Does Pulmonary Function Differ by Time of Day?

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Abstract

Researchers have suggested that pulmonary function may vary by time of day, but other studies have shown contradictory results. The purpose of this investigation was to determine if pulmonary ventilation in college age subjects exhibited a circadian rhythm. The lung function of 31 male and female college students between the ages of 18 to 26 years without any lung dysfunction was tested. A Spiropet Spirometer was used to measure forced vital capacity (FVC) in the morning (0700hr-0800hr), and in the afternoon (1600hr-1700hr) in the same week. Three measurements were taken during each testing period, and the mean was used as the subjects’ FVC. The FVC and gender differences were analyzed statistically using repeated measure ANOVA and independent t-test. Significant differences (p<0.001) were observed between male and female forced vital capacities. There were no significant differences in forced vital capacity observed within subjects tested in the morning and evening. This study determined vital capacity of normal individuals did not differ significantly; therefore large variations in vital capacity may be used as an indicator of disease.

Introduction

Pulmonary function tests assess the effectiveness of ventilatory muscles to move air in and out of the lung. Measuring the resistance to pulmonary airflow provides a pattern of gas movement that may indicate disease (Clausen and Zarens 1982). Previous studies on pulmonary function have concluded that ventilatory efficiency as well as peak oxygen uptake is dependant upon age, sex, race, gender, body size, and height (Habedank et al.1998). Burioka et al. (1999) suggested that lung diffusion capacity was related to gas exchange between alveolar air and erythrocytes in alveolar capillaries. They determined that it was influenced by the diffusion distance, the surface area of the lung and the size of the capillary bed in the lung, the pulmonary capillary blood volume, the hemoglobin content of erythrocytes, and the unequal amounts of air that reach the blood.

Researchers have suggested that pulmonary function may vary by time of day, but other studies have shown little or no effect. Burioka et al. (1999) examined 13 healthy men (31.5 ±4.3 years), without any cardiopulmonary disease and determined that lung
diffusing capacity for carbon monoxide did not exhibit a circadian rhythm, but that alveolar volume peaked in the morning hours. Other investigators showed that the peak expiratory flow, a measure of ventilatory capacity and a value related to forced vital capacity, did follow a circadian rhythm with the highest values being observed late afternoon, and lowest values at night or early morning (van Aalderen et al. 1993, Jindal et al. 2002). Calhoun (2003) stated that lung function in a healthy individual varied in a circadian rhythm, with peak lung function occurring near the 1600 hour and minimal lung function at the 0400 hour. A study conducted by Aguilar et al. (1996) reported that there was no significant daytime variance in maximum expiratory and inspiratory pressures, values which measure the maximum respiratory muscle force developed by all respiratory muscles.

Jindal et al. (2002) suggested that diurnal variability in peak expiratory flow (PEF) was more exaggerated in patients with asthma. A study on the pathophysiology of asthma conducted by Silkoff and Martin (1998) concluded asthma attacks showed a pronounced circadian variation with the majority of patients experiencing increased symptoms at night. Calhoun (2003) described an episode of nocturnal asthma as an exaggeration in normal variation in lung function from daytime to nighttime, with diurnal changes in pulmonary function of >15%. Jindal et al. (2002) suggested that diurnal variability of PEF was perhaps one of the most important causes of concern for a clinician. The purpose of this investigation was to determine if pulmonary ventilation in college age subjects exhibited a circadian rhythm.
Materials and Methods

After approval from the Brigham Young University Hawaii Human Subjects Committee, the lung function of 31 normal individuals (16 males, 15 females) lacking any lung dysfunction (such as asthma or emphysema) was tested. The test subjects chosen were college students, male or female between the ages of 18 to 26 years. A questionnaire was filled out by each subject to ensure that he/she was healthy (having no current symptoms of illness), not currently taking medications, and had not suffered from a lung disorder prior to testing. A Spiropet Spirometer was used to measure forced vital capacity (FVC) in the morning (0700hr-0800hr), and in the afternoon (1600hr-1700hr) in the same week. During testing the subjects were asked to stand erect, keeping the Spiropet horizontal. Subjects were asked to inhale maximally, and then promptly exhale into the spirometer as quickly and with the greatest force possible. Lips were securely sealed around the mouthpiece of the Spiropet to avoid a loss of air into the surrounding environment. A nose clip was used to ensure expired air was not lost through the nasal passages. Three measurements were taken during each testing period, and the mean was used as the subjects’ FVC. The coefficient of variation of the spirometer was measured. The FVC and gender differences were analyzed statistically using repeated measure ANOVA and independent t-test.
Results

The coefficient of variation of the spirometer used in this study was 2.3%. A value below 5% is considered reliable. Significant differences (p<0.001) were observed between male and female forced vital capacities. A mean of 2957.78 ml was observed for females and a mean of 4023.96 ml was observed for males tested in the morning. Mean values for females and males tested in the afternoon were 2999.99 and 4016.67 respectively (Fig.1).

![Figure 1: The mean forced vital capacity (FVC) between males and females tested during morning and afternoon hours. * = p < 0.001](image)

Figure 2 shows the mean forced vital capacity of all subjects tested. There were no significant differences in forced vital capacity observed within all subjects tested in the morning and afternoon (Fig. 2, Table 1).
Figure 2: The forced vital capacity of all subjects in the morning and in the afternoon.

The mean forced vital capacity within female subjects did not change significantly from the morning to afternoon; nor did the FVC change within male subjects (Table 1).

Table 1: The forced vital capacity averages (± S.D.) and p-Values for: all subjects, females alone, and males alone.

<table>
<thead>
<tr>
<th>Subjects Combined</th>
<th>Morning (mean)</th>
<th>Afternoon (mean)</th>
<th>p-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>FVC (cc)</td>
<td>3528.49 (±831.04)</td>
<td>3494.09 (±847.63)</td>
<td>0.5007</td>
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</table>

<table>
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<tr>
<th>Females</th>
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</thead>
<tbody>
<tr>
<td>FVC (cc)</td>
<td>2957.78 (±762.41)</td>
<td>2999.99 (±753.01)</td>
<td>0.5124</td>
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</table>

<table>
<thead>
<tr>
<th>Males</th>
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<tbody>
<tr>
<td>FVC (cc)</td>
<td>4023.96 (±557.57)</td>
<td>3996.88 (±580.66)</td>
<td>0.7399</td>
</tr>
</tbody>
</table>
Discussion

The significant differences found between the forced vital capacities of males and females, indicate gender differences with respect to the ability to force air out of the lungs. These differences are primarily due to size of the thoracic cavity and strength of the intercostal muscles.

These data indicate forced vital capacity does not follow a circadian rhythm in healthy college age persons, therefore the results are consistent with the findings of Aguilar et al. (1996) who observed no significant daytime variance in maximum expiratory and inspiratory pressures. Although there were differences individually among subjects, this variation was inconsistent and not significant. This study differs from those of Burioka et al. (1999) and van Aalderen et al. (1993) by focusing on vital capacity a pulmonary value more related to total air movement than peak expiratory flow which measures only exhalation.

The study of Calhoun (2003) emphasized the importance of considering patterns of ventilatory efficiency in diagnosing respiratory problems. This study determined vital capacity of normal individuals did not differ significantly; therefore large variations in vital capacity may be used as an indicator of disease. These findings suggest that if pulmonary disease exists in patients, differences in pulmonary function may occur diurnally. Although the focus of this study was not to evaluate lung capacity changes in individuals with pulmonary disease, the results contribute to the potential of using daily fluctuations in vital capacity to gauge lung dysfunction.
Acknowledgements

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References


