Original Article

Systemic effects of nocturnal hypoxemia in patients with chronic obstructive pulmonary disease without obstructive sleep apnea syndrome*

Efeitos sistêmicos da hipoxemia noturna em pacientes com doença pulmonar obstrutiva crônica sem síndrome da apnéia obstrutiva do sono*

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Abstract

Objective: To study the effects of nocturnal hypoxemia in patients with chronic obstructive pulmonary disease without obstructive sleep apnea syndrome. **Methods:** We studied 21 patients—10 desaturators and 11 nondesaturators—submitted to arterial blood gas analysis, polysomnography, spirometry, cardiopulmonary exercise testing (cycle ergometer), and hand-grip dynamometry, as well as measurements of maximal inspiratory pressure, maximal expiratory pressure, and C-reactive protein (CRP) levels. Patients with arterial oxygen tension > 60 mmHg were included; those with an apnea-hypopnea index > 5 events/hour of sleep were excluded. Maximal oxygen uptake, maximal power, systolic blood pressure, diastolic blood pressure (DBP), and maximal heart rate were measured during exercise in order to detect hemodynamic alterations. Patients presenting CRP levels above 3 mg/L were considered CRP-positive. **Results:** Minimum peripheral oxygen saturation during sleep was significantly higher among nondesaturators ($p = 0.03$). More desaturators presented CRP > 3 mg/L ($p < 0.05$). No differences were observed in terms of any variables. However, mean oxygen saturation during sleep correlated with DBP and maximal inspiratory pressure ($p < 0.001$ and $p = 0.001$, respectively). **Conclusions:** Although nocturnal hypoxemia does not reduce exercise capacity or hand-grip strength in patients with mild/moderate COPD, its effect on maximal exercise DBP seems to depend on the degree of hypoxemia. In addition, there is a positive relationship between maximal inspiratory pressure and mean oxygen saturation during sleep, as well as evidence of pronounced inflammatory activation in patients with nocturnal hypoxemia.

Keywords: Pulmonary disease, chronic obstructive; Exercise test; Anoxia; Respiratory function tests.

Resumo

Objetivo: Estudar os efeitos da hipoxemia noturna em pacientes com doença pulmonar obstrutiva crônica sem síndrome da apnéia obstrutiva do sono. **Métodos:** Estudamos 21 pacientes—10 dessaturadores e 11 não-dessaturadores—submetidos a gasometria arterial, polissonografia, espirometria, teste de exercício cardiopulmonar (cicloergômetro), dinamometria manual e medidas de pressão inspiratória máxima, pressão expiratória máxima e proteína C reativa (PCR). Incluíram-se os pacientes com pressão parcial arterial de oxigênio > 60 mmHg; excluíram-se os com índice de apnéia-hipopnéia > 5 eventos/hora de sono. Foram medidos consumo máximo de oxigênio, potência máxima, pressão arterial sistólica, pressão arterial diastólica (PAD) e frequência cardíaca máxima durante exercício, visando detectar alterações hemodinâmicas. A PCR foi considerada positiva quando acima de 3 mg/L. **Resultados:** A saturação periférica de oxigênio mínima durante o sono foi significativamente maior nos não-dessaturadores ($p = 0,03$). Mais dessaturadores apresentaram PCR > 3 mg/L ($p < 0,05$). Não houve diferença quanto a capacidade de exercício e demais variáveis. No entanto, PAD ($p < 0,001$) e pressão inspiratória máxima ($p = 0,001$) correlacionaram-se com saturação periférica de oxigênio média durante o sono. **Conclusões:** A hipoxemia noturna não reduz a capacidade de exercício e a força de preensão manual em pacientes com DPOC leve/moderada, mas o ajuste da PAD durante o exercício máximo parece depender do grau de hipoxemia. Além disso, há uma relação positiva entre pressão inspiratória máxima e saturação periférica de oxigênio média durante o sono, bem como indícios de ativação inflamatória diferenciada em pacientes com hipoxemia noturna.

Descritores: Doença pulmonar obstrutiva crônica; Teste de esforço; Anóxia; Testes de função respiratória.

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Introduction

Patients with chronic obstructive pulmonary disease (COPD) can present oxygen desaturation during sleep (nocturnal desaturation), without obstructive sleep apnea syndrome (OSAS).[1] Consequently, such patients can present strong indications of concomitant systemic inflammation associated with the bronchial inflammatory process, capable of inducing abnormal oxidative stress,[2,3] which can be exacerbated by chronic daytime hypoxemia.[4] However, the systemic effects of nocturnal hypoxemia have been little studied in patients with COPD.

Intermittent nocturnal hypoxemia has been extensively studied in patients with OSAS, as well as in experimental models, and has been strongly associated with numerous dysfunctions that affect such patients, such as cardiac abnormalities,[5,6] muscle abnormalities,[7] pulmonary arterial hypertension,[8,9] peripheral neuropathy,[10] and autonomic abnormalities.[11] All of the compartments involved are determinants of exercise capacity. Some authors have found reduced exercise capacity in patients with OSAS,[12,13] although others have demonstrated no such impairment.[14,15]

It is also known that increases in the levels of C-reactive protein (CRP), platelets, fibrinogen, and interleukin-6 are associated with nocturnal hypoxemia in patients with OSAS,[16] together with altered autonomic tone,[11] altered daytime catecholaminergic activity,[17] and increased diastolic blood pressure (DBP) during maximal exercise.[18]

Our objective in this study was to evaluate the impact of nocturnal oxygen desaturation on maximal aerobic capacity and on its hemodynamic alteration components, as well as to determine maximal respiratory pressures, maximal voluntary isometric contraction (MVIC) force, and comparative CRP levels in patients with COPD, presenting normoxemia or mild hypoxemia during the day, with and without nocturnal oxygen desaturation.

Methods

This was a cross-sectional study involving 21 patients with mild to moderate COPD.[19] All patients were referred to the COPD outpatient clinic of the Department of Pulmonology of the Federal University of Mato Grosso do Sul from primary health care clinics or smoking cessation outpatient clinics between May of 2006 and May of 2007.

We used a modified version of the list of criteria established in the Global Initiative for Chronic Obstructive Lung Disease[19] and by the American Thoracic Society/European Respiratory Society task force for diagnosis and treatment of COPD[20]: being between 40 and 75 years of age; being a smoker or a former smoker (smoking history of ≥ 20 pack-years); and having no orthopedic impairments or comorbidities that affect exercise capacity, such as diabetes, heart failure, asthma, or pulmonary hypertension. As additional criteria, the following spirometry results were required: a ratio between forced expiratory volume in one second (FEV_1) and forced vital capacity lower than 70%; and a postbronchodilator FEV_1 greater than 50% of predicted.

None of the patients participated in pulmonary rehabilitation programs or had used medications that could potentially affect exercise capacity, such as systemic corticosteroids or androgenic anabolic steroids, within the preceding 3 months. The patients were required to be exacerbation-free for at least 6 weeks prior to the study and to present resting arterial oxygen tension (PaO_2) > 60 mmHg on room air. All patients were informed of the objective of the study and the tests involved. All participating patients gave written informed consent. The study protocol was approved by the Ethics Committee of the Federal University of Mato Grosso do Sul..

The study was performed in three consecutive visits made within a single week. In the first visit, venous blood samples were collected (following a fast of at least 2 h) in order to obtain hematologic and biochemical variables, and anthropometry was performed in order to determine body mass index (weight in kilograms divided by height in meters squared)—weight measured using a scale (Welmy S.A., Santa Bárbara do Oeste, Brazil) calibrated before each measurement, and height measured using an appropriate stadiometer. In addition, the patients completed a basic questionnaire on sleep and underwent physical examination, after which spirometry was performed (Master Screen; Jaeger, Würtzburg, Germany, 2003). After a short interval, arterial blood samples were collected under anaerobic conditions in order to perform blood gas analysis (ABL 5; Radiometer, Copenhagen, Denmark).

In the second visit, overnight polysomnography was performed using a 32-channel device (Meditron

Eletromedicina Ltda., São Paulo, Brazil), in a clinic accredited by the Brazilian Sleep Research Society, according to the criteria set forth in the Brazilian Consensus on Sleep.[21] The term "nocturnal desaturator" was used in order to define a patient presenting a drop in peripheral oxygen saturation (SpO_2, measured using digital oximetry) that is greater than 4% in relation to baseline (15 min after signal stabilization) and persists for at least 5 min, as recommended by Block et al.[22] Three patients were excluded from the study due to the nocturnal oximetry results or the exercise test results (underexertion).

In the third visit, we measured upper limb MVIC using an analog Jamar dynamometer (Sammons Preston; Jamar, Bolingbrook, IL, USA). A total of five measurements were performed on each hand, and the measurement with the highest value was chosen.

The measurement of maximal respiratory pressures was performed, based on total lung capacity and residual volume, using a digital a vacuum manometer (MVD 300; Globalmed, Porto Alegre, Brazil), together with software, in accordance with the 2002 Pulmonary Function Test Guidelines.[23]

For the cardiopulmonary exercise testing, we used a cycle ergometer (Ergometrics 900; Ergoline, Bitz, Germany) and a mixing chamber measurement analyzer (Jaeger, Würtzburg, Germany), with an incremental protocol on a sliding scale and increments, calculated using the Wasserman formula, ranging from 2 to 4 W every 10 s, until maximal oxygen uptake during exercise (VO_2max) or oxygen

Table 1 - Anthropometric, demographic, pulmonary function, exercise, and polysomnography variables, together with C-reactive protein levels, for the sample as a whole, as well as for the desaturator and nondesaturator groups.

Variable	Sample as a whole (n = 21)	Group		p
		D (n = 10)	ND (n = 11)	
BMI (kg/m^2)	24.8 ± 4.4	23.5 ± 3.5	26.0 ± 5.0	0.195
Age (years)	60.8 ± 7.8	62.1 ± 7.6	59.5 ± 8.2	0.469
Gender (male/female)	15/6	6/4	9/2	-
Smoking (former smoker/current smoker)	9/12	4/6	5/6	1.000
Inhaled corticosteroids (use/non-use)	9/12	4/6	5/6	1.000
FEV_1 (% of predicted)	75.8 ± 18.6	77 ± 16.6	74.6 ±21.0	0.778
FVC (% of predicted)	102.9 ± 16.5	103.8 ± 14.2	102.1 ± 18.9	0.828
FEV_1/FVC (%)	56.6 ± 8.8	57.6 ± 8.1	55.6 ± 9.7	0.621
MIP (% of predicted)	101.5 ± 25.4	97.7 ± 18.1	104.9 ± 31.2	0.529
MEP (% of predicted)	119.9 ± 18.9	114.2 ± 19.8	125.1 ± 17.3	0.195
PaO_2 (mmHg)	76.9 ± 9.0	73.1 ± 7.3	80.3 ± 9.4	0.070
VO_2max (% of predicted)	93.1 ± 15.3	89.1 ± 17.9	96.7 ± 12.4	0.267
Wmax (% of predicted)	86.5 ± 30.7	79.1 ± 31.3	93.1 ± 29.9	0.307
MESBP (mmHg)	210.8 ± 27.9	205.4 ± 35.2	215.7 ± 19.8	0.412
MEDBP (mmHg)	101.2 ± 22.2	99.4 ± 19.0	102.9 ± 25.5	0.727
MVIC (kgf)	35.5 ± 11.6	34.9 ± 13.8	36.0 ± 9.8	0.821
SpO_2rest (%)	96.4 ± 1.0	96.2 ± 1.2	96.5 ± 0.7	0.860
SpO_2peak (%)	94.9 ± 1.9	95.3 ± 1.5	94.5 ± 2.2	0.350
meanSpO_2sleep (%)	93.7 ± 1.5	93.4 ± 1.5	93.8 ± 1.4	0.610
minSpO_2sleep (%)	87.2 ± 4.7	85.1 ± 5.8	89.1 ± 2.5	0.030*
AHI (events/hour of sleep)	2.3 ± 1.8	2.4 ± 1.8	2.3 ± 1.8	0.884
CRP (≤3 mg/L/>3 mg/L)	13/8	4/6	9/2	0.045*

D: desaturators; ND: nondesaturators; BMI: body mass index; FEV_1: forced expiratory volume in one second; FVC: forced vital capacity; MIP: maximal inspiratory pressure; MEP: maximal expiratory pressure; PaO_2: arterial oxygen tension; VO_2max: maximal oxygen uptake during exercise; Wmax: maximal power (watts) during exercise; MESBP: maximal exercise systolic blood pressure; MEDBP: maximal exercise diastolic blood pressure; MVIC: maximal voluntary isometric contraction; SpO_2rest: peripheral oxygen saturation at rest; SpO_2peak: SpO_2 at peak exertion; meanSpO_2sleep: mean SpO_2 during sleep; minSpO_2sleep: minimum SpO_2 during sleep; AHI: apnea-hypopnea index; and CRP: C-reactive protein. *$p < 0.05$.

uptake at peak exertion. The protocol included an automatic measurement of blood pressure every 60 s using the technique of impedance plethysmography. To that end, we used a device, calibrated and connected to the cycle ergometer by the manufacturer, with a cuff containing a sensor to determine blood pressure and pulse. Immediately before the end of, or immediately after, the exercise, a measurement was made by manual computer command.

The CRP levels were measured by quantitative immunonephelometry (CardioPhase; Dade Behring, Marburg, Germany), and values below 3 mg/L were considered normal.[24]

The patients were divided into two groups (desaturators and nondesaturators) using the criterion described. Patients with COPD and presenting an apnea-hypopnea index greater than 5 events/hour of sleep were excluded.

The results are expressed as mean ± standard deviation. The Mann-Whitney test was used to compare the groups in terms of SpO_2 during exercise and during sleep. The Student's t-test was used for the other numerical data, and Fisher's exact test was used for nominal variables. The chi-square test was used to compare the groups in terms of CRP levels. Spearman's linear correlation test was used to assess the correlation between the variables related to SpO_2 during sleep and the other relevant variables. In addition, a partial correlation analysis was carried out to determine the degree of influence that significant variables had on a final variable—mean SpO_2 during sleep. The primary outcome measure of the present study was nocturnal oxygen desaturation. Considering a mean incidence of nocturnal oxygen desaturation of 45%,[1] it was estimated that the evaluation of 20 patients (10 in each group)

Table 2 - Mean and minimum peripheral oxygen saturation during sleep: correlations with body mass index, pulmonary function variables, and exercise variables for the sample as a whole, as well as for the desaturator and nondesaturator groups.

Variable	Sample as a whole (n = 21)		Group			
			D (n = 10)		ND (n = 11)	
	$meanSpO_2$sleep	$minSpO_2$sleep	$meanSpO_2$sleep	$minSpO_2$sleep	$meanSpO_2$sleep	$minSpO_2$sleep
BMI (kg/m^2)	r = –0.171	r = –0.105	r = –0.209	r = –0.123	r = –0.221	r = –0.159
	p = 0.458	p = 0.649	p = 0.562	p = 0.735	p = 0.514	p = 0.641
FEV_1 (L)	r = 0.535	r = 0.472	r = 0.560	r = 0.615	r = 0.529	r = 0.424
	p = 0.012*	p = 0.031*	p = 0.092	p = 0.058	p = 0.094	p = 0.193
FEV_1 (% of predicted)	r = 0.435	r = 0.231	r = 0.345	r = 0.462	r = 0.558	r = 0.250
	p = 0.049*	p = 0.314	p = 0.329	p = 0.179	p = 0.075	p = 0.458
VO_2max (% of predicted)	r = 0.304	r = 0.068	r = 0.080	r = –0.031	r = 0.561	r = –0.009
	p = 0.180	p = 0.769	p = 0.826	p = 0.933	p = 0.073	p = 0.978
Wmax (% of predicted)	r = 0.489	r = 0.084	r = 0.351	r = 0.135	r = 0.501	r = 0.233
	p = 0.025*	p = 0.718	p = 0.320	p = 0.709	p = 0.116	p = 0.490
MESBP (mmHg)	r = 0.073	r = 0.000	r = 0.166	r = 0.062	r = –0.221	r = 0.266
	p = 0.754	p = 1.000	p = 0.646	p = 0.866	p = 0.513	p = 0.428
MEDBP (mmHg)	r = –0.449	r = –0.255	r = –0.935	r = –0.695	r = –0.235	r = 0.306
	p = 0.041*	p = 0.266	p = 0.000**	p = 0.026*	p = 0.487	p = 0.360
MVIC (kgf)	r = 0.353	r = 0.259	r = 0.201	r = 0.315	r = 0.518	r = 0.220
	p = 0.116	p = 0.257	p = 0.578	p = 0.376	p = 0.102	p = 0.516
MIP (% of predicted)	r = 0.529	r = 0.551	r = 0.866	r = 0.598	r = 0.308	r = 0.462
	p = 0.014*	p = 0.010*	p = 0.001**	p = 0.068	p = 0.357	p = 0.153
MEP (% of predicted)	r = –0.089	r = 0.191	r = –0.222	r = –0.086	r = 0.083	r = 0.229
	p = 0.701	p = 0.408	p = 0.538	p = 0.813	p = 0.809	p = 0.499

D: desaturators; ND: nondesaturators; $meanSpO_2$sleep: mean peripheral oxygen saturation during sleep; $minSpO_2$sleep: minimum SpO_2 during sleep; BMI: body mass index; FEV_1: forced expiratory volume in one second; VO_2max: maximal oxygen uptake during exercise; Wmax: maximal power during exercise (watts); MESBP: maximal exercise systolic blood pressure; MEDBP: maximal exercise diastolic blood pressure; MVIC: maximal voluntary isometric contraction; MIP: maximal inspiratory pressure; and MEP: maximal expiratory pressure. *$p < 0.05$. **$p < 0.01$.

would allow exploratory associative analyses among the principal variables of interest. Values of $p < 0.05$ were considered statistically significant. The statistical analysis was carried out using the Statistical Package for the Social Sciences, version 13.0 for Windows (SPSS Inc., Chicago, IL, USA).

Results

In the period from May of 2006 to May of 2007, we studied 21 patients—6 (29%) of whom were female—divided into two groups: desaturators and nondesaturators. The anthropometric and demographic data, as well as data on polysomnography results, pulmonary function, and CRP levels, are shown in Table 1, which presents total values and values for each of the two groups.

We found a statistically significant difference between the two groups in terms of minimum SpO_2 during sleep ($p = 0.03$), and the number of patients presenting CRP levels above those considered normal was significantly greater in the desaturator group (Table 1). Values for the exercise variables were, on average, slightly lower in the desaturator group, although the differences were not significant. No significant differences were found between the groups in terms of being a smoker/former smoker or the use/non-use of inhaled corticosteroids (Table 1).

In the sample as a whole ($n = 21$), there was a significant positive correlation between maximal power during exercise (in watts) and mean SpO_2 during sleep ($p = 0.025$). However, this statistical significance did not hold after the partial correlation analysis with PaO_2 at rest as a control variable ($r = 0.219$; $p = 0.354$). The two groups presented minimum SpO_2 during sleep greater than that found at peak exertion (Table 1).

No significant differences were found between the groups in terms of peripheral strength as measured by MVIC ($p = 0.821$; Table 1), and this variable did not correlate with the parameters of nocturnal SpO_2 for the groups separately (Table 2).

Although there was no statistical difference between the groups in terms of mean SpO_2 during sleep, this variable correlated, inversely and closely, with DBP during maximal exercise ($p < 0.001$; $r = -0.935$; Figure 1) and, directly, with maximal inspiratory pressure (MIP; $p = 0.001$; $r = 0.866$; Figure 2) in the desaturator group. Although the correlations with those two variables were significant when we considered the sample as a whole, we found no such correlations when we analyzed the nondesaturator group separately (Table 2).

In the sample as a whole, FEV_1 in liters ($r = 0.535$; $p = 0.012$) and FEV_1 in percentage of predicted ($r = 0.435$; $p = 0.049$) were found to present a close, positive correlation with mean SpO_2 during sleep. In addition, FEV_1 in liters ($r = 0.472$; $p = 0.031$) was found to present a close, positive correlation with minimum SpO_2 during sleep (Table 2).

Discussion

In our study, there were no differences between the two groups in terms of exercise capacity in the cycle ergometer test. There were a significantly greater number of patients with CRP levels above the normal values in the desaturator group, and, in this group, DBP during maximal exercise on the cycle ergometer adjusted, inversely and closely, to mean SpO_2 during sleep.

The effect of nocturnal oxygen desaturation on exercise capacity has previously been studied in patients with OSAS. Some studies have revealed no reduction in aerobic capacity on the cycle ergometer test,[12,13] whereas others have reported a significant reduction.[14,15] One study showed a significant increase in VO_2max after the use of noninvasive support ventilation.[25] However, in those studies,

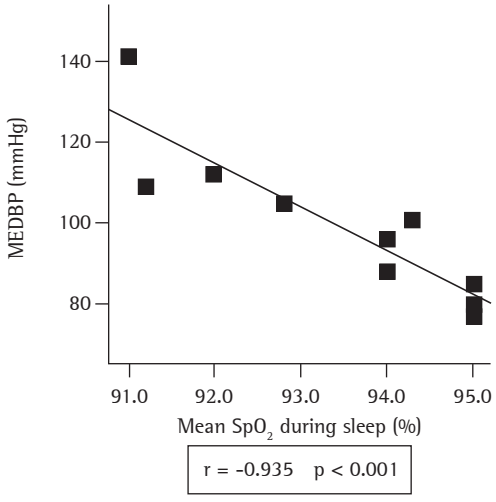

Figure 1 - Correlation between maximal exercise diastolic blood pressure (MEDBP) and mean peripheral oxygen saturation (SpO_2) during sleep.

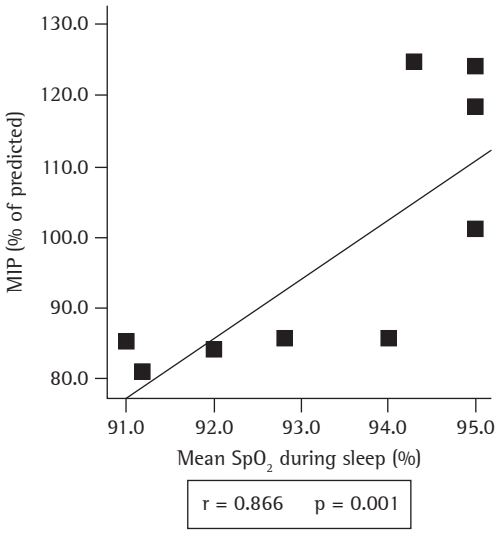

Figure 2 - Correlation between maximal inspiratory pressure (MIP) and mean peripheral oxygen saturation (SpO_2) during sleep.

patients were not studied in terms of peripheral strength or respiratory muscle strength. In addition, the desaturation criterion differs between the two diseases. In patients with OSAS, hypoxemic episodes last 15-45 s, whereas, in patients with COPD, such episodes last for more than 5 min, as in our study.

Patients with COPD have well-known mechanisms of limitations of exercise capacity. In our study, the values of exercise variables were slightly lower, on average, in the desaturator group patients, although there were no significant differences between the two groups. Despite the positive, significant correlation between maximal power and mean SpO_2 during sleep, this significance did not hold after the partial correlation analysis with daytime PaO_2 as a control variable, unlike the close correlation found between VO_2max and minimum SpO_2 during sleep in 12 patients with OSAS.[17]

The desaturation found during maximal exercise in relation to rest was quite low (an average of 1%) compared to the much more significant desaturation during sleep, with a mean 9% drop in SpO_2. It is estimated that cardiovascular stress during sleep can be, in some cases, even more intense than that reached during maximal exercise.[1] Nevertheless, nocturnal oxygen therapy is not indicated as frequently as is oxygen therapy during exercise.[19]

The groups did not differ in terms of peripheral strength as measured by MVIC or strength generated by respiratory muscles, indicating that, on average, the patients in the desaturator group maintain their capacity to generate strength preserved when compared to those in the nondesaturator group. We point out that MIP (% of predicted) correlated with mean SpO_2 during sleep in the sample as a whole and, especially, in the desaturator group, corroborating findings in the literature.[26] It is known, however, that high-intensity training of the respiratory musculature can reduce the depth of nocturnal oxygen desaturation,[27] although this was not the case in our patients.

There were no differences between the groups in terms of maximal exercise systolic blood pressure or DBP during maximal exercise, although the desaturator group presented a good correlation between DBP during maximal exercise and mean SpO_2 during sleep, as has been reported in studies involving patients with OSAS.[15,18] We can speculate that this correlation might be an initial presentation of the systemic arterial hypertension that develops in patients with nocturnal oxygen desaturation, since the autonomic dysfunction in blood pressure control, due to upregulation of the baroreflex controlled by carotid bodies, has been well established in experimental models and clinical studies of OSAS.[11]

Oxidative stress is certainly a factor related to intermittent hypoxemia. Markers of oxidative stress are increased in patients with OSAS, and they decrease after treatment with noninvasive support ventilation.[25]

Another consistent effect of intermittent hypoxemia, associated with oxidative stress, is increased serum levels of biomarkers, such as CRP. The fact that the desaturator group presented a significantly greater number of patients with CRP levels above the normal cut-off value is consistent with studies on OSAS,[16] despite the fact that the groups did not differ in terms of smoking, use of inhaled corticosteroids, or body mass index, all of which are factors that could affect the results. Levels of CRP are of prognostic importance in patients with COPD[28] and correlate statistically with the distance covered on the six-minute walk test,[29] as well as constituting a significant and independent predictor of endurance on the submaximal cycle ergometer test in patients with COPD.[29]

Correlations between individual spirometry variables and mean SpO_2 during sleep have been

established by some authors,[1,30] and, in our case, FEV_1 correlated with mean SpO_2 during sleep. However, the former is not an important predictor of nocturnal hypoxemia in studies.

Among the limiting factors of this study is the fact that fat-free mass, which could better characterize a relationship between exercise capacity and nocturnal hypoxemia, was not measured. Another limiting factor is the desaturation criterion adopted. Although some authors recommend using a 10% drop in saturation or saturation below 90% during more than 30% of total sleep time,[1] we followed the recommendation of Block et al.[22] since this was a study involving patients with mild to moderate COPD, in whom those criteria would rarely be met.

Therefore, we conclude that mild nocturnal hypoxemia does not reduce exercise capacity in patients with mild to moderate COPD. However, its effect on DBP during maximal exercise seems to depend on the intensity of nocturnal oxygen desaturation, and MIP in percentage of predicted correlates with mean SpO_2 during sleep. In addition, there is evidence of greater systemic inflammatory activation (determined by measuring CRP levels) in patients with COPD who present desaturation during sleep.

As a clinical implication, we suggest that patients with mild to moderate COPD be better investigated as to the need for oxygen supplementation during sleep.

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