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RESEARCH PAPER

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A Study of Certain Pulmonary Function Tests in Professional Singers

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ABSTRACT

It has universally been observed that trained professional singers have superior vocal ability as compared to untrained persons. It appears to be due to their better breathing capacity and better ventilator efficiency. Therefore, we have tried to establish the fact that superior pulmonary capacity and breathing efficiency is because of training and presumably does not depend solely on heredity or other factors. To prove our point we determined pulmonary function tests namely FVC, FEV_1, FEV_1/ FVC ratio (%), PEFR and maximum breathing capacity (MBC) in 21 professional singers and 30 untrained persons (control group).

On analysis of the results, it was found that in trained singers there is significant increase in FVC, FEV1, PEFR and MBC while FEV_1/ FVC ratio (%) also showed a definite increase but it was not significant statistically. These parameters also showed improvement with length of vocal training. It is suggested that these parameters have improved because of the ability of professional singers to utilize their residual volume for prolonged expiratory efforts during singing, since total lung capacity cannot be increased.
Key words: Spirometry, FVC, FEV1, FEV1 / FVC ratio (%), PEFR, MBC and Singing.

INTRODUCTION

Pulmonary function tests (PFTS) are important tools in the investigation and monitoring of patients with respiratory pathology. They provide important information related to the large and small airways, the pulmonary parenchyma and the size and integrity of the pulmonary capillary bed. Although they do not provide a diagnosis per se. Different patterns of abnormalities are seen in various respiratory diseases which help to establish a diagnosis. An efficient vocal system uses a balance of airflow and laryngeal muscle activity. Vocal exercises can be used to enhance the function of this system (**Price and Gosling, 2003**, **Heller et al., 1960**).

A healthy voice depends upon healthy respiration. An understanding of respiratory function is essential in evaluating disorders that affect the voice.

Singing, the act of producing musical sounds with the voice, is so basic to human beings that its origin are lost in antiquity, and predate the spoken language. It is well known that respiration has a key role in generating the voice, and it is an essential factor for singing as well. The practice of singing involves strong and fast inspirations followed by extended, regulated expirations. Singing, therefore, requires the presence of an accurate control of breathing. In addition, people who sing are practicing a particular type of respiratory exercise that repeatedly demands diaphragm contractions for full inspirations, followed by sustained contractions of expiratory muscles against semi-closed vocal cords during expirations. This training involving breathing control and respiratory muscle exertion has the potential of interfering with the pulmonary function of COPD patients. Besides its possible effects on respiratory function, singing has been associated with improvements of mood and depression in different settings and may also induce the same kind of response in patients with chronic respiratory failure.

There are conflicting opinions as to whether vocal training results in a superior pulmonary function in trained singers. Some studies have shown there to be no differences between singers and non-singers. While **Carroll**, et al, (1996) suggested that due to their training, singers have a greater pulmonary function and therefore a separate set of normative data is required in order to assess the vocal athlete. **Gould** (1976) also supported the notion that singers have developed increased pulmonary functions and suggested that this is due to trained singers having a reduced residual volume/total lung capacity (RV/TLC) ratio. That is, their vital capacity is expanded at the expense of their residual volume resulting in an increased breathing capacity

MATERIAL AND METHODS

All the pulmonary function tests were performed in the forenoon as described by **Khan**, et al (2002) & **American thoracic society** (1987). The respiratory function tests were performed in Career Institute of Medical Sciences & Hospital, Lucknow (U.P.). The study was done with the help of a computer controlled spirometer (Medspiror). The subject was asked to take deepest possible breath and then to put the mouthpiece of spirometer into the mouth tightly so that no air could leak out from the mouth. Thereafter by closing the nostrils with the other hand, the subject was asked to exhale the air by maximum forceful expiratory effort. In this way the maximum inspiratory effort was followed by a maximum expiratory effort.

The reading for forced vital capacity (FVC), forced expiratory volume in one second (FEV1) and peak expiratory flow rate (PEFR) was directly recorded using spirometer. The percent ratio between FEV1 and FVC was also calculated from the reading.

For recording maximum breathing capacity (MBC), the subject was asked to breathe as rapidly and deeply as he could for a 15 seconds interval. The volume of air moved was recorded by spirometer and the result was expressed as litres/minute.

Pulmonary function tests are a group of tests that measure how well the lungs take in and release air and how well they move gases such as oxygen from the atmosphere into the body's blood circulation & CO_2 from blood circulation to the atmosphere. Pulmonary function tests are done to diagnose certain types of lung diseases such as asthma, bronchitis, and emphysema etc.

These tests also help to:

1. Find the cause of shortness of breath.
2. Measure whether exposure to chemicals at work affects lung function.
3. Check lung function before someone has surgery.
4. Assess the effect of medication and measure progress in disease treatment.

Spirometry

Description - Spirometry is the most frequently used measure of lung functions and is a measure of volume against time. It is a simple and quick procedure to perform. Patients are asked to take a maximal inspiration and then to forcefully expel air for as long and as quickly as possible. Reduction in the amount of air exhaled forcefully in the first second of the forced exhalation (FEV1) may reflect reduction in the maximum inflation of the lungs (TLC), obstruction of the airways, or respiratory muscle weakness. Airway obstruction is the most common cause of reduction in FEV1. Airflow obstruction may be secondary to bronchospasm, airway inflammation, loss of lung elastic recoil, increased secretions in the airway or any combination of these causes. Response of FEV1 to inhaled bronchodilators is used to assess the reversibility of airway obstruction (**Hegewald and Crapo, 2010**).

Indications

Spirometry is used to establish baseline lung functions, evaluate dyspnoea, detect pulmonary disease, monitor effects of therapies used to treat respiratory disease, evaluate respiratory impairment, evaluate operative risk, and perform surveillance for occupational-related lung disease (**Reynolds, 2011**).

Pulmonary function tests

Forced Vital Capacity (FVC) – It is the maximum volume of air that can be expelled out forcefully after a forceful & maximal inspiration (value about 4600 ml in a normal adult male).

Forced Expiratory Volume in 1 sec. (FEV1) – It is the volume of air, which can be expired forcefully in first second (about 83% of forced vital capacity i.e. FEV1/FVC % = 83%, in a normal adult male).
Peak Expiratory Flow Rate (PEFR) – It is the maximum rate at which the air can be expired after a deep inspiration (value 400 to 600 litres/minute or 7 to 10 litres/sec. in a normal adult male).
Maximum Breathing Capacity (MBC) – It is the maximum volume of air which can be breathed in and out of lungs by forceful respiration (value 80-170 litres/minute, average 100 litres/minute in a normal adult male).

RESULTS AND STATISTICAL ANALYSIS

Data was analyzed using Statistical Package for Social Sciences version 15.0. Both control and study groups were assessed for normality of distributions for all the parameters. All the distributions were found to be normal; hence a parametric evaluation plan was conducted. Student 't'- test was used to compare between group data. Within cases, among different categories, intergroup comparison was made using analysis of variance (ANOVA). Confidence level of the study was kept at 95%, hence a "p" value less than 0.05 indicated a statistically significant association.

Table 1 (a). Comparison of Demographic Profile and Anthropometric Parameters of Cases and Controls.

SN	Variable	Cases (n=21)	Controls (n=30)	Statistical Significance
1.	Mean age ± SD (years)	40.33 ± 8.99	35.87 ± 5.53	t = 2.198 ; p = 0.033
2.	Mean Height ± SD (cm)	163.86 ± 6.10	163.77 ± 4.51	t = 0.098 ; p = 0.958
3.	Mean body weight ± SD (kg)	63.39 ± 3.62	60.66 ± 2.39	t = 3.248 ; p = 0.002
4.	Mean BMI ± SD (kg)	23.67 ± 1.81	22.66 ± 1.40	t = 2.248 ; p = 0.029

Table 1 (a) shows that statistically, a significant difference between cases and controls was observed with respect to mean age, mean body weight and mean BMI. It was observed that for all these parameters, mean values of cases were significantly higher as compared to controls ($p<0.05$).

Table 1 (b). Comparison of Demographic Profile and Anthropometric Parameters of Cases and Controls (Modified).

SN	Variable	Cases (n=21)	Controls (n=30)	Statistical Significance
1.	Mean age ± SD (years)	40.33 ± 8.99	39.13 ± 6.03	t = 0.572 ; p = 0.570
2.	Mean Height ± SD (cm)	163.86 ± 6.10	163.77 ± 4.51	t = 0.098 ; p = 0.958
3.	Mean body weight ± SD (kg)	63.39 ± 3.62	62.76 ± 2.57	t = 0.726 ; p = 0.471
4.	Mean BMI ± SD (kg)	23.67 ± 1.81	23.44 ± 1.46	t = 0.496 ; p = 0.622

Table 1 (b) represents that both the cases and controls were matched statistically for age, height, body weight and BMI, showing no statistically significant difference between two groups (p>0.05).

Table 2. Comparison of Pulmonary Function Tests of Cases and Controls.

SN	Variable	Cases (n=21)	Controls (n=30)	Statistical Significance
1.	FVC (litres)	5.12 ± 0.29	4.71 ± 0.40	t = 3.196 ; p < 0.001
2.	FEV_1 (litres)	4.37 ± 0.35	4.03 ± 0.48	t = 2.748 ; p = 0.008
3.	FEV_1/FVC – ratio (%)	85.32 ± 4.18	85.37 ± 3.71	t = 0.048; p = 0.962
4.	PEFR (litres/sec)	11.00 ± 1.64	9.24 ± 1.52	t = 3.930 ; p < 0.001
5.	MBC (litres/minute)	131.57 ± 18.28	116.83 ± 13.76	t = 3.286 ; p = 0.002

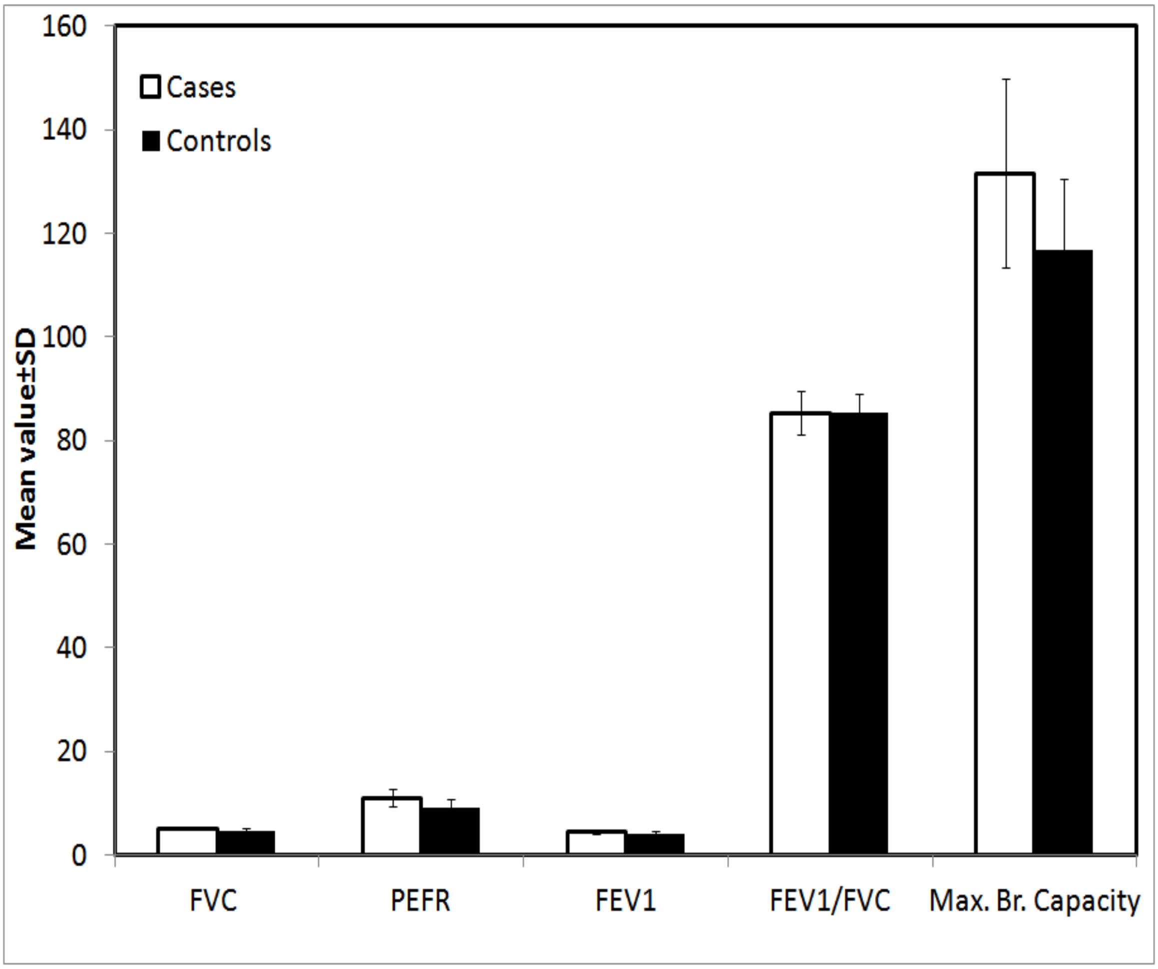

Figure 1. Showing comparison of PFTs of cases and controls.

According to table 2 and figure 1, except for FEV_1/FVC ratio (%), statistically significant difference between cases and controls was observed with respect to all the pulmonary function parameters. It was observed that mean FVC, FEV_1 & PEFR and MBC values in cases were significantly higher as compared to controls (p<0.05). Although mean FEV_1/FVC ratio (%) of cases was also slightly higher as compared to that of controls yet this difference was not significant statistically (p=0.962).

Table 3. Association between exposure to professional singing and pulmonary functions.

SN	Variable	<10 Yrs (n=3)	10-14 Yrs (n=11)	15-20 Yrs (n=7)	Statistical significance (ANOVA)
1.	FVC (litres)	4.85 ± 0.06	5.03 ± 0.25	5.37 ± 0.24	F = 6.942 ; p = 0.006
2.	FEV_1 (litres)	4.03 ± 0.17	4.29 ± 0.31	4.63 ± 0.29	F = 5.345 ; p = 0.015
3.	FEV_1/FVC ratio (%)	83.20 ± 3.12	85.26 ± 4.33	86.33 ± 4.50	F = 0.565 ; p = 0.578
4.	PEFR (litres/sec)	9.21 ± 0.93	11.04 ± 1.56	11.70 ± 1.57	F = 2.874 ; p = 0.083
5.	MBC (litres/minute)	108.67 ± 1.16	125.18 ± 9.72	151.43 ± 12.58	F = 22.681; p < 0.001

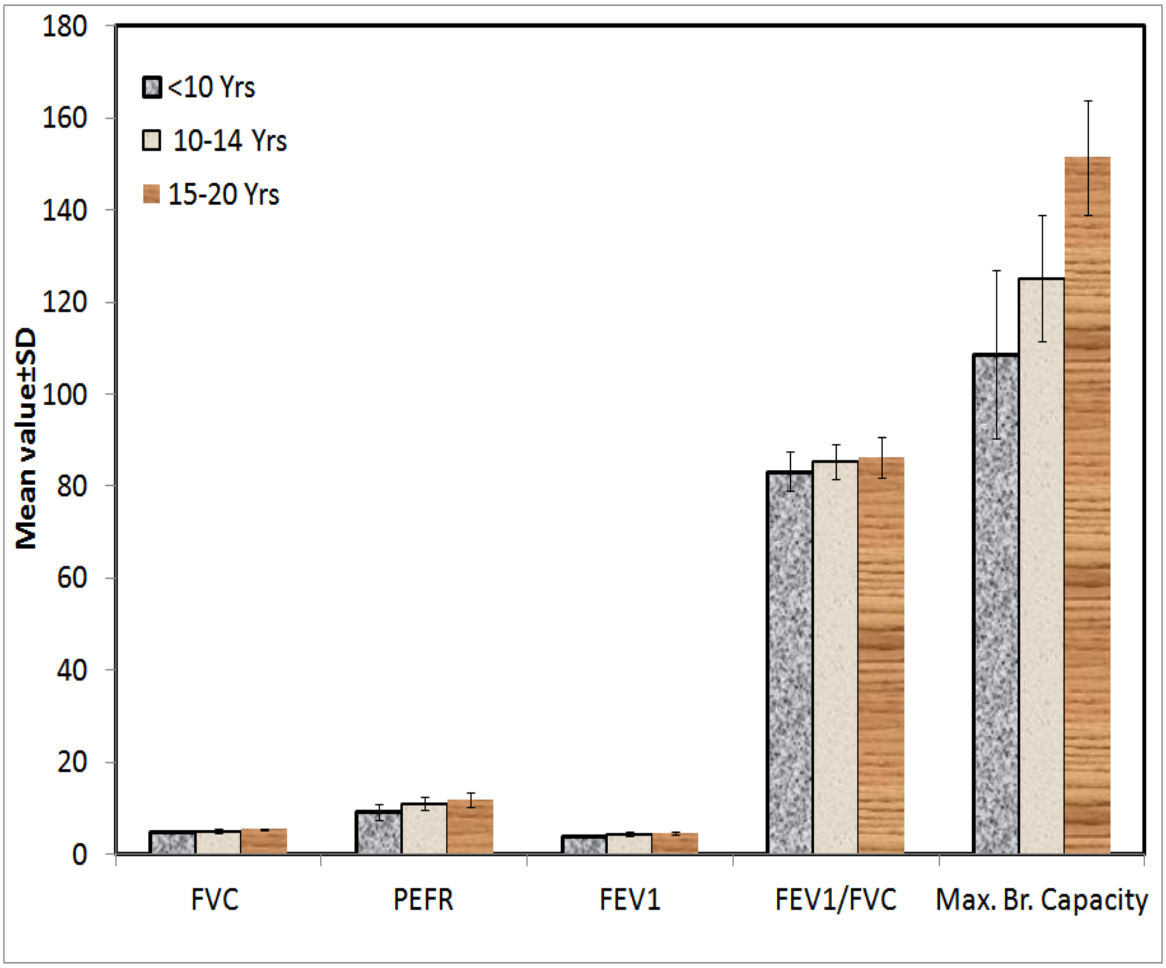

Figure 2. Showing association between PFTs and exposure to professional singing.

Table 3 and figure 2 show that with increasing exposure an increase in all the parameters except FEV_1/FVC ratio (%) and PEFR, was observed. On evaluating the data statistically, the difference was found to be significant statistically for FVC, FEV_1 and MBC ($p<0.05$).

DISCUSSION

The present study showed that singing is a feasible practice to improve pulmonary functions. There is improvement of FVC, FEV1, FEV1/FVC ratio (%), PEFR and MBC in professional singers. It was observed that mean FVC, FEV1, PEFR and MBC values in cases were significantly higher statistically, as compared to controls ($p<0.05$). Mean FEV1/FVC ratio (%) of cases was also slightly higher as compared to that of controls but the difference was not significant statistically ($p=0.962$).
Study further showed that with increasing exposure of professional singing statistically significant increase in all the parameters except FEV1/FVC ratio (%) and PEFR, was observed. This result may also help the patients of respiratory disorders, like patients of COPD, etc. to improve their pulmonary functions.

Amanda et al (2009) studied the effects of training of singing on 43 patients of Chronic Obstructive Pulmonary Disease (COPD). In their study they showed that singing classes are well tolerated activity even for patients of COPD. They also observed in their study that despite its limitations, the singing classes are amusing, non-risky and well tolerated activity for selected subjects of COPD. Additional studies are recommended to better define the potential role of singing as a new tool for pulmonary rehabilitation.

Grasch, et al (2013) also studied the effect of singing on patients of COPD. Their study done to determine that 10 minutes of singing everyday might lead to improved pulmonary function and quality of life in COPD-patients. Singing requires a controlled and precise use of respiratory musculature suggesting its daily use as rehabilitation tool could help reduce respiratory symptoms. While the question remains whether these results bear clinical significance, together these findings build support for the possibility of singing as a therapeutic tool in the treatment of COPD patients meriting further investigations.

Spiegel, et al (1988) mentioned after their study that a healthy voice depends upon healthy respiration. An understanding of respiratory functions is essential in evaluating disorders that affect the voice. Special problems that confront the professional voice user, e.g. the need to optimize respiratory functions even in mild disease states, exposure to environmental irritants, and the athletic demand of performance, are related especially to respiratory function.

In study of **Hoit, et al** (1996), respiratory functions during speaking & singing were investigated in few professional country singers. Their discussion includes the comparison of respiratory performance of present singers with untrained singers & classically trained singers. Implications are offered regarding how the results might be applied to the prevention of voice disorders by education and training of country singers.

CONCLUSION

Hence our study showed that in trained singers there is statistically significant increase in FVC, FEV1, PEFR and MBC while FEV_1/FVC ratio (%) also showed a definite increase but it was not significant statistically. These parameters also showed improvement with length of vocal training. It is suggested that these parameters have been improved because of the ability of professional singers to utilize their residual volume (RV) for prolonged expiratory efforts during singing, since total lung capacity (TLC) cannot be increased.

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