

Effects of dorsal and lateral decubitus on peak expiratory flow in healthy subjects

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ABSTRACT | Background: One of the measures of the pulmonary function is the peak expiratory flow (PEF) that can be defined as the major flow obtained in an expiratory pressure after a complete inspiration to the level of the total lung capacity. This measure depends on the effort and strength of expiratory muscles, the airway diameter and the lung volume. **Objective:** To compare the results of the peak expiratory flow in healthy male and female obtained in a seated position and dorsal decubitus (DD), right lateral decubitus (RLD) and left lateral decubitus (LLD). **Method:** Thirty young subjects with mean age 22.7 years, healthy and non-smokers were included at the study, 15 of male sex. They did spirometry and IPAQ questionnaire to check the normal pulmonary function and physical activity level. The measures of PEF were performed in four positions, being performed 3 measures in which position, in a random order. Statistical analysis was performed according to Student's t test, with significance level set at 5%. **Results:** There was a difference between the values obtained in sitting position (481 ± 117.1 L/min) with DD (453.2 ± 116.3 L/min) and RLD (454 ± 112.9 L/min) ($p < 0.05$), however, did not find a significant difference between the sitting position and LLD (469 ± 83 L/min). **Conclusions:** Body position affects the values of PEF, with decreasing values in DD and RLD. The LLD can be an alternative to optimize the expiratory flow in situations of constraint to the sitting position.

Keywords: peak expiratory flow rate; meter; physical therapy.

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● Introduction

Several tests are available to assess pulmonary function. Lung volume and flow are the most commonly used measures. Lung volume does not directly assess pulmonary function; however, changes in lung volumes and flows are associated with pathological respiratory conditions¹. Pulmonary function tests play a key role in the diagnosis and quantification of the intensity of respiratory disorders and management of patients with pulmonary diseases, both in adult and pediatric populations². The peak expiratory flow (PEF) rate is a measure of pulmonary function that may be defined as the greatest flow assessed in a forced expiration from a full inspiration at total lung capacity level^{1,2}.

PEF is dependent on volunteer effort, expiratory muscle strength, airway caliber, lung volume and strength of lung elastic recoil³. The muscles activated during inspiration cause the increase in thoracic volume and consequent pleural and alveolar pressure

drop to sub-atmospheric values, enabling ambient air, at atmospheric pressure, to move into the lungs. Upon expiration, the thorax and lungs passively return to the rest position moving the air out of the lungs at the expense of their elastic forces. Upon forced expiration, however, several thoracic and abdominal wall muscle groups should be contracted to decrease the thoracic volume⁴⁻⁶.

PEF values may be related to the ability of coughing. Effective coughing requires generating high PEF rates at a level sufficient to move secretions from the airways surface. Coughing protects the airways from inhalation of foreign substances in healthy people and is responsible for eliminating the excess mucus in hypersecretory diseases. High flows may be generated by forced contraction of expiratory muscles, which generate high thoracic and abdominal pressure changes⁶. The high intrapulmonary pressure reached from a deep inspiration, glottis closure and contraction

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of expiratory muscles provides high flows in the cough explosive phase, and that high flow transfers kinetic energy from the air to the secretion or foreign body, removing them from the bronchial wall and transporting them into the pharynx or mouth, where they may be removed⁴.

The simplicity of the PEF measuring method is its main advantage and it may be performed using different instruments, including portable devices^{7,8}. The portable peak flow meter is a simple, reliable, inexpensive device, which is easy to transport, handle and understand. The gauges of adults typically range from 100 to 850 L/min (no less than 100 L/min)⁹. The satisfactory completion of PEF is volume effort-dependent. The forced expiratory effort should be launched from a neutral position because neck extension increases and flexion decreases PEF through changes in tracheal complacency⁹. At least three measurements should be performed at each session. The maneuver should be repeated until three readings fall within a range of less than 20 L/min from each other¹⁰. The highest value of the three readings should be recorded⁹.

Although PEF measurements are affected by the different devices and measuring methods¹¹, some studies show there are no differences between measurements assessed in the sitting or standing up positions¹²⁻¹⁴, while others suggest differences¹⁵. Regardless of those controversies, the guidelines of international associations¹⁶ recommend performing the maneuver in the standing up position¹⁶. However, hospitalized patients, in particular, may have limitations and difficulties in performing the measurement standing up¹⁵.

It is known that the regional distribution of ventilation in the supine position may be affected by body posture, with a predominance of ventilation in areas dependent on gravity¹⁶⁻¹⁹. However, the effect of different postures on PEF, particularly relevant for physical therapy, has yielded controversial results. Respiratory therapy uses several techniques that may associate forced expirations, cough and various body positions aiming to remove secretions, with improved pulmonary ventilation and gas exchange²⁰.

This study aimed to compare the results of PEF in young and healthy adult men and women assessed in the sitting position with measures assessed in dorsal decubitus (DD), right lateral decubitus (RLD) and left lateral decubitus (LLD).

● Method

This research consisted in a cross-sectional observational study. Young adults were recruited according to the following inclusion criteria: age between 18 and 30 years, nonsmokers, without neurological and/or respiratory diseases, able to adequately perform the maneuvers and not using stimulants.

The study was approved by the Research Ethics Committee of the University Hospital of the School of Medicine of Ribeirão Preto, University of São Paulo (Universidade de São Paulo – USP), Ribeirão Preto, São Paulo (SP), Brazil, HCRP (University Hospital of Ribeirão Preto) process No. 8731/2010. All volunteers read and freely signed the informed consent form.

The physical evaluation of the volunteers was subsequently performed, and data were recorded on an evaluation form, which contained the name, age, vital signs, peripheral oxygen saturation and PEF data. All subjects performed spirometry towards assessing the normality of lung function, and filled out the International Physical Activity Questionnaire (IPAQ)²¹ to measure the level of physical activity.

The evaluations were performed by the same rater, always in the afternoon period.

Spirometry

Each volunteer performed a rest period of five to ten minutes before the test. The procedure was carefully described and conducted according to the guidelines for pulmonary function tests of 2002⁹.

A previously calibrated spirometer (Koko PFT system version 4.11, 2007 nSpire Health, Inc; Pulmonary Data Services, United States) was used for the measurements. The volunteers sat upright, feet flat and head in a neutral position, avoiding flexion and extension, using a nose clip to prevent air from escaping through the nose.

The volunteers were instructed to put the mouthpiece in their mouths to avoid air leakage and breathe at tidal volume. Shortly after, they were instructed to perform a laminar flow inspiration to total lung capacity (TLC), a forced and maximum expiration and again inspiration until TLC.

The maneuver was performed until the volunteer performed three acceptable and two reproducible flow-volume curves, within eight attempts, to ensure the reproducibility of the curves.

Evaluation of peak expiratory flow

A Mini Wright® (Clement Clarke International Ltd, England) portable device, with disposable mouthpiece, easily handled and belonging to the institution was used to perform the PEF measurements.

The measurements were performed at four positions: sitting and lying on DD, LLD and RLD. The position at which the volunteer should start the measurements was randomly defined by draw towards avoiding the effect of the order of measures and consequent fatigue in the last measurements.

The volunteers performed three measurements at each position, with one minute of rest between measurements, and the readings should not have more than 20 L/min difference between them. The highest value found among the measurements performed was considered the final value.

Statistical analysis

The variables analyzed followed a normal distribution according to the Shapiro-Wilk test. The sitting position was compared to the DD, LLD and RLD positions according to the paired Student t test, with significance level set at 5% probability.

Results

A total of 30 volunteers, with 15 females and 15 males, with a mean age of 22.2 ± 2.4 years were studied. The male subgroup mean age was 22.13 ± 1.9 and the female subgroup mean age was 22.27 ± 2.4 years.

The mean body mass index (BMI) was 26 ± 4.95 Kg/cm² in the male subgroup and 22.5 ± 2.28 Kg/cm² in the female subgroup.

According to the IPAQ, most subjects were classified as sedentary (n=23) or with irregular physical activity (n=7).

The results of spirometry are outlined in Table 1, showing that all subjects were healthy, with normal lung function test.

The PEF values found in the sitting, DD, LLD and RLD positions for healthy male and female volunteers are shown in Table 2.

Comparing the results found in the whole group or separately for males and females, the sitting position with lying on DD, LLD and RLD positions, the values found in the sitting position were higher than those

assessed in DD and RLD ($p < 0.05$), albeit without significant differences between the sitting and LLD positions (Figure 1).

Discussion

The purpose of this study was to evaluate the changes that occur in the values of PEF in healthy adults at different positions. The results suggest a decrease in PEF values at DD and RLD when compared with the sitting position, albeit without significant differences regarding the LLD.

The effect of DD in healthy people on different variables of pulmonary function is already well established in the literature, with a decrease in forced vital capacity (FVC) and forced expiratory volume in one second (FEV₁)²², in addition to increased airway resistance¹⁸ and decreased maximal expiratory pressure (MEP)^{18,23}.

Regarding PEF in healthy subjects, some authors found decreased values in the supine position²⁴, while others found similar values^{14,15}. Furthermore, others found a decrease only when the volunteers were in the head down position⁸.

The decrease in at lung volumes and flow rates at DD has already been described in obese subjects with asthma also. Haffejee²⁵ studied the effect of supine position on PEF values in asthmatic children, aged between four and 11 years, using the Mini Wright portable meter. A first measurement was performed with the child in orthostatic position, subsequently lying down the child and performing the measurements every 30 minutes for four hours. The results showed a significant decrease in PEF in asthmatic children in the supine position.

A similar effect was also found in obese subjects. Domingos-Benício et al.²⁶ compared the FVC, FEV₁ and FEV₁/FVC values in the standing, sitting and lying down positions in volunteers in the age group from 20 to 40 years, eutrophic and obese, sedentary, by spirometry. They found a 20% reduction in the FVC of both eutrophic and obese subjects when subjects shift into the lying down position.

Regarding the effect of lateral decubitus (LD) on PEF, our results showed a decrease in the values at RLD, comparable to DD, albeit similar to those at the sitting and LLD positions. These results differ from other authors, who found no differences when comparing the LLD and RLD position²²⁻²⁴.

Table 1. Means and standard deviations of spirometric variables in male volunteers and female.

Spirometric variables	Male		Female	
	Mean	SD	Mean	SD
FCV (L)	5.36	0.68	3.52	0.48
FCV%	95.93	9.74	93.43	9.71
FEV1 (L)	4.5	0.49	3.38	1.30
FEV1%	96.60	8.20	92	6.20
FEV1/FCV	0.84	0.07	0.9	0.05
FEV1/FCV %	101.13	8.36	101	5.42
PEF (L/s)	8.02	1.59	5.75	1.13
PFE%	82.13	17.93	81.71	25.71

FVC: forced vital capacity; FEV1: forced expiratory volume in one second; FEV1/FVC: index Tiffenau; PEF: Peak expiratory flow; SD: Standard deviation.

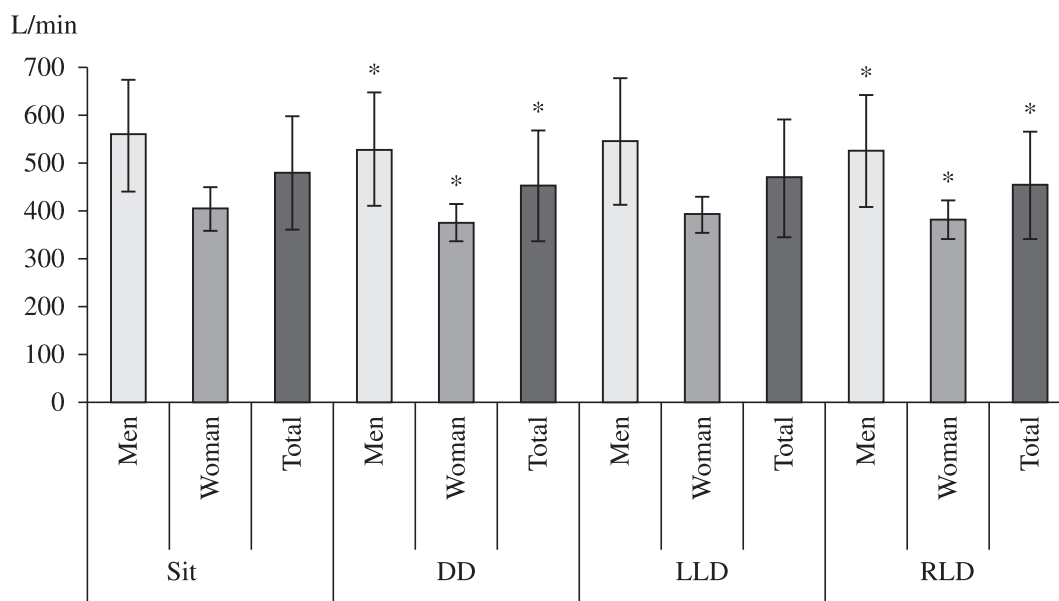
Table 2. Means and standard deviations of peak expiratory flow in L/min for males and females in the sitting, supine, left lateral and right lateral position.

Position	Males		Female	
	Mean	SD	Mean	SD
Sitting	558	116.7	404.7	45.1
Supine position	530	118.2	375.7	37.4
Left lateral decubitus	545.3	132.2	393	38.7
Right lateral decubitus	526.7	117	382.3	39.7

Meysman and Vincken²² evaluated the effect of the sitting, DD, RLD and LLD positions on the flow-volume curve, showing that PEF at the sitting position was higher than at decubitus positions and the FEV₁/PEF ratio was higher in the lateral decubitus positions. The authors explain that diaphragm strength is affected by the supine position, with an increase in intrathoracic blood volume and consequent decrease in lung volume. Furthermore, the size of the pharynx is smaller at DD, given the gravitational force acting on the tongue and soft palate, and LD may decrease the resistance of the upper airways.

Badr et al.²³ studied the PEF and MEP in 25 healthy adults between 18 and 65 years of age and 11 with chronic airflow limitation. The PEF measurements were performed using a spirometer, and the results showed that the standing position had the highest values, followed by the sitting position. There was no significant difference between the decubitus positions (dorsal and lateral), although the LD values were slightly lower than at supine. The explanation provided by the authors indicates that the dependent hemithorax expandability may have decreased.

Elkins et al.²⁴ evaluated PEF and MEP in patients with cystic fibrosis at least 18 years of age, using

**Figure 1.** Peak expiratory flow in healthy men and women and for the whole group in the sitting position, supine position (SP), left lateral decubitus (LLD) and right (DLD). * Significant difference compared to sitting position ($p < 0,05$)

spirometry and manovacuometry in eight different positions and showed differences in the values of PEF between the positions, with sitting, at 45°, supine, LD and head down tilt showing results significantly lower than both standing and sitting with legs stretched, and the largest difference occurred between the standing (6.35 L/s) and supine (5.79 L/s) positions. However, they found no differences between the lateral decubitus positions. Conversely, they found that MEP values at LD were significantly lower than standing and sitting on a chair.

The results of Shinde and Shinde⁸, who evaluated eight different positions in healthy adults and patients with chronic obstructive pulmonary disease (COPD) and found no significant trend to higher values of PEF at RLD in relation to LLD in both groups, are also controversial. The authors attributed that result to the higher volume of the right lung and a reduction in the compression of the heart on the lungs at RLD⁸.

This mechanism does not explain the results of the present study. The LD position enables the forward displacement of the abdominal content. Thus, the authors speculate that the hemidiaphragm, which is in the position dependent on gravity, is elongated, thereby improving its ability to generate pressure, while the non-dependent hemidiaphragm remains less elongated⁸. Conversely, the larger volume of the right lung may have inferably contributed to an increased elongation of the left hemidiaphragm on our results because the diaphragm position was not assessed in any of the studies.

The therapist should define the method of PEF assessment in clinical practice, including patient positioning, enabling to compare PEF values between different periods or between different patients¹⁵.

Subjects should be positioned with the torso at a higher position to aid the removal of secretions from the airways^{8,15}, especially those with reduced ability to cough, considering that PEF is important for performing an effective cough, requiring a peak flow >180 L/min for an effective cough²⁷ and the body position may affect the PEF. The flow and rate of air at the time of cough are the main factors responsible for the clearance of airways^{4,5}. Thus, it is important to consider that LLD may be an alternative, especially for bedridden patients, although it is crucial to know and understand the physiological effects of different decubitus positions, especially unilateral,

and different pathologies on lung function, in the selection process.

Roquejani et al.²⁸ analyzed the position effects on the values of muscle strength, which may also affect the PEF. The authors studied the maximal inspiratory and expiratory pressures (MIP and MEP) in healthy adults with ages ranging from 18 to 55 years, using a manovacuometer. The measurements were performed in seven positions and the results of that study showed that significant interactions occurred between the body position and the subject's gender. The highest values of MIP were found at 45° in women and at RLD in men, whereas the lowest values were found in the Trendelenburg position. However, only the MEP values assessed in the male group were higher, albeit with no effect from the decubitus position.

We chose to show the results separately for men and women, given the predicted differences according to gender in several pulmonary function variables, established by different predictive equations for each gender, although we emphasize that the differences found were confirmed in the whole group and in the male and female groups separately. In our study, we established an age group for inclusion of subjects from 18 to 30 years because aging triggers a reduction of lung elasticity and decreased elastic recoil pressure, contributing to a reduction in respiratory muscle strength, and PEF has its highest peak between 18 and 20 years of age and maintains this level until 30 years of age^{7,29}. Only sedentary subjects or those without regular physical activity were evaluated towards reducing the confounding factors because physical activity may contribute to the increase in PEF^{5,30}. Additionally, they were randomly positioned, with no fatigue effect on the results.

Regarding limitations, PEF measurements were performed at different positions using only the portable device; thus, we are not sure whether the results would change when measured by spirometry. Other pulmonary function tests assessing other measures, including residual volume or regional ventilation, were not performed either, or imaging tests towards confirming the position of the dependent hemidiaphragm.

● Conclusion

The body position affects the PEF values in healthy adults, nonsmokers, with a decrease at DD and RLD positions. However, there is no difference between

the sitting and LLD positions. Thus, the LLD may be an alternative to optimize the expiratory flow in situations restricting the sitting position.

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