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Utilization of Sleep Application and Pulse Oximetry in the Short-Term Follow-Up of Mandibular Advancement Device Therapy: A Case Report

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Abstract

Pulse Oximetry (PO) has been a qualified method to determine cardiorespiratory stability of the subjects for home-based sleep studies. However, not any user friendly methods have been presented yet to score the snoring severity of subjects in home conditions. Sleep applications (apps), which is claimed to score snoring severity of the patients, have been came into use with technological opportunities provided by smart phones. Nevertheless, there are not any reports in the literature about the usage of these apps yet.

This report describes the utilization of a sleep app in the short-term follow-up of Mandibular Advancement Device (MAD) therapy applied for a moderate Obstructive Sleep Apnea (OSA) patient with habitual snoring. Initially Epworth Sleepiness Scale (EPSS) of the patient was determined and sleep app recordings were performed simultaneously with PO at three different nights. The mean snore score and Oxygen Desaturation Index (ODI) were calculated. A custom MAD was fabricated and all recordings were repeated at the end of the 6 months usage.

The initial EPSS value of the patient was decreased from 16 to 3 with MAD therapy. Moreover, the mean ODI of the patient was reduced by 60% as compared with its initial value. Furthermore, snore scores obtained by the sleep app showed highly compatible alterations both with EPSS and PO values. Using a sleep app in the scoring of snore severity seems like a promising innovation for the future home-based sleep studies.

Keywords: Snoring; Obstructive sleep apnea; Mandibular advancement device; Sleep application; Pulse oximetry

Introduction

Overnight, technician-attended, in-laboratory Polysomnography (PSG) is considered as a gold standard for definitive diagnosis of Obstructive Sleep Apnea (OSA) [1,2]. However, these PSG studies require high costs withal long waiting time for appointments due to the limited number of sleep laboratories despite the presence of increasing demand [1]. In addition, some patients tend to prefer home-based studies rather than hospitalization required methods because of the higher comfort afforded by natural sleep environment [1]. Pulse Oximetry (PO) which has been successfully used in medicine for the last 40 years have become an effective home-based screening technique for OSA patients [1-3]. Respiratory stability of subjects can be easily monitorized and recorded with overnight PO in home conditions. Thus, apneic and hypopneic episodes which indicate fluctuating arterial oxygen saturation can be safely detected and crucial events such as Oxygen Desaturation Index (ODI) and Heart Rate Variability (HRV) may be predicted from PO records [1-3]. However, predicting the snoring severity can be more challenging than detecting the respiratory stability in home conditions, due to the absence of approved medical devices [4,5]. Fortunately, it seems that a new promising opportunity arises with the wide usage of Smartphone's (SP) and their applications (apps) [6]. Recently, program creators have presented several SP apps to record snoring sounds during sleep. Some of these apps can convert the recorded data to the numerical values and provide a

Figure 1: The result of the first diagnostic record of the SnoreLab app.
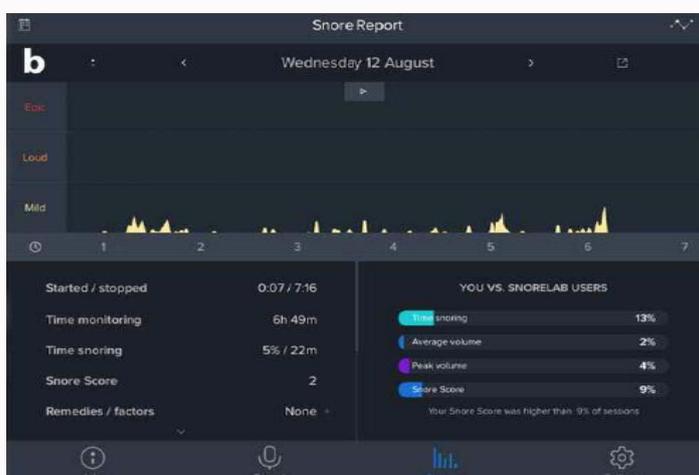

Figure 2: The result of the first diagnostic and the last follow-up records of the SnoreLab app.

snore score using a special algorithm [6]. Despite the wide availability and ease of usage, only one *in vitro* study has been published about sleep apps yet [6]. The present case report was aimed to describe utilization of a novel home-based evaluation technique that was consisted of sleep app and PO in short-term follow-up of Mandibular Advancement Device (MAD) therapy applied for a moderate OSA patient with habitual snoring.

Case Presentation

A 43 year-old Caucasian male patient was referred to the otolaryngology, head and neck surgery clinic of our hospital with the complaint of severe snoring, witnessed apnea and excessive daytime sleepiness. In clinical interview, he reported he had a serious traffic accident one year ago caused by daytime sleepiness. The patient's history did not contain any systemic disorders, cigarette smoking and alcohol or drug abuse.

On the physical examination, the waist and neck circumferences and body mass index of the patient were 108 cm, 42 cm, and 29.8 kg/m^2 respectively. Not any signs were detected during temporomandibular joint examination. On intraoral examination, presence of elongated soft palate, moderate macroglossia and slightly narrowed oropharynx were noted. Oropharengeal relationship of the patient was classified as Class 4 according to the Mallampati scale. His Epworth Sleepiness Scale (EPSS) was 16 and the provisional diagnosis was OSA. Thus, overnight PSG evaluation was required for definitive diagnosis.

According to the medical history, the patient had been referred to a sleep laboratory by a chest physician two years ago. However, having had difficulty in falling asleep and felt discomfort arising from cables and electrodes he had left the test unfinished. Therefore, it was decided to perform overnight PO recording at home in order to check his cardiorespiratory stability during sleep. In addition, snoring monitorization was planned concurrent with the PO recordings. Thus, a sleep app (SnoreLab, Reviva Soft works Ltd, London, UK) was downloaded and set as the creators' instructions. To obtain the most accurate data, the noise level of the patients' bedroom was checked with a sound level meter (LM-8102, Lutron Ltd, Taipei, Taiwan) and conveniences of the room conditions were confirmed. The patient was informed in detail about the working principals of the PO and the app. The Smartphone (IPhone 4S, Apple, CA, USA) was switched and the app was activated before sleep. Finally, the PO (Beurer PO80, Beurer Medical, Ulm, Germany) was inserted by a sleep technician and overnight recordings were performed at the patient's home. In total, three recordings were executed in order to minimize the error margin. While the PO data were scored by an experienced chest physician and snore score values were calculated by the algorithm of the app. Results of the first snoring evaluation were given at the Figure 1. PO and sleep app values of three overnight Diagnostic Recordings (DRs) were given at the Table 1.

According to DRs, the patient was diagnosed with moderate OSA and habitual snoring. The final treatment decision was to

Table 1: The diagnostic results of the PO and sleep app recordings.

	Results of the diagnostic PO recordings							
	Results of the 1st DR		Results of the 2nd DR		Results of the 3rd DR		The mean values of DRs	
	SpO2	Pulse	SpO2	Pulse	SpO2	Pulse	SpO2	Pulse
Total events	199	158	138	82	126	119	154	119
Time in events	105.8	61.2	87.8	31.9	76.6	45.4	90	46.1
Average event duration	31.9	23.2	37.9	23.3	36.5	22.9	35.4	23.1
% Artifact	18.1	18.1	20	20	0.3	0.3	12.8	12.8
ODI	21.6	17.1	20.7	12.2	20.1	19	20.8	16.1
Basal SpO2	91		91.3		90.5		90.9	
Minimum SpO2 (%)	78		81		81		80	
Average pulse rate (bpm)		66.8		62.4		68.3		65.8
Lowest pulse rate (bpm)		55		54		58		55.6
	Results of the diagnostics snoring recordings							
	Results of the 1th DR		Results of the 2nd DR		Results of the 3rd DR		The mean values of DRs	
Time monitoring (min)	423		386		362		390,3	
Time snoring (min)	99		49		62		70	
Snore score	23		19		27		23	

Table 2: The follow-up results of the PO and sleep app recordings.

	Results of the follow-up PO recordings							
	Results of the 1st FR		Results of the 2nd FR		Results of the 3rd FR		The mean values of FRs	
	SpO2	Pulse	SpO2	Pulse	SpO2	Pulse	SpO2	Pulse
Total events	57	89	63	134	15	49	45	90.6
Time in events	28.3	38.7	36.3	47.3	6.3	13.3	23.6	33.1
Average event duration	29.8	26.1	34.5	21.2	25.3	16.9	29.8	21.4
% Artifact	11.8	11.8	4.7	4.7	19.7	19.7	11.9	11.9
ODI	9.6	15	9.7	20.7	6.7	21.8	8.6	19.1
Basal SpO2	90.7		90.3		89.6		90.2	
Minimum SpO2 (%)	83		75		84		80.6	
Average pulse rate (bpm)		67		68		82		72.3
Lowest pulse rate (bpm)		55		57		70		60.6
	Results of the follow-up snoring recordings							
	Results of the 1th FR		Results of the 2nd FR		Results of the 3rd FR		The mean values of FRs	
Time monitoring (min)	370		389		409		389.3	
Time snoring (min)	34		19		22		25	
Snore score	8		2		2		4	

fabricate an individual Mandibular Advancement Device (MAD) to increase the volume of the patient's upper airway. Impressions were made with irreversible hydrocolloid material (CA37, Cavex, Haarlem, Holland) and the master casts were obtained from Type III dental stone (Moldano, Heraeus Kulzer, Hanau, Germany). Maxillary and mandibular occlusal splints were manufactured with Autopolymerising Clear Acrylic Resin Material (ACARM) (Ortocryl, Dentaurum, Ispringen, Germany) on isolated master models such as to cover occlusal and incisal surfaces of the existing dentition. Prepared splints were inserted in the mouth and adjusted on dental arches. Afterwards, intermaxillary relationship was recorded at 75% of maximal mandibular protrusion and intraoral records were mounted on a semi-adjustable articulator (Artex Type NK, Amann Girrbach, Pforzheim, Deutschland). The vertical opening amount was increased up to 10 mm, approximately. Maxillary and mandibular splints were attached to each other using ACARM and finishing procedures were performed. After intraoral adjustments, the MAD was delivered to the patient with recommendations. Three Follow-Up Recordings (FRs) were performed at the end of the 6th month of the MAD treatment. The same recording procedure applied in the DRs was also performed during Frs. Insertion of the MAD during sleep was the only difference between DRs and FRs protocols. The results of the last snoring recording were shown in the Figure 1.

At the end of the six months follow-up period, the EPSS of the patient dramatically decreased at 3. The mean ODI of the patient was improved significantly with the MAD therapy. In addition, significant improvement in HRV was observed with the MAD therapy. Moreover, therapeutic effect of the MAD was recorded successfully with the sleep app. All snore scores obtained by the sleep app showed

highly compatible alterations both with EPSS and PO values. Not any serious complaints were reported by the patient except dry mouth that generally occurred in mornings.

Discussion

According to our knowledge, this is the first report describing the utilization of a sleep app and PO in the management of a moderate OSA patient with habitual snoring. Gradually increasing usage of the PO in sleep studies can be observed from the current literature, and its diagnostic value has been qualified by previous studies [1-3]. However, there exist some studies notifying the variable sensitivity of PO according to the severity of the OSA. Chung et al. [2] stated that PO recordings could be more sensitive for the patients having ODI above 10 (93%). The reason of the highly coherent ODI values obtained from three DRs could be arisen from the moderate severity of the OSA in the present case. In fact, three ODI values obtained from the DRs was extremely close to each other. However, a little less proximity was detected among ODI values obtained from FRS Nevertheless; strong and coherent relations was seen among EPSS, PO and sleep app values in terms of DRs and FRS Moreover, EPSS, PO and sleep app values dramatically decreased in chorus at the end of six months.

As seen in the present case, snoring may be the foremost signs of OSA directing the patients to seek a medical assistance. However, there is no agreement in the literature on the accuracy of snoring severity predicted with the provided information by bed partners. In fact, objective findings may affect the treatment planning of patients or have an importance for avoiding elective surgical interventions [4]. In the present case, simultaneous decrease in EPSS, IDO, HRV and snoring scores displayed not only treatment efficiency of the MAD therapy for a moderate OSA patients, but also problem solving capacity of sleep apps on the existence of an objective method to score the snoring severity of subjects in home conditions. Thus, using a sleep app in the scoring of snoring severity may be an option for the home based sleep studies at the foreseeable future. However, some unknown titles should be made clear to take yet another turn, as previously stated by Stipping et al. [6]. Numerous brand of SP with different hardware and software have been presented in market up to now. Thus, structural properties of the Smartphone's can be quite varied from each other's and their recording quality may be affected from these variations. In addition, some of them may record human snoring sounds more effectively than the others. However, there are not any comprehensive studies in the literature which responds to these queries, yet. Therefore, absence of data about the reliability and repeatability of sleep apps algorithms should be fulfilled.

Unfortunately, an *in vivo* study about the usage of sleep apps has not been published yet. Thus, impossibility of making a comparison is one of the most important limitations of the present case study. However, absence of any PSG data, which can be enabled the verification of obtained results, is the major limitation of the present case. Additionally, findings of this single case cannot be extended to all related population. Therefore, present findings need to be verified by further studies conducted with inclusion of more participants. Moreover, not only sufficiency of widely used SPs but also accuracy and repeatability of existing sleep apps should be evaluated with further studies. More preferably, standard PSG evaluations can be used to constitute a reference point to compare accuracy and repeatability of both SPs and sleep apps. Despite it is as yet too early to make a definite decision, using a sleep app in the scoring of snore sounds seems like a promising innovation for the future sleep studies to be executed in home conditions.

References

1. Flemons WW, Littner MR, Rowley JA, Gay P, Anderson WM, Hudgel DW, et al. Home Diagnosis of Sleep Apnea: A Systematic Review of the Literature. Chest. 2003;124(4):1543-79.

2. Chung F, Liao P, Elsaid H, Islam S, Shapiro CM, Sun Y. Oxygen desaturation index from nocturnal oximetry: A sensitive and specific tool to detect sleep-disordered breathing in surgical patients. Anesth Analg. 2012;114(5):993-1000.

3. Netzer N, Eliasson AH, Netzer C, Kristo DA. Overnight pulse oxymetry for sleep-disordered breathing in adults: a review. Chest. 2001;120(2);625-33.

4. Rohrmeier C, Fischer R, Merz AK, Ettl T, Herzog M, Kuehnel TS. Are subjective assessments of snoring sounds reliable? Eur Arch Otorhinolaryngol. 2015;272(1):233-40.

5. Piskin B, Uyar A, Senel B, Avsever H, Karakoc O, Tasci C, et al. Can nocturnal use of implant-retained overdenture improve cardiorespiratory stability of a patient with obstructive sleep apnea? A clinical report. J Prosthet Dent. 2017;117(6):706-8.

6. Stipping A, Hübers U, Emerich M. Apps in sleep medicine. Sleep Breath. 2015;19(1):411-7.