Research Article

Body Position Effect on Respiratory Measures in Normal Adults

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Ravva Sathyanarayana, Sampath Kumar Lagishetti and G. V. Haripriya

Affiliations

Helen Keller's Institute of Research and Rehabilitation for the Disabled Children (HK), Secunderabad

Corresponding Author

Ravva Sathyanarayana
Lecturer in Speech and Hearing
Helen Keller's Institute of Research and Rehabilitation for the Disabled Children (HK), Secunderabad
Email: sathyaravva@gmail.com

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Abstract

Respiration plays a major role in the human for breathing and speech production. Respiratory measures vary depending on age, gender, weight, height. The present study was aimed to obtain normative baseline for respiratory parameters like forced vital capacity (FVC), forced vital capacity in 1 second (FEV1), peak expiratory flow rate (PEFR), maximum voluntary ventilation (MVV), and vital capacity (VC) at five different body positions like sitting, supine, prone, right lateral recumbent i.e., right side lying (RLR), and standing. A total number of 60 normal healthy individuals (30 male and 30 female) in the age range of 18-30 years were considered for the present study. A Spirometer system RMS Helios 401 was used to measure FVC, FEV1, PEFR, MVV and VC for every subject at different positions. Comparison between respiratory parameters to the five body positions and between genders was done. The mean values were higher at standing position, lesser at prone position for all the parameters in males and females. The mean differences were also observed between positions and between genders for the five parameters in repeated measures of ANOVA results. Thus, respiratory measures changes depending on the body position which might be due to physiological changes in thoracic cavity and muscles of respiratory system.

Introduction

Respiration is an essential and important process in all living organisms. It helps in the exchange of gases and provides oxygen which is very important for the survival. The primary function of respiration is to sustain life, and it is source for the speech production. (Herlihy, 2007). Respiratory measures like lung volumes and lung capacities are useful in understanding in working of respiratory system. Any abnormality in respiration involves in coordination of breathing patterns for speech production. The respiratory parameters pressure, volumes, capacities, flow, and chest wall shape are important for speech production. Spirometry is a physiological test for the assessment and management of chronic obstructive pulmonary disease (COPD), Asthma, acute myocardial infarction, abdomen surgeries, and many other pulmonary diseases. Spirometry plays an important role in assessing and managing respiratory function in production of speech. It is useful for the respiratory function and determining volumes such as vital capacity (VC), tidal volume (VT) and peak expiratory flow rate (PEFR) etc. In normal healthy persons, the volume of air in lungs primarily depends upon the body size. However the body positions also influence the pulmonary measures. It has been found that most of the volumes decrease when person is lying down, sitting, supine rather than in standing position (Hixon, Goldman & Mead, 1973; Townsend, 1984; Lalloo et al., 1991, Badr et al., 2002; Fang et al., 2006).

Nisha and Shinde, (2012) premeditated on COPD and non COPD subjects, PEFR measured with explanation in eight different positions (standing, forward bend sitting, chair sitting, recline sitting, supine lying, side lying(right), side lying (left), head down). Body position has significant effect on PEFR in patients with COPD and normal subjects. Hence, the PEFR increases with increase in up right position. There was strong correlation between PEFR and body position.

Siva Jyothi and Yatheendra Kumar (2015) examined respiratory parameters (PEFR and peak inspiratory flow rate (PIFR)) in normal adults, results reported that a significant change with each position in the order of standing, sitting, supine and prone. Thus, they concluded that standing position is the most preferred for gaseous exchange and prone least.

The respiratory measures are influenced by a number of factors particularly height, age, usual habitat, and geographical conditions. (Da Costa, 1971; Sider & Peter 1973; Cotes & Ward, 1996). A comparative study was done by Zemlin (1981) among the American, European, Jordanian, and the Pakistani subjects. It was found that the former three groups were superior to the remaining groups. The VC varies with the age, sex, height, weight, body surface area, body build and other factors.

Table 1: BMI classification adapted from World Health Organization (WHO 1995, 2004)

Body Weight	BMI
Under weight	<18.50
Normal	18.50-24.99
Over weight	>25.00
Obese	>30.00

Lallo, Becklace, and Goldsmith (1991) examined the effect of the standing versus sitting position on spirometric indices in healthy non-obese adult subjects. On average all the spirometric indices examined except the PEFR, were higher in standing position compared to sitting, reduction in FEV1 with the change in position was statistically related to pond real index but not the age, height or the initial lung function level. Vilke, Chan, Neuman, and Clausen (2000) also stated small differences in spirometric values between sitting, supine and prone position in the normal adult population in FVC, FEV1, and MVV (maximum voluntary ventilation) in sitting, supine, and prone positions.

Krishna Murthy (1986) and Chatterjee, Nag and Dev (1988) reported no significant difference between the vital capacities and mean flow rates for both males and females. Several studies have provided information on the normal standards for air volume measurements in two or three different positions (Hixon, Goldman & Mead, 1973; Pierson, Dick & Petty, 1976; Lallo, Becklace & Goldsmith, 1991). There are no established comparative norms for air volume measurements in five positions that is sitting, standing, supine, prone & right lateral recumbent i.e. right side lying (RLR). For a speech language pathologist, such norms are especially important for estimating the respiratory capacity and efficiency in patients with various voice disorders and speech disorders. It also enhances our understanding of respiratory measures in professional singers who use different position such as sitting and standing.

Thus, literature indicates that the VC and FVC, PEFR and MVV among other aerodynamic factors, play an important role in speech production and also the duration for which an individual can sustain phonation (Hixon, 1973; Kent, 1994).

The aim of the present study was to obtain normative data for FVC, FEV1, PEFR, MVV, and VC in five different positions sitting, standing, supine, prone, and RLR, comparison of the respiratory parameters between the five positions, comparison of the respiratory measures obtained across the gender.

Method

Participants

A total number of 60 normal healthy individuals (30 male and 30 female) in the age range of 18-30 years were considered for the present study. All the subjects were taken based on the inclusionary criteria.

Participant Selection Criteria

The participants were selected based on no history of major health issues such as asthma, chronic obstructive pulmonary disease, abdomen surgeries etc., and no history of orthopedic issues, any alcohol consumption, any smoking, and vigorous exercises were not to be done 30 minutes before the test. Participants were not supposed to consume alcohol for 4 hours prior to the test. They should not have heavy meal before the test in order to avoid inconvenience during the test (British Thoracic Society, 1994). A body mass index (BMI, defines as weight in kilograms divided by height in meters, squared, mentioned in table 1), >30 kg/m2 were also excluded. Pre-testing conditions to performing the spirometric test, subject's were instructed to wear loose clothing for the purpose of the test accurate height, weight of subject's body mass index were calculated for ruling out obesity. For calculating BMI the individuals' body weight is divided by the square of their height using the following formula (WHO 1995, 2004).

$$BMI = \frac{Weight(Kg)}{Height^2(m^2)}$$

Procedure

Each participant was tested individually in the morning hours and was instructed about the test procedure, along with demonstration model given by the researcher. Before starting the test, mouth pieces were cleaned and sterilized properly. Each participant was instructed based on the spirometry parameters. A spirometer system RMS Helios 401 was used to measure the FVC, FEV1, PEFR, MVV, and VC of each subject. All subjects had full range of motion of the supine, prone positions, right lateral recumbent (RLR) position i.e. The participant lay on right side on an examination table, with head facing parallel to the body, legs are extended and feet together.

In each position subjects were made comfortable and a brief rest of 2 minutes was given to minimize the fatigue effect on the respiratory musculatures. The subject has been asked to take deepest breath orally as much as possible (without the spirometer) and blow hard into the transducer tube of the spirometer for obtaining FVC, FEV1, and PEF. To obtain VC the subjects were asked to take normal inhalation and exhalation orally for two times, then to take slowly deep breath as possible and to blow slowly as possible and then to take normal inhalation and exhalation orally. To obtain MVV the subjects were instructed to take deep inhalation orally and to blow out into the transducer tube of the spirometer as fast as possible for 6 sec. Three trails for all these parameters were obtained in different positions. This study is a quasi experimental design.

Statistical Analysis

The data obtained was tabulated and statistically analyzed using analysis of variance (ANOVA) with repeated measures (SPSS Ver.17) to know the significant difference in different positions and parameters.

Results and Discussion

Mean and standard deviation values of FVC, FEV1, PEFR, MVV and VC in five positions are shown in table 2. It can be inferred that for all the five parameters, the mean values were higher in standing position that other positions. On the other hand, the mean values were lesser in prone position in all the parameters except PEFR.

Table 3 represents the mean values of five parameters in both males and females at different positions. The mean values for all the positions was higher in males compared to females, but standing position elicited higher mean than other positions in males and females.

In accordance with the present study results, standing position has lead to the higher lung volumes (Badr et al., 2002; Fang et al., 2006; Lalloo et al., 1991). This might be due to greater elastic recoil of the lungs and the expiratory muscles are at a more optimal part of the length-tension relationship curve and thus capable of generating higher intra thoracic pressures (Leith, 1968; McCool & Leith, 1987). Increased lung volumes in the standing position appear to be related to increased thoracic cavity volume, first gravity pulls the abdominal contents caudally within the abdominal cavity, increasing the vertical diameter of the thorax (Castile et al., 1982). Whereas Vilke et al., (2000) found significant difference between prone, sitting and supine positions. In the prone position, basically lung volume reduces even more compared to other positions because the anterior ribs are compressed by the weight of the body and as a result cannot expand completely, limiting both volume and the ability to force air out of the lungs. Thus, it suggests that respiratory measures vary according to the position of the participants.

Table 2: Mean and standard deviation in parenthesis of FVC, FEV1, PEFR, MVV, and VC in Five positions

Parameter / Position	FVC (lit)	FEV1 (lit)	PEFR (lit)	MVV (lit)	VC (lit)
Sitting	2.73 (.77)	2.61 (.66)	6.53 (1.76)	116.97 (30.43)	2.82 (.66)
Supine	2.56 (.69)	2.49 (.63)	6.26 (1.60)	110.38 (27.94)	2.74 (.64)
Prone	2.48 (.69)	2.35 (.67)	6.33 (1.74)	107.73 (28.55)	2.65 (.68)
RLR	2.56 (.74)	2.46 (.66)	6.19 (1.59)	111.23 (29.83)	2.66 (.74)
Standing	2.91 (.78)	2.77 (.68)	7.07 (1.79)	123.27 (32.04)	2.88 (.78)

**lit- liter*

Table 3: Mean values of 5 parameters in males and females at different positions

Parameter / Position	Gender	N	FVC (lit)	FEV1 (lit)	PEFR (lit)	MVV (lit)	VC (lit)
Sitting	F	30	2.09	2.07	5.33	96.77	2.28
	M	30	3.37	3.16	7.74	137.17	3.36
Supine	F	30	2.02	2.00	5.12	90.73	2.26
	M	30	3.11	2.97	7.41	130.03	3.22
Prone	F	30	1.92	1.87	5.17	88.47	2.22
	M	30	3.04	2.84	7.49	127.00	3.09
RLR	F	30	1.95	1.93	5.08	89.17	2.20
	M	30	3.16	3.00	7.29	133.30	3.13
Standing	F	30	2.18	2.14	5.74	96.90	2.42
	M	30	3.46	3.26	8.46	139.63	3.38

N- Number of Participants, lit- liter

Therefore, males have higher mean values compared to females; standing position elicited higher mean values than other positions. This might be due to the body size, height and physiological characteristics of lungs in different positions. However, the mean differences were observed between positions and between gender for all the parameters. In order to find out the statistical difference between the positions and between gender repeated measures of ANOVA were used. Table 4 represents the F values and significance levels for all the parameters.

Conclusions

Present study was a preliminary attempt to study the effect of body position on respiratory measures in Indian context. The present study aimed to study effect of body position (sitting, supine, prone, RLR and standing) on respiratory measures in both males and females. Spirometry was used to assess FVC, FEV1, PEFR, MVV and VC in above mentioned positions.

The mean values for all the positions was higher in males compared to females, but standing position elicited higher mean prone position lesser mean than other positions in males and females. This might be due to increasing the vertical diameter of the thorax, condensed anterior ribs due to body weight which limits the expansion of lungs resulting in less volume. Difference in all positions for all parameters was observed except in vital capacity. Comparisons of five respiratory parameters between males to females at five positions have exposed significant differences. Males had significantly higher respiratory parameters compared with females. This boldness is due to body build, muscular strength and nutritional status thereby showing higher values in males as compared to females whose body construction is delicate and muscle mass is replaced with more of fat deposits.

Implications of the study

Body position has an effect on the respiratory function test. Change in position alters the lung volumes and capacities. The more standing position the higher the lung volumes. This data serve as a preliminary reference for estimation of lung measurements among subjects with parkinson's disease, cerebellar disease, cervical spinal cord injury, cerebral palsy, voice disorders, chronic obstructive pulmonary disease and asthma other respiratory diseases etc.

Limitation of the study

Only few respiratory parameters were considered for the study. Numbers of participants were less.

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