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Research Article

The estimation of pulmonary functions in various body postures in normal subjects

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ABSTRACT

Background: The frequently measured index of pulmonary function is vital capacity which gives useful information about the strength of respiratory muscles and other aspects of lung function. The purpose of the study was to investigate changes that occur in vital capacity in different postural attitudes like standing, supine, right lateral, left lateral positions compared with the reference position such as upright sitting in normal subjects.
Methods: Young non-smoker healthy male medical students (n=20, age 19-22 years) of PSG Medical College participated as volunteers in this study. Pulmonary function tests like forced vital capacity (FVC), Forced Expiratory Volume in one second (FEV_1), FEV_1 to FVC% i.e. (FEV_1%) was recorded in various postures using computerized spirometer in BIOPAC systems, Inc., MANBSL3S, student version, following the standard procedure.
Results: A repeated measure ANOVA-multiple comparison study revealed FVC, FEV_1 and FEV_1% values in standing posture was significantly higher than supine, sitting, right and left lateral positions.
Conclusions: Naturally, in standing posture factors contributing to increased vital capacity are increased, vertical diameter of thorax which increases thoracic capacity volume and lung compliance increasing lung volume.

Keywords: Postural changes, Pulmonary functions, Vital capacity

INTRODUCTION

The hospitalized patients often assume recumbent body positions, such as supine and side lying (right lateral and left lateral position). Bedridden patients are routinely turned side to side for comfort and also to avoid the negative effects of recumbent static body positions, such as skin breakdown and contractures.[1] The physiotherapists also recommend body positioning to increase oxygen transport and oxygenation to minimize the risk of aspiration and to drain pulmonary secretions. The recumbent body positions have well documented deleterious effects on lung function, such as reduced lung volumes and capacities, increased closing volume of dependent airways, reduced flow rate and reduced arterial saturation.[2]

The right and left lateral side lying positions are commonly used clinically by all patients; the differential effects of these positions compared with a reference position such as upright sitting and standing have not been studied in detail. There are a few reports of improved arterial oxygenation in left versus right side lying in patients with unilateral[3] and bilateral lung disease.[4] In patients with unilateral lung disease, there is an enhancement of gas exchange in the inferior portion of the lung because of the cephalad displacement of the hemidiaphragm which is a great mechanical advantage. In patients with bilateral lung disease gas exchange may be enhanced due to increased volume of the right lung anatomically and less effect of cardiac compression on this lung.[2]

The incidence of paraplegia, hemiplegia and other CNS disorders are on the increasing trend due to uncontrolled diabetes or hypertension in old age, hence most paraplegic patients are bedridden. The purpose of our study was to replicate and extend the existing body of knowledge pertaining to the normal relationship between supine, right and left lateral side lying and lung function variables in normal healthy individuals by comparing with standard postures like standing and the reference sitting posture so that mortality due to respiratory complications can be prevented in bedridden hospitalized patients.

METHODS

This study was conducted in the department of Physiology, PSG institute of medical sciences and research (PSGIMS & R), Coimbatore. Prior to the commencement of the study, the permission of the institute research council and the institute ethics committee were obtained.

This study was carried out on 20 normal human volunteers' i.e. medical students who were aged from 18 to 25 years, after obtaining informed consent from the subjects. Those suffering from diabetes mellitus, hypertension, asthma, other respiratory problems, smokers and females were excluded.

The height in centimeters and weight in kilograms was recorded for all subjects before subjecting them to the following tests. The following parameters were recorded using BIOPAC systems, Inc., MANBSL3S, student version.

Forced vital capacity (FVC)

The computer was turned on. The air flow transducer [SS11LA] was plugged into channel I of the biopic unit. The MP 30 data acquisition unit was switched on. The filter was placed at the end of the calibration syringe, which was then inserted into airflow transducer. The biopic student lab programme was started, lesson 12 for recording the forced vital capacity was chosen and the file name was typed. Calibration was carried out using calibration syringe connected to airflow transducer.

The mouth piece was inserted into airflow transducer. Care was taken that there is no air leak between the mouth piece and oral cavity. The subject was asked to apply nose clip and he was instructed to begin breathing through air flow transducer normally for three breaths. Then he was asked to inspire as deep as possible and to expire maximally and forcefully and as quickly as possible through the mouth piece which was followed by normal breathing.

Caution was taken that there was no gap between the mouth piece and the lips. The area of forceful inspiration to forceful expiration was selected using I beam cursor. This gave the peak to peak measurement of forced vital capacity.[5] The procedure was repeated thrice and the best of three readings was noted. This procedure was carried out in various postures like sitting, standing, lying, and left lateral and right lateral positions. The different values in different positions was noted

Forced expiratory volume in one second (FEV_1)

Forced expiratory volume in one second is the volume of gas expired in the first second during the performance of forced vital capacity maneuver.[6] It is the most sensitive index of lung function.[7]

The computer was turned on. The air flow transducer [SS11LA] was plugged into channel I of the biopic unit. The MP 30 data acquisition unit was switched on. The filter was placed at the end of the calibration syringe, which was then inserted into airflow transducer. The biopic student lab programme was started, lesson13 for recording the forced expiratory volume in one second was chosen and the file name was typed. Calibration was carried out using calibration syringe connected to airflow transducer. The mouth piece was inserted into airflow transducer.

The subject was asked to apply nose clip and he was instructed to begin breathing through air flow transducer normally for three breaths. Then the subject was asked to inhale deeply as possible and to hold the breath for just a moment. Then he was asked to exhale completely to the maximum and then breathe normally for three breaths. The area of maximum exhalation is selected for three seconds. Then FEV_1 set up button was clicked. Then using I beam cursor a period of one second was selected on the graph which gave the forced expiratory volume in one second.[5] The procedure was repeated thrice and the best of three readings was noted. This procedure was carried out in various postures like sitting, standing, supine lying, left lateral and right lateral positions. The different value in different positions was noted.

Forced expiratory volume$_1$% (FEV_1%)

FEV_1 / FVC x 100 = FEV_1%

Forced expiratory volume in one second divided by forced vital capacity multiplied by 100 gave FEV_1%. The FEV_1 % was calculated for various postures like sitting, standing, supine lying, left lateral and right lateral positions.

The data obtained was compared with the reference standard predicted values of FVC, FEV_1, FEV_1%, in relation to the height and age of the individual. These predicted values were calculated using the formula from American thoracic society.[8] The values obtained were analyzed in SPSS package using one way Anova-multiple comparison study [least significant difference] and p value of less than 0.05 was considered significant.

RESULTS

The overall average valves of FVC, FEV_1, FEV_1% across all the subjects, in different postures were compared. Table 1 shows the comparison of FVC, FEV_1, FEV_1% in standing versus sitting posture with statistical significance of $p < 0.002$ and $p < 0.006$ for FEV_1, FEV_1% respectively.

Table 1: Comparison of standing FVC, FEV_1 and FEV_1/FVC% to sitting posture.

Postures	FVC [liters]	FEV_1 [liters]	FEV_1/FVC, percent
Standing	3.71±0.34	3.04±0.33	81.93± 3.57
Sitting	3.50 ± 0.42	2.70± 0.33	77.12± 4.45
Difference of the mean	0.20	0.33	4.80
'P' Valve	0.10	‹ 0.002	‹ 0.006

Table 2 shows the comparison of FVC, FEV_1, FEV_1% in standing versus lying posture with statistical significance of $p < 0.001$ and $p < 0.001$ and $p < 0.002$ for FVC, FEV_1, FEV_1% respectively.

Table 2: Comparison of standing FVC, FEV_1 and FEV_1/FVC% to lying posture.

Postures	FVC [liters]	FEV_1 [liters]	FEV_1/FVC, percent
Standing	3.71±0.34	3.04±0.33	81.93± 3.57
Lying	3.28±0.43	2.51±0.38	76.40± 5.87
Difference of the mean	0.42	0.52	5.83

Table 3 shows the comparison of FVC, FEV_1, FEV_1% in standing versus right lateral lying posture with statistical significance of $p < 0.04$ and $p < 0.001$ and $p < 0.001$ for FVC, FEV_1, FEV_1 % respectively.

Table 3: Comparison of standing FVC, FEV_1 and FEV_1/FVC% to right lateral posture.

Postures	FVC [liters]	FEV_1 [liters]	FEV_1/ FVC, percent
Standing	3.71±0.34	3.04±0.33	81.93±3.57
Right lateral	3.46± 0.39	2.56± 0.29	74.34± 5.88
Differences of the mean	0.24	0.47	7.59
'P' Valve	‹ 0.04	‹ 0.001	‹ 0.001

Table 4 shows the comparison of FVC,FEV_1, FEV_1% in standing versus left lateral lying posture with statistical significance of $p < 0.009$ and $p < 0.001$ and $p < 0.001$ for FVC, FEV_1, FEV_1% respectively. This denotes vital capacity in standing posture is increased when compared to other postures.

Table 4: Comparison of standing FVC, FEV_1 and FEV_1/FVC% to left lateral posture.

Postures	FVC [liters]	FEV_1 [liters]	FEV_1/FVC, percent
Standing	3.71±0.34	3.04 ± 0.33	81.93± 3.57
Left lateral	3.38 ±0.35	2.48±0.32	73.47± 6.79
Difference of the mean	0.32	0.56	8.45
'P' Valve	‹ 0.009	‹ 0.001	‹ 0.001

Table 5 shows the comparison of FVC, FEV_1, FEV_1% in sitting versus lying posture with statistical significance of $p < 0.08$ and $p < 0.07$ for FVC, FEV_1, respectively.

Table 5: Comparison of sitting FVC, FEV_1 and FEV_1/FVC% to lying posture.

Postures	FVC [liters]	FEV_1 [liters]	FEV_1/FVC, percent
Sitting	3.50±0.42	2.70± 0.33	77.12± 4.45
Lying	3.28 ±0.43	2.51 ±0.38	76.40± 5.87
Difference of the mean	0.22	0.19	4.80
'P' Valve	‹ 0.08	‹ 0.07	0.67

Table 6 shows the comparison of FVC, FEV_1, and FEV1% in sitting versus right lateral posture with statistical significance of $p < 0.04$ for FEV_1 only.

Table 6: Comparison of sitting FVC, FEV_1 and FEV_1/FVC% to right lateral lying posture.

Postures	FVC [liters]	FEV_1 [liters]	FEV_1/FVC, percent
Sitting	3.50±0.42	2.70±0.33	77.12± 4.45
Right lateral lying	3.46±0.39	2.48 ± 0.32	74.34± 5.88
Difference of the mean	0.71	0.22	2.78
'P' Valve	0.71	‹ 0.04	0.10

Table 7 shows the comparison of FVC, FEV_1, FEV_1% in sitting versus left lateral posture with FEV_1% alone showing statistical significance of $p < 0.03$.

Table 7: Comparison of sitting FVC, FEV_1 and FEV_1/FVC% to left lateral lying posture.

Postures	FVC [liters]	FEV_1 [liters]	FEV_1/ FVC, percent
Sitting	3.50 ±0.42	2.70 ±0.33	77.12± 4.45
Left lateral lying	3.38 ±0.35	2.56 ±0.29	73.47±6.79
Difference of the mean	0.12	0.13	3.65
'P' Valve	0.31	0.20	0.03

Table 8 shows the comparison of FVC, FEV_1, FEV_1% in lying versus right lateral posture with FEV1% alone showing statistical significance of $p < 0.02$.

Table 8: Comparison of lying FVC, FEV_1 and FEV_1/FVC% to right lateral lying posture.

Postures	FVC [liters]	FEV_1 [liters]	FEV_1/FVC, percent
Lying	3.28±0.43	2.51 ±0.38	76.40± 5.87
Right lateral lying	3.46 ±0.39	2.56±0.29	74.34± 5.88
Difference of the mean	- 0.17	- 0.05	2.05
'P' Valve	0.16	0.62	0.02

Table 9 shows the comparison of FVC, FEV_1, FEV_1% in lying versus left lateral posture with FEV_1% alone showing statistical significance of $p < 0.03$.

Table 9: Comparison of lying FVC, FEV_1 and FEV_1/FVC% to left lateral lying posture.

Postures	FVC [liters]	FEV_1 [liters]	FEV_1/FVC, percent
Lying	3.28±0.43	2.51±0.38	76.40± 5.87
Left lateral lying	3.38± 0.35	2.56± 0.29	73.47± 6.79
Difference of the mean	0.12	0.13	3.65
'P' Valve	0.31	0.20	0.03

DISCUSSION

Changes in body position significantly affected forced vital capacity, forced expiratory volume in one second and percentage of expiratory volume in one second.

In majority of studies in which spirometric measures for assessing the lung function was recorded either in sitting or standing posture. Sitting is considered to be a standard posture for recording the timed measurement of dynamic lung volumes during forced inspiration and expiration to quantify how effectively and how quickly the lungs can be emptied and filled.

The increase in spirometric values in standing posture was attributed to descent of diaphragm for the extra volume of air inspired during forced vital capacity manoeuvre which had the highest lung volumes[9] and when standing was not measured, upright sitting resulted in the highest lung volumes.[10] At higher lung volumes there is greater elastic recoil of the lungs and chest wall.[11] Following a deep inspiration, a larger amount of potential energy is stored in the tissues of the chest wall. Further the contracting diaphragm increases pressure on abdominal contents pushing them forward and distending the abdominal cavity. This places the abdominal muscles at a slight stretch and stronger contraction of which results in forceful expiration. The expiratory muscles are at a more optimal part of the length tension relationship curve and thus are capable of generating higher intrathoracic pressures[12] for forceful expiration during standing.

Increase in lung volumes in standing position appear to be related to the increased thoracic cavity volume.

First gravity pulls the abdominal contents caudally within the abdominal cavity, increasing the vertical diameter of thorax.[13]

Second, unlike in supine position, the bases of the lungs are not compressed by the weight of the heart and abdominal contents. This allows alveoli that had been compressed to reopen and increase lung compliance.

Third the inspiratory muscles are able to expand the unrestricted thorax in all directions.[14] As a result the diaphragm is able to contract even further caudally and thus increase lung volumes.

Chair sitting often led to the second highest lung volume results after standing. It has been hypothesized and this may be due to subjects taking in slightly less inspiration than in standing position because the abdominal contents are higher in the abdominal cavity interfering with diaphragmatic motion. The hip flexion required in chair sitting and the higher position of abdominal contents may be implicated in a less optimal abdominal muscle length. Further in the sitting position, the back of the chair may slightly limit thoracic expansion. Thus limited thoracic cavity capacity in sitting position appears to result in lower lung volumes.

In lying position there is a decrease in lung volume, so the flow rates also decreases as the diaphragm ascends upwards. It is not only related to a decrease in vital capacity but also to decrease in total lung capacity and residual volume. The related changes are mainly due to an increase in intrathoracic blood volume due to gravitational facilitation of venous return and cephalic displacement of diaphragm caused by abdominal encroachment.[1] Since airway calibre is clearly dependant on lung volume, it is to be expected that flow rates also decreases with decreasing lung volume in recumbent postures. The lower airway resistance increases with decreasing lung volume which is responsible for the significantly reduced values observed in comparison of standing to lying posture in our study

When we compared the side lying [right lateral & left lateral] and supine no significant difference was found. In side lying position the abdominal contents move forward and may place the abdominal muscles at a better length [compared with supine]. However thoracic volume is decreased due to the expansion of one hemithorax being limited by the bed. This may result in lower lung volumes and less elastic recoil compared to other postures like sitting or standing. The small changes between the two positions balance each other and account for the similar FVC, FEV_1, FEV_1% values seen in supine and side lying postures.

CONCLUSIONS

Body position has an effect on spirometric values like FVC, FEV1, FEV1%. Generally the more upright the position like standing and sitting higher the FVC, FEV_1, FEV_1% values.

The standing posture has the highest lung volumes and chair sitting to the second highest lung volumes. In recumbency, factors contributing to impaired lung function are external compression of the chest wall, impingement of abdominal contents on the diaphragm, compression of airways and blood vessels by the heart. This is an indication that bedridden or post-operative patients [on the 2nd postoperative day] should be placed in an upright position when attempting to clear off the secretions from larger airways. Changing to a better position may be especially useful for those patients with weak expiration. Patients having difficulty clearing secretions in postural drainage position [such as supine lying, left lateral or right lateral position] may find it worthwhile to switch to a more upright position for the clearance maneuver.

This would be very helpful to prevent pulmonary morbidity following major surgeries, despite improvements in surgical technique and anaesthetic methods.

Limitations: This was a short duration study with small sample size, since it was an ICMR project.

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Ethical approval: The study was approved by the institutional ethics committee

REFERENCES

1. Manning F, Dean E, Ross J, RT A. Effects of Side Lying on Lung Function in Older Individuals Phys Therap. 1999;79:456-66.
2. Dean E. Effect of body position on pulmonary function. Phys Ther. 1985;65:613–8.
3. Zack MB, Pontoppidan H, Kazemi H. The effect of lateral positions on gas exchange in pulmonary disease: a prospective evaluation. Am Rev Respir Dis. 1974;110:49–55.
4. Dean E. Invited commentary on “Are incentive spirometry, intermittent positive pressure breathing, and deep breathing exercises effective in the prevention of postoperative pulmonary complications after upper abdominal surgery? A systematic overview and meta-analysis.” Phys Ther. 1994;74:10–5.
5. Biopac Student Laboratory Manual; part no MANBSL3S: Lesson 12, pg. 1-21; Lesson 13, pg. 1-25.
6. A K Jain, Manual of Practical Physiology; II edition, pg 180.
7. Sarada Subramanyam and K. Madhavan kutty, Text Book of Human Physiology, 6th edition pg. 213 & 258.
8. American Thoracic Society. Standardisation of spirometry: 1994 update. Amer Jou of Resp & Critical Care Med. 1995;152:1107-36.
9. Wade OL, Gilson JC. The effect of posture on diaphragmatic movement and vital capacity in normal subjects with a note on spirometry as an aid in determining radiological chest volumes. Thorax. 1951;6:103-6.
10. Jenkins S, Soutar S, Moxham J. The effects of posture on lung volumes in normal subjects and in patient’s pre and post coronary artery surgery. Physiotherapy. 1988;74:492-6.
11. Leith DE. Cough Physical therapy. 1968;48:439-47.
12. McCool FD, Leith DE. Pathophysiology of cough. Clinics in Chest Medicine. 1987;8:189-95.
13. Castile R, Mead A. Effect of posture on flow-volume configuration in normal humans. J Appl Physiol. 1982;53:1175-83.
14. De Troyer A, Loring SH. Actions of the respiratory muscles. In RoussosC [Ed]: The Thorax [2nd Ed.] New York: Dekker, 1995; 535-563.

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