can therefore be useful for patients and their bed partners when deciding how to treat sleep apnea and snoring.

Conclusion

This study is the first to demonstrate through objective (psycho-) acoustic measurements that MAD has a significant and also positive effect on snoring and thus noise exposure for bed partners in addition to treating obstructive sleep apnea. This information can be put to good use by affected patients and their bed partners when selecting potential alternative treatments for OSA and snoring.

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