The Effect of Continuous Positive Airway Pressure on Basal Metabolism Rate in Patients with Severe Obstructive Sleep Apnea Syndrome

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ABSTRACT

Objectives: The aim of this study was to assess the effect of the continuous positive airway pressure (CPAP) treatment on basal metabolism rate in patients with severe obstructive sleep apnea syndrome (OSAS).

Methods: Demographic characteristics, body-mass index (BMI), apnea-hypopnea index (AHI) and smoking history of the patients were recorded. Basal metabolism rate was measured via indirect calorimetry in the morning following the nights of polysomnography and CPAP titration. Basal metabolism rate, VO_2 and VCO_2 levels were compared before and after CPAP administration.

Results: Six (24%) female and 19 (76%) male, totally 25 patients with mean age of 51.4 ± 13.7 years were included into the study. A significant reduction in the basal metabolism rate ($p=0.049$), VO_2 ($p=0.042$) and VCO_2 ($p=0.008$) values were observed after single night administration of CPAP compared to before treatment. Furthermore, it was detected that this reduction provided by CPAP treatment was more significant in current smokers, patients with AHI>60 and BMI ≥ 30.

Conclusion: It is suggested that there is a correlation between basal metabolism rate and the severity of OSAS and it is possible to provide significant reduction in basal metabolism rate with single night administration of CPAP depending on the patient's smoking history, degree of obesity and disease severity.

Keywords: CPAP treatment, basal metabolic rate, OSAS, VO_2, VCO_2

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INTRODUCTION

Obstructive Sleep Apnea Syndrome (OSAS) is a sleep disorder that is characterized by recurrent episodes of complete or partial upper airway collapse during sleep in the presence of breathing effort. These episodes are associated with recurrent oxyhemoglobin desaturation (1). OSAS is an independent risk factor for the development of several comorbid conditions especially cardiovascular and metabolic disorders. Basal metabolism rate (BMR) is defined as the energy consumption required maintaining body functions and metabolic activities. Previous studies have shown significantly higher energy consumption in patients with OSAS compared to healthy subjects (2). Undesirable outcomes of high BMR include fatigue, tachycardia, arrhythmia, dyspnea, insomnia, muscle weakness and mortality (3).

OSAS should be approached as chronic disease requiring multi-disciplinary management. In spite of there are medical, surgical, behavioral and adjunctive treatment strategies, the positive airway pressure (PAP) is preferred treatment option (4). Alternative treatments may be considered with respect to patient's anatomy, risk factors and disease severity. The primary goal of the PAP treatment is to normalize apnea hypopnea index and improve sleep quality therefore prevent the unfavorable outcomes of hypoxemia and hypercapnia occurred during sleep. Previous studies were presented that PAP treatment was associated with significant reductions in cerebrovascular and cardiac adverse events in patients with OSAS (5,6). However, it is not clear whether it has beneficial effects on increased basal metabolism rate. The aim of this study is to evaluate the effects of short-term CPAP treatment on basal metabolism rate in patient with severe OSAS.

MATERIAL AND METHOD

Thirty patients admitted to our outpatient clinic with the symptoms of snoring, excessive daytime sleepiness and witnessed apneas and who will undergo polysomnography in order to diagnose OSAS were included in the study. In the morning of polysomnography night, basal metabolism rate was measured via indirect calorimetry. Five patients who were diagnosed as mild and moderate OSAS according to polysomnography were excluded from the study. The basal metabolism rate was re-measured in remaining twenty five patients with severe OSAS in the morning of the CPAP titration night and the effect of single night CPAP application on basal metabolism rate was evaluated.

Demographic characteristics of the patients including smoking history, co-morbid conditions, body-mass index (BMI), apnea-hypopnea index (AHI) and regularly used medications were recorded.

Polysomnography records were performed with Compumedics E series system by hospitalizing the patients for one night (between 11.00 PM and 08.00 AM) in the Sleep Disorders Center of our department. In polysomnography, electro-encephalography, electromyography of jaw and legs, respiratory movement of chest and abdomen, body position, airflow of oronasal cannula were recorded. Fingertip pulse oximeter was used to monitor oxygen saturation and snoring was recorded through tracheal microphone placed on the neck. The number of both apneas and hypopneas per sleep hour were defined as apnea-hypopnea index. According to AHI, the patients were evaluated as mild (AHI=5 to 15), moderate (AHI=15 to 30) and severe OSAS (AHI $\geq$ 30). The assessment of the sleep

records were done by an experienced sleep laboratory specialist. CPAP titration was performed the patients in whom diagnosis of OSAS was established and CPAP treatment was planned. CPAP titration was done through automatic-CPAP (DEVILBISS respironics, USA) within the values that have been found convenient by the clinician.

Basal metabolism rate was measured through indirect calorimetry instrument (N Spire ZAN 600 Ergospirometry) assessing respiratory gas exchange. It was performed after at least eight-hour night sleep when the patients were awake, hungry and in supine position by keeping room temperature constant in 22 to 24 ^{0}C.

The study was approved by the local ethical committee of Faculty of Medicine of Kocaeli University (Approval Date of Ethical Committee and Project Number: July 10, 2012 and 2012/55) and all patients were given written informed consent.

Statistical Analysis

SPSS (Statistical Package for Social Sciences) Ver. 13.0 software package was used in the statistical analysis of data. Categorical measurements were summarized as number and percent and numeric measurements were summarized as mean and standard deviation (median and minimum-maximum when necessary). Shapiro-Wilk test was used to examine whether data fit to normal distribution. In the comparison of values before and after PAP treatment, significance test of the difference between two pairs (test in dependent groups) were applied. Statistical significance level was taken as $p<0.05$ in all tests.

RESULTS

Overall, twenty five patients; six female (24%) and nineteen male (76%), with a mean age of 51.4 ± 13.7 years were included in the study. Mean BMI of the patients was 34.06 ± 6.02 (min: 24.6, max: 48.4) and mean AHI was 60.76 ± 15.03 (min: 44, max: 90). Before and after treatment values of BMR VO_2 and VCO_2 of study population were shown in Figure 1,2, 3 respectively.

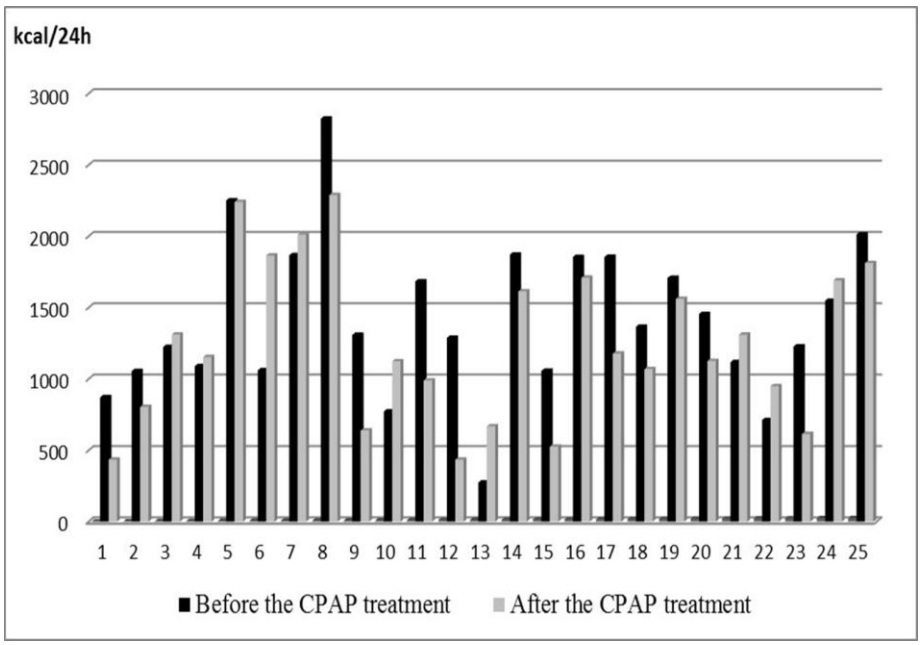

Fig.1: BMR levels of each patient before and after the CPAP treatment

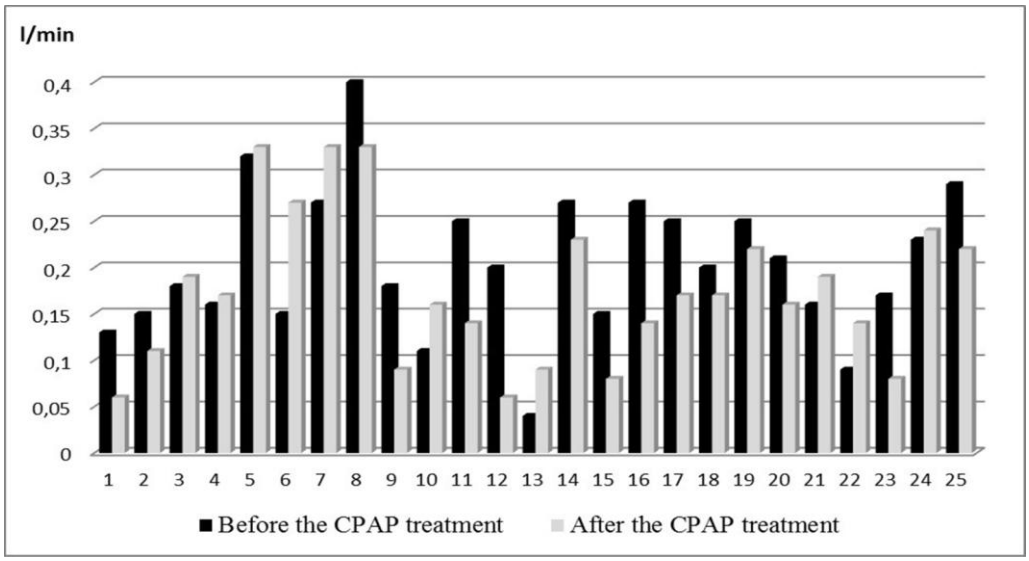

Fig.2: VO_2 levels of the patients before and after the CPAP treatment

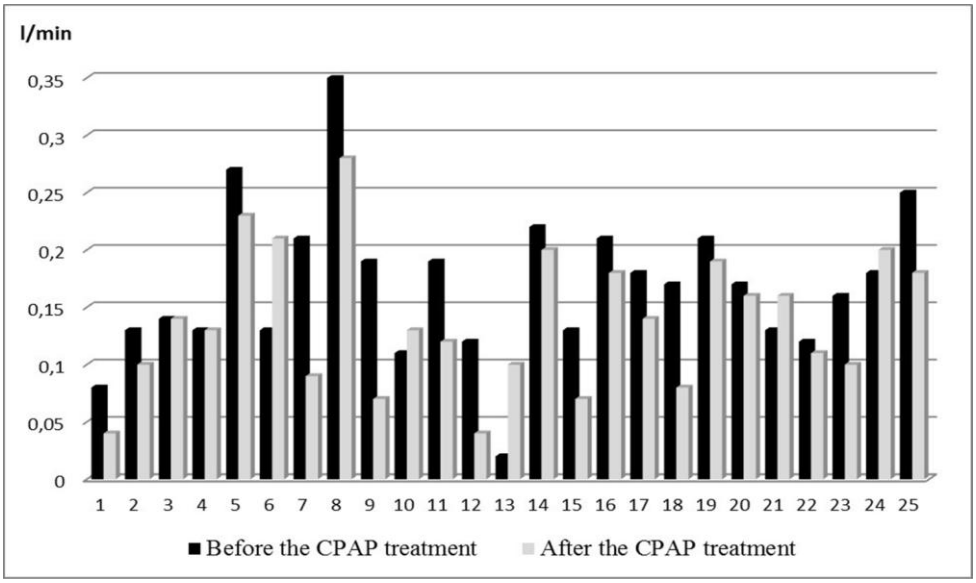

Fig.3: VCO_2 levels of the patients before and after the CPAP treatment

There were ten non-smokers (40%) and fifteen current smokers (60%) in the study population and mean AHI index of smokers was significantly higher than non-smokers (61.5 ± 5.13 vs. 51.6 ± 6.03, $p<0.05$).

It was found that values of basal metabolism rate, VO_2 and VCO_2 after CPAP administration were significantly lower compared to before treatment evaluation ($p=0.049$, 0.042 and 0.008 respectively) regarding all study population (Table-1).

Table 1: The effect of CPAP treatment on BMR, VO_2 and VCO_2

	Before CPAP treatment	**After CPAP treatment**	**p**
BMR (kcal/24h)	1414.35±547.7	1245.12± 554.47	**0.049**
VO_2 (l/min)	0.20±0.08	0.17±0.08	**0.042**
VCO_2 (l/min)	0.17±0.07	0.14±0.06	**0.008**

We compared before and after treatment values of patients with BMI $\geq$ 30 kg/m^2 and < 30 kg/m^2 in order to evaluate the possible effects of BMI on basal metabolism rate and found significant association between these parameters. CPAP treatment for one night was significantly reduced BMR, VO_2 and VCO_2 values in those with BMI $\geq$30 kg/m^2

(p=0.001; p=0.001; p=0.001 respectively). In those with BMI<30 kg/m^2, a slight increase was observed, however this increase was not statistically significant (Table-2).

Table 2: The effect of CPAP treatment on BMH, VO_2 and VCO_2 according to BMI

	BMI	Before CPAP treatment	After CPAP treatment	p
BMR	< 30	1266.16 ± 554.95	1450.08±485.16	0.08
(kcal/24h)	≥30	1513.14±538.63	1108.47±570.69	< **0.001**
VO_2	< 30	0.18± 0.07	0.21±0.07	0.06
(l/min)	≥30	0.21±0.07	0.14±0.07	< **0.001**
VCO_2	<30	0.14±0.06	0.15±0.04	0.75
(l/min)	≥30	0.18±0.06	0.12±0.06	< **0.001**

When the relationship between smoking history and the effect of CPAP treatment on BMR was investigated; it was found that single night of CPAP administration reduced basal metabolism rate (p=0.001), VO_2 (p=0.004) and VCO_2 (p=0.001) values in statistically significant level in current smokers. Although BMR, VO_2 and VCO_2 values of non-smokers were decreased with CPAP administration compared to before treatment, this reduction reached statistically significance level only in VO_2 value (p=0.039) (Table-3).

Table 3: The effect of CPAP treatment on BMH, VO_2 and VCO_2 according to smoking history

	Smoking history	Before CPAP treatment	After CPAP treatment	p
BMR	(+)	1574.76 ± 532.95	1328.24 ± 643.26	**0.001**
(kcal/24h)	(-)	1173.74 ± 500.91	1120.43±383.88	0.05
VO_2	(+)	0.23 ± 0.07	0.18 ± 0.09	**0.004**
(l/min)	(-)	0.17 ± 0.07	0.17 ± 0.06	0.039
VCO_2	(+)	0.19 ± 0.07	0.15 ± 0.07	**0.001**
(l/min)	(-)	0.14 ± 0.05	0.12 ± 0.03	0.98

Similar association was also observed in patients with higher AHI (>60) compared to patients with AHI lower than this level. Single night of CPAP administration achieved significant reduction in BMR (p=0.00), VO_2 (p=0.014) and VCO_2 (p<0.001) values in patients with AHI greater than 60 while the decrease was not statistically significant in all study parameters in patients with AHI lower than 60 (Table-4).

Table 4: The effect of CPAP treatment on BMH, VO_2 and VCO_2 according to apnea-hypopnea index

	AHI	Before CPAP treatment	After CPAP treatment	p
BMR	≤60	1326.39 ± 518.41	1288.45 ± 474.57	0.74
(kcal/24h)	>60	1526.3 ± 588.19	1189.96 ± 662.63	**0.008**
VO_2	≤60	0.19 ± 0.07	0.18 ± 0.06	0.73
(l/min)	>60	0.21 ± 0.08	0.16 ± 0.09	**0.014**
VCO_2	≤60	0.15 ± 0.05	0.15 ± 0.04	0.77
(l/min)	>60	0.18 ± 0.07	0.12 ± 0.07	**< 0.001**

DISCUSSION

This study demonstrated that CPAP administration for one night reduced basal metabolism rate, VO_2 and VCO_2 levels in patients with severe OSAS and this reduction was especially remarkable in current smokers, patients with AHI level greater than 60 and BMI greater than 30.

OSAS is an independent risk factor for the development of several comorbid conditions especially cardiovascular and metabolic disorders. Previous studies investigated the exercise metabolism in patients with OSAS demonstrated that VO_2max (maximum

oxygen consumption) levels of those with OSAS were lower compared to control group (7). However, studies investigating the effects of CPAP treatment in VO_2max level reported incompatible results (8,9). These different results might be related to patient's comorbid diseases, drug usage and severity of OSAS. Even though there are few studies investigating the relationship between OSAS and basal metabolism rate, it was demonstrated that basal metabolism rate was higher in patients with OSAS (2,10,11). This study suggested that this unfavorable outcome of OSAS occurred in basal energy metabolism might be improved with CPAP treatment and showed significant reductions in basal metabolism rates with one night administration of CPAP.

Basal metabolism rate is the amount of the required energy consumption in order to maintain body functions and metabolic activities. Total energy consumptions of the individuals consist of three parts. The first of these is the basal metabolism rate and this constitutes approximately 70% of total daily energy consumption; the second part is the energy consumption related to physical activity and this is approximately in 20%-ratio and the last part is the thermal effect formed by the foods and this constitutes 10% of the general consumption (12). Many factors such as physical activity, thermogenesis depending on diet, gender, age, height, weight, heredity, race, sleep, body temperature, environment temperature, sympathetic stimulation, thyroid and growth hormones and pregnancy can be counted as parameters affecting basal metabolism rate . In our study; environmental factors were minimized by performing basal metabolism rate measurements of the patients following the twelve-hour hunger between 08.30 AM and 10.30 AM, in a silent room

having 22^0C to 24^0C-medium temperature, furthermore, pregnant females and those with thyroid disease were not included into the study.

The most valuable tool to measure basal metabolism rate is indirect calorimetry. Indirect calorimetry determines basal metabolism rate by measuring oxygen consumption and carbohydrate production. Since it measures caloric burning rate with oxygen intake it is referred as indirect (13). In our study, basal metabolism rates of the patients were measured through indirect calorimetry methods by ensuring optimum conditions. Studies conducted in either animals or humans have demonstrated that experimental interruption of sleep is related with increasing energy expenditure (14,15). Repetitive apnea and hypopnea episodes in patients with OSAS not only disrupt normal respiration but also increase energy consumption (11). Ryan et al have found higher energy consumption in patients with OSAS compared to control group (2). Similarly, Stenlof et al have reported that patients with OSAS spent higher energy compared to control group and that energy expenditure was reduced following CPAP treatment for three months (10). In our study, acute response of CPAP treatment has been evaluated and found that CPAP treatment reduced basal metabolism rate.

Male gender predominance is well-known demographic feature in OSAS patients. Bixler et al have found male/female ratio as 3.3/1 in patients with sleep apnea (16). In a study conducted by Young et al, prevalence was detected as 2% in females and as 4% in males (17). In our study, male/female ratio was 3/1. Basal metabolism rate in males was significantly higher than females in this study. However, since the number of female patients was low, statistical comparison could not be performed. No difference was

observed between genders in terms of the effect of CPAP treatment on basal metabolism rate.

It is suggested that smoking is a risk factor in the development of apnea by causing nasal congestion (18). Wetter et al. studied the relationship between respiratory disorders in sleep and smoking in 811 cases and they found that the prevalence of simple snoring and sleep-related respiratory disorders were significantly higher in smokers (19). Kashyap et al were compared 108 OSAS patients with AHI greater than 10 with 106 of simple snoring patients with AHI less than 5 and found that smoking prevalence was higher in OSAS group (20). In our study 60% of the patients were current smokers and it was seen that AHI values of smokers were higher than non-smokers. Furthermore, it was observed that basal metabolism rate was higher in smokers and that the reduction in basal metabolism rate was more significant in these patients after CPAP treatment.

The relationship between obesity and OSAS has been demonstrated in many studies. Wolk et al has been reported that 70% of OSAS patients were obese and 40% of obese people have OSAS. Moreover, it has been reported that 10% of gaining weight was associated with six-fold increase in the risk for sleep apnea development. Since night sleepless seen in OSAS will reduce daytime physical activity, it has been stated that OSAS has an important effect on increasing obesity (21). In our study, BMI≥30 was found in 60% of the patients. When the relationship between basal metabolism rate and BMI was studied, a statistically significant reduction was observed in basal metabolism rate after CPAP treatment in patients with BMI≥30. On the other hand, in patients with BMI<30; even though it was not statistically significant, an elevation in basal metabolism rate was seen

after CPAP treatment. This finding suggested that since the effect of OSAS on basal metabolism rate was more prominent in patients with BMI greater than 30, beneficial effect of CPAP treatment was more significant in these patients.

Basal metabolism rate was also shown to be correlated with severity of OSAS evaluated by AHI (22). In this study, basal metabolism rate of the patients with AHI>60 was higher compared with those having AHI<60. Furthermore, a statistically significant reduction was observed in basal metabolism rate of the patients with AHI>60 following CPAP treatment. Similarly, significant beneficial effect of CPAP treatment on basal metabolism rate was not noted in patients with AHI of lower than 60.

The limitations of this study were the limited number of patients, the inhomogeneity of the gender distribution and evaluating only one-night effect of CPAP on basal metabolism rate.

In conclusion, it is suggested that there is a correlation between basal metabolism rate and the severity of OSAS and it is possible to provide significant reduction in basal metabolism rate with single night administration of CPAP depending on the patient's smoking history, degree of obesity and disease severity. Future studies including more patients are required in order to determine long-term outcomes of high basal metabolism rate observed in patients with OSAS and possible beneficial effects of CPAP treatment.

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