Original Article

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Physiology Section

Effect of Recumbent Body Positions on Dynamic Lung Function Parameters in Healthy Young Subjects

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ABSTRACT

Introduction: The change in body position can alter pulmonary functions parameters, therefore it is important to understand the physiological basis of these alteration. Ideally, spirometry is done in sitting position until the subject is unable to do so. Hospitalized patients often assume recumbent body positions irrespective of underlying pathology. Hence, need arises to find out best recumbent body positions for the benefit of these patients to make breathing comfortable for them.

Aim: The aim of this study was to find out whether the change from the supine position to crook lying and Fowler's position (45° dorsal elevation) causes change in spirometric parameters.

Materials and Methods: The present work was carried out at Department of Physiology, King George's Medical University, Lucknow. A total 131 apparently healthy individuals were enrolled in this cross-sectional study. Lung function was assessed using a PC-based spirometer according to American Thoracic Society guideline in the supine, crook lying and Fowler's position (45^0 dorsal elevation).

Results: The study consisted of 131 subjects (male 66%, female 34%), with mean age of 20.15±2.71 years and BMI 21.20±3.28 Kg/m^2. Repeated measures ANOVA with post hoc Bonferroni test was used to compare the mean values between each body position. Compared with the other two positions, Fowler's position showed significantly ($p<0.05$) higher values for FVC, FEV_1, PEF, $FEF_{25-75\%}$.

Conclusion: Recumbent body position influences spirometric parameters in young healthy subjects. We demonstrated that spirometric values are higher in the Fowler's position than in the supine or crook lying position. The results of this study will help in the selection of the best alternative position for the spirometry in bed ridden patients.

Keywords: Bedridden, Crook lying position, Fowler's position, Spirometry

INTRODUCTION

Spirometry is a physiological test that measures how an individual inhales or exhales volume of air as a function of time. Spirometry is invaluable as a screening test of general respiratory health [1]. Spirometric values are dependent on age, sex, height and ethnicity of the subject [2]. Change in body positioning and the consequent change of gravity effect is among other factors that cause change in spirometric parameters. Ideally, spirometry is done in sitting position until the subject is unable to do so, but indoor hospitalized patients often assume a recumbent body posture irrespective of underlying pathology. Hence, knowledge of the physiological effects of different recumbent body posture on spirometric parameters is essential for the diagnostic as well as therapeutic procedures in clinical practice [3].

We hypothesized that changes in body positions from supine to crook lying and Fowler's position causes substantial alteration in the spirometric indices in apparently healthy subject and Fowler's position improves spirometric indices as compared to crook lying and supine position. The objective of this study was to assess spirometric parameters (FVC, FEV_1, $FEF_{25-75\%,}$ PEF) in the supine, crook lying and Fowler's position by using computerized spirometer.

MATERIALS AND METHODS

This cross-sectional study was conducted in the Department of Physiology, King George's Medical University (KGMU), Lucknow, Uttar Pradesh, India. The subjects enrolled in the study were mostly from the apparently healthy young medical student from KGMU, aged between 18-35 years. Subjects having a history of any known cardio-respiratory disease or insufficiency, haemoptysis of unknown origin, any surgery/injury to the thorax or abdomen were excluded. The study was approved by the Research Ethics Committee of the university (75^{th} ECM II-B Thesis/P6). Of the 136 volunteers initially considered for the study, testing was terminated in five subjects who could not perform forced expiratory maneuver satisfactorily. All subjects signed an informed consent form. Data collection was taken from September 2015 to June 2016.

Spirometric measurements were done according to the 2005 American Thoracic Society/European Respiratory Society guidelines [1] using PC-based spirometer (NDD medical technologies, Two Dundee Park, Andover, MA, USA). The three positions used in the present study were supine, crook lying and Fowler's positions. Crook lying position was achieved by lying supine with his/her both hip joints 45^0 and feet lying flat on the couch. Fowler's position was achieved by inclining the backrest of a bed upwards 45^0 from the supine position with flexed or straight knees. The order of the body position was randomized with a random number table and the test positions were standardized. Then, subjects lied on couch in the particular position, were made comfortable and asked to relax for five minutes. Following a detailed explanation of the test, nose clip was applied, mouthpiece was placed in mouth and close lips around the mouthpiece. Subjects were asked to perform a maximal inhalation completely and rapidly with a pause of <1 second at total lung capacity followed by a maximal expiration until no more air can be expelled while maintaining an upright posture. The spirometric value adopted in each position was the highest value among three measurements with less than 10% difference between them.

Mean and standard deviation were used to represent the spirometric values obtained in different body positions analysed. Repeated measures Analysis of Variance (ANOVA) with post hoc Bonferroni tests were used to compare the mean values between each body position in both sexes. All analyses were performed using SPSS version 23.0.

RESULTS

[Table/Fig-1] shows the demographic characteristics of the subjects. The population consisted of 131 subjects (86 males, 45 females), mean age of 20.15±2.71 years, BMI of 21.20±3.28 Kg/m^2. Values of spirometric parameters (mean±SD) in different positions in both sexes are shown in [Table/Fig-2]. Compared with the other two positions, Fowler's position showed significantly higher values for FVC, FEV_1, PEF, $FEF_{25-75\%}$ in both male and female. There were also

Anthropometric parameters	Mean ± SD	Minimum	Maximum
Age (years)	20.15±2.71	18	34
Height (cm)	167.64±9.94	143	192
Weight (kg)	60.53±8.74	38	88
Body mass index (BMI) (kg/m^2)	21.20±3.28	14.70	28.80

[Table/Fig-1]: Demographic data of subjects.

Variable	Sex	Supine position	Crook lying position	Fowler's position	p-value[1]
FVC (L)	Male	3.39±0.61	3.55±0.60	3.68±0.60	0.009*
	Female	2.44±0.20	2.58±0.26	2.66±0.27	0.001*
FEV_1 (L)	Male	2.83±0.46	2.96±0.46	3.09±0.47	0.002*
	Female	2.07±0.23	2.20±0.25	2.30±0.26	0.001*
$FEF_{25-75\%}$ (L/s)	Male	3.27±0.74	3.44±0.73	3.64±0.75	0.05*
	Female	2.56±0.52	2.69±0.49	2.89±0.48	0.009*
PEF (L/s)	Male	6.27±1.19	6.74±1.23	7.14±1.27	0.001*
	Female	4.72±0.69	5.14±0.77	5.47±0.90	0.001*

[Table/Fig-2]: Evaluation of the lung function parameters between different recumbent body positions in both males (n=86) and females (n=45).
[1]ANOVA * Significant difference ($p < 0.05$)

significant differences between the supine position with crook lying for spirometric values.

DISCUSSION

The present study found that spirometric values increases progressively from supine to Fowler's positions in young healthy individuals. The present study also found that males had higher spirometric values compared to female because of large chest size, more muscle power and more body surface area [4]. Compared to other positions, there was a significant decrease in FVC, FEV_1, PEF, $FEF_{25-75\%.}$ in supine position in both sexes. This occurs due to decreased dynamic lung compliance and increased airway resistance caused by increase intrapulmonary blood flow [5,6]. In supine position, the reduction of pharyngeal diameter occurs, which increases the upper airway resistance. The cephalic displacement of the diaphragm due to increased abdominal pressure results in reduced lung volume at rest in the supine position [7]. In supine position, anterio-posterior diameter of the chest wall is limited. Another factor in the spirometric value reduction in supine position may be the reduction in alveolar area.

In the present study, Fowler's position showed an increase in FVC, FEV_1, PEF, $FEF_{25-75\%.}$ compared to the other two study positions, in both male and female. This finding may be related to the favorability of deep breaths and overcomes the tendency to airway closure in this position. Fowler's position has been shown lower intra-abdominal pressure over the diaphragm that results in highest lung volume [8]. At higher lung volume, there is greater elastic recoil of the lung and the chest wall and the expiratory muscles are at a more optimal part of the length-tension relationship curve and thus are capable of generating higher intrathoracic pressures [9].

The effect of body position on spirometric values was found to be different across the studies. Lakshmi A et al., had evaluated vital capacity of 100 subjects (50 males, 50 females) and observed higher vital capacity in males in comparison to females. This study also demonstrated that vital capacity in standing position was more compared to sitting position [4]. Martinez BR et al., has evaluated vital capacity of 30 subjects in supine (head at 0^0 and 45^0), sitting and standing positions in patients after the postoperative upper abdominal surgery. Compared with the other positions, standing position showed significantly higher values in relation to sitting, supine at 45^0, and supine at 0^0 [10]. Sudan DS et al., analysed FVC of 100 subjects in sitting and crook lying position. The results show that FVC was more in sitting position as compared to crook lying position [11]. Melam GR et al., investigated the effect of different positions on pulmonary function test values in 30 subjects with severe asthma aged between 20–39 years. Spirometer measurements were taken in the supine, side lying on right, side lying on the left, sitting and standing positions. There was a significant difference in the FEV_1, FVC values obtained between standing and supine positions. This study showed standing as the best position for measuring FEV_1 and FVC of asthmatic subjects [12]. Gudmundsson G et al., reported the results of a study in 50 obese subjects (BMI >30 kg/m^2), and found that there was a small but statistically significant difference between FVC in the standing versus sitting positions, but there was no significant difference in FEV_1 between sitting and standing positions [13]. According to Pereira CA et al., FVC in adults and elderly is higher in the upright position (1%-2%) and lower in the supine position (7%-8%) compared to the sitting position, which does not occur in younger people [14].

In contrast, Costa GM et al., and Domingos-Benicio et al., found no statistically significant difference in FVC between the sitting and upright positions in healthy young population [9,15]. Thomas P et al., has analysed the effect of semi-recumbent and sitting positions on gas exchange, respiratory mechanics and haemodynamics in 34 intubated and ventilated subjects. Subjects were passively mobilized from supine into a seated position and from a supine to a semi-recumbent position (>45^0 backrest elevation). There were no clinically important changes in arterial blood gas, respiratory mechanic or haemodynamic values due to either position [16]. Pierson DJ et al., has evaluated spirometry of 235 individuals with normal to severe ventilatory impairment in both sitting and standing position and observed that the sitting value of both FVC and FEV_1 were significantly more, but the magnitudes of differences were small [17].

The results of this study showed that the body position has an effect on various spirometric parameters. It reveals an important connection between posture and pulmonary function that could increase the quality of life in many individuals. Thus, knowledge of body positions that favour lung function can be used as a diagnostic as well as therapeutic purpose.

LIMITATION

This study has some limitations, as it was carried out on apparently healthy volunteers. The effect of Fowler's position on different spirometric measurement in cardiac or pulmonary disease patients is not known. Hence, if the same research was carried out on subjects suffering from a particular disease, clinically valid outcome would be seen.

CONCLUSION

This study has shown a significant postural change in lung volume and flow rates in young healthy individuals in both sexes. The results

of this study will help in the selection of the best alternative position for the spirometry in bedridden subjects, aiming at improving lung volume, oxygenation, and respiratory mechanics. The most favored recumbent body position for respiratory function is the Fowler's position compared with the crook lying and supine position. Hence this position can be used for therapeutic purposes also.

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