THE EFFECT OF BILEVEL POSITIVE AIRWAY PRESSURE THERAPY ON BASAL METABOLIC RATE IN PATIENTS WITH OBESITY HYPOVENTILATION SYNDROME

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ABSTRACT

Introduction: Obesity hypoventilation syndrome (OHS) is one of the respiratory diseases associated with obesity. The aim of this study is to determine the effect of one night of bi-level positive airway pressure (BPAP) treatment on the basal metabolic rate (BMR) of OHS patients.

Materials and methods: The BMR of OHS patients who were newly diagnosed and hospitalized for BPAP treatment was measured with indirect calorimetry before and after one night (at least 8 hours) BPAP treatment. Additionally association between BMR and parameters such as gender, smoking, body-mass index (BMI), oxygen consumption (VO2) and carbon dioxide production (VCO2) were assessed.

Results: Twenty newly diagnosed OHS patients were included in the study. A statistically significant difference in BMR and VO2 levels were observed after one night of BPAP treatment (p=0.01 and p=0.02, respectively). There was no statistically significant relationship between the reduction in BMR and gender, smoking and BMI. Lower VCO2 levels were measured after the BPAP treatment but there was no statistical significance.

Conclusion: Even short term use of BPAP treatment in patients with OHS may reduce the BMR by improving pulmonary mechanics and respiratory muscle capacity and reducing breathing effort. Longer studies with more patients are needed to evaluate both short and long term effect of BPAP treatment on BMR.

Keywords: Basal metabolic rate, Obesity hypoventilation syndrome, Bi-level positive airway pressure.

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Introduction

Obesity hypoventilation syndrome (OHS) is a condition characterized by the triad of obesity [body mass index (BMI) > 30 kg/m²], awake arterial hypercapnia (PaCO₂>45 mmHg) and sleep hypoventilation during sleep in the absence of other causes of hypoventilation include neurological, muscular, mechanical or metabolic disease. In order to confirm the diagnosis of OHS, other causes of hypercapnia such as obstructive airway disease, interstitial lung disease, chest wall and neuromuscular disease are also ruled out. The etiopathogenesis of the disease is not clearly understood. The commonly accepted hypothesis in the etiopathogenesis is that the disease develops as a result of an abnormally increased mechanical respiratory load, blunted central respiratory drive, sleep-disordered breathing. Hypoxia and hypercapnia resulting from these mechanisms lead to a number of adverse effects on many systems, particularly the cardiovascular system.
Low quality of life, high health expenditure and comorbidities such as pulmonary hypertension, right sided heart failure, angina and insulin resistance are common.

Basal energy metabolism is also negatively affected in patients with OHS. Total daily energy consumption of individuals consists of three main sections. The first of these is the basal resting energy expenditure which accounts for approximately 70% of the total daily energy consumption. Resting energy expenditure is the energy required to maintain the vital functions during the rest and keep the cells alive. Indirect calorimetry is the most important method to measure the basal resting energy consumption. Baseline energy consumption is determined by measuring oxygen consumption (VO$_2$) and carbon dioxide production (VCO$_2$). Parameters affecting the metabolic energy consumption rate are listed as physical activity, sex, age, height, weight, heredity, race, body temperature, climate, thyroid and growth hormones, sex hormones and pregnancy.

Although resting energy consumption depends on lean body mass, basal energy needs increase in obese patients because of a high work required for breathing. The amount of oxygen consumed for respiration increases about 10-fold in patients with OHS compared to healthy individuals.

First line treatment of the OHS is nocturnal bi-level positive airway pressure (BPAP) therapy. The primary goals of the BPAP treatment are to improve both hypoxemia and hypercapnia and to decrease respiratory workload. It is thought that decreased respiratory workload might be related with decreased energy consumption for basal metabolism. However, there are limited studies evaluating the relation between PAP treatment and basal metabolism rate and 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 BPAP treatment on basal metabolism rate in patients with OHS.

Materials and methods

20 patients who were newly diagnosed with OHS according to daytime hypercapnia and hypoxemia (PaCO$_2$ >45 mmHg and PaO$_2$ <70 mmHg at sea level) in an obese patient (BMI >30 kg/m$^2$) with sleep-disordered breathing in the absence of any other cause of hypoventilation and who volunteered to participate in the study were included in this prospective study. Patients with acute decompensated OHS, chronic renal diseases, chronic hepatic diseases, hypo-hyperthyroidism, psychological and neurological diseases were excluded from the study. In addition, patients under 18 years old and with condition that hinder the PAP therapy such as facial deformities, jaw deformities, enlarged tongue, growths in the head or neck, nasopharyngeal anatomic abnormalities etc. were excluded. Demographic characteristics of the patients including smoking history, co-morbid conditions, BMI and regularly used medications were recorded.

Basal metabolic rate (BMR) was measured after at least 8 hours of fasting, comfortable night's sleep without exercise and at least half an hour of rest. Inspiratory (IPAP) and expiratory (EPAP) pressures were determined by saturation monitoring with pulse oximetry (SpO$_2$ > 90%) and arterial blood gas analysis during the day. PAP treatment was performed overnight. BPAP vision device (Respironics Inc., PA, USA) and Performa Trak face mask (Respironics Inc., PA, USA) were used for PAP therapy. BMR was measured through indirect calorimetry instrument (N Spire ZAN 600 Ergospirometry) assessing respiratory gas exchange before and after PAP treatment. It was performed after at least an eight-hour night sleep when the patients were awake, hungry and in the supine position by keeping room temperature constant between 22 to 24 °C. VO$_2$ and VCO$_2$ were measured and BMR was calculated.

The study was approved by the local ethical committee of Faculty of Medicine of Kocaeli University (Approval Date of Ethical Committee and Project Number: 2012/54) and written informed consent was obtained from all patients.

Statistical analysis

Statistical Package for Social Sciences (SPSS) 13.0 (SPSS Inc., Chicago, IL, USA) was used in the statistical analysis of data. Categorical measurements were summarized as number and percentage and numeric measurements were summarized as mean and standard deviation (median and minimum-maximum when necessary). The Pearson chi-square test was used for the analysis of association between categorical variables. The student t test was used in the case of normal distribution, and the Mann-Whitney U test was used in the case of non-normal distribution. A p value <0.05 was considered as statistically significant.
Results

In the current study, the mean age of the patients was 57.9±12.5 years. The study included 11 (55%) women and 9 (45%) men. Mean BMI of the patients was 51.2±9.2 kg/m². Thirty percent of the patients were active smokers.

After BPAP therapy for patients, statistically significant differences were observed in BMR compared to pre-treatment (1484.5±583.5 vs 1079.4±620.9 kcal/24h, p = 0.01). VO₂ levels were significantly lower after BPAP therapy compared to pre-treatment (0.27±0.10 vs 0.22±0.17 lt/min., p= 0.02). No significant difference was observed in VCO₂ values before and after therapy. Before and after treatment values of BMR, VO₂ and VCO₂ of the study population were shown in Table 1.

<table>
<thead>
<tr>
<th></th>
<th>Before BPAP treatment</th>
<th>After BPAP treatment</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BMR (kcal/24 h)</strong></td>
<td>1484.5±583.5</td>
<td>1079.4±620.9</td>
<td>0.01*</td>
</tr>
<tr>
<td><strong>VO₂ (lt/min)</strong></td>
<td>0.27±0.10</td>
<td>0.22±0.17</td>
<td>0.02*</td>
</tr>
<tr>
<td><strong>VCO₂ (lt/min)</strong></td>
<td>0.20±0.09</td>
<td>0.18±0.15</td>
<td>0.16</td>
</tr>
</tbody>
</table>

Table 1: Baseline and post-treatment levels of BMR, VO₂ and VCO₂

When evaluating the parameters of BMR, VO₂ and VCO₂ according to smoking status, there was no statistically difference.

<table>
<thead>
<tr>
<th></th>
<th>Gender</th>
<th>Before BPAP treatment</th>
<th>After BPAP treatment</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BMR(kcal/24h)</strong></td>
<td>Male</td>
<td>1600.8±669</td>
<td>1206.0±765</td>
<td>0.14</td>
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<tr>
<td></td>
<td>Female</td>
<td>1389.3±516</td>
<td>975.8±487</td>
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<tr>
<td><strong>VO₂ (lt/min)</strong></td>
<td>Male</td>
<td>0.28±0.11</td>
<td>0.26±0.24</td>
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<tr>
<td></td>
<td>Female</td>
<td>0.26±0.09</td>
<td>0.18±0.09</td>
<td>0.03*</td>
</tr>
<tr>
<td><strong>VCO₂ (lt/min)</strong></td>
<td>Male</td>
<td>0.20±0.10</td>
<td>0.21±0.21</td>
<td>0.82</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>0.20±0.10</td>
<td>0.15±0.07</td>
<td>0.23</td>
</tr>
</tbody>
</table>

Table 2: Baseline and post-treatment levels of BMR, VO₂ and VCO₂ according to gender.

Discussion

In the current study, PAP administration for one night reduced BMR and VO₂. Only VO₂ levels in females and in patients with BMI greater than 50 kg/m² were significantly decreased with PAP treatment. Short-term treatment with PAP might be reduce breathing effort required in patients with OHS.

Pulmonary mechanics and respiratory muscle capacity are strongly influenced by obesity. OHS is one of the respiratory diseases associated with obesity. Appearance of awake hypercapnia due to the alveolar hypoventilation is a part of the basic definition of OHS. At least 10 mmHg increase in PaCO₂ during sleep is an important finding to support the diagnosis. However, sleep hypoventilation without awake hypercapnia is not sufficient for the diagnosis.
Other diseases that cause hypoventilation such as obstructive pulmonary disease, severe restrictive lung disease, severe chest wall deformity, neuromuscular diseases and metabolic diseases need to be excluded\(^{[6, 10]}\). If left untreated, OHS can lead to impaired quality of life, pulmonary hypertension, right sided heart failure, angina, and insulin resistance. Positive airway pressure (PAP) therapy, weight loss and rehabilitation program are used for treatment\(^{[6, 11]}\).

BMR is greater in people with obesity compared to non-obese. Obese patients make an extra effort to breathe and expend extra energy for breathing that contributes to the increase in BMR. An indirect calorimeter is the most valuable tool to measure the BMR which is calculated by using the oxygen consumption and carbon dioxide production\(^{[12, 13, 14, 15, 16, 17]}\). In a study carried out by Sharp et al., it was showed that total lung compliance was significantly reduced and breathing effort was increased in patient with OHS\(^{[18]}\). There are many studies carried out to describe the effects of PAP treatment in patients with OHS. Perez De Llano et al. reported that CO\(_2\) levels and breathing effort were shown to be markedly reduced in patients with OHS when treated with PAP for 24 hours\(^{[19]}\).

In another prospective, randomized study, which investigated the CO\(_2\) levels in OHS, CO\(_2\) levels were significantly decreased after PAP treatment\(^{[20]}\). Priou et al. similarly demonstrated that arterial blood gases and sleep quality were improved after 6 months of PAP. These findings support that both short-term and long-term treatment with PAP reduce the breathing effort in patients with OHS. In the present study, when BMR is examined, a significant reduction in BMR was observed in patients with OHS.

Although there is a sufficient number of studies evaluating the BMR in obese patients, a limited number of studies evaluating the relationship between BMR and PAP therapy in patients with obesity is available in the literature. In a study by Kress et al. including patients with OHS showed that VO\(_2\) was used to calculate BMR, was found to be higher in OHS groups compared to control. There was no difference in VO\(_2\) levels between spontaneous respiration and PAP treatment in control groups. However, VO\(_2\) levels in obese patients was decreased by 16% with PAP treatment compared to controls\(^{[21]}\). In the current study, VO\(_2\) and BMR decreased significantly compared to the baseline values after one night of PAP treatment. However, there were no differences in VCO\(_2\) values. This is explained by the limited number of patients and the implementation of short-term PAP therapy.

Obstructive sleep apnea syndrome (OSAS) is associated with OHS and the prevalence of OHS in OSAS is approximately 30%. The energy expended for breathing increases in patients with OSAS in the same way\(^{[22, 23, 24, 25]}\). In a study including patients with obesity, BMR in OSAS group was found to be higher compared to control groups with similar BMI\(^{[3]}\). Ryan et al. similarly reported that a higher BMR in patients with OSAS was detected\(^{[26]}\). In another study by Stenölf et al., it was stated that patients with OSAS had higher 24 hour energy expenditure and BMR compared to controls and after 3 months treatment with PAP, 24 hour energy expenditure and BMR decreased significantly\(^{[27]}\). In both this study and likewise in the present study, PAP have been shown to decrease respiratory energy consumption.

In conclusion, in the study conducted, a significant decrease in the BMR of the patients with OHS was shown with short-term treatment. Pulmonary mechanics and respiratory muscle capacity might be improved and breathing effort might be reduced with PAP treatment in patients with OHS. Designing new studies including more patients as well as an extended period of treatment should be used in the future. This would be valuable in determining the possible beneficial effects of PAP treatment.

References

The effect of bilevel positive airway pressure therapy on basal metabolic rate in patients with obesity hypoventilation syndrome


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