ORIGINAL ARTICLE

EFFECT OF INTENSIVE EXERCISE ON LUNG VOLUMES: ATHLETE VERSUS NON-ATHLETE CHILDREN

Sara Sadiq, Javaria Latif, Azizullah Langah*, Nasima Iqbal, Syed Fazal e Karim Faisal***, Muhammad Aitmaud uddolah Khan†**

Department of Physiology, CMH Institute of Medical Sciences, Bahawalpur, *Department of Paediatric Medicine, People's University of Health Sciences, Nawabshah, **Department of Pathology, Baqai Medical University, Karachi, ***Department of Anaesthesia, Fazaia Ruth Pfau Medical College, Karachi, †Department of Pharmacology, Liaquat National Hospital and Medical College, Karachi, Pakistan

Background: Age, sex, height, weight, ethnicity, smoking habits, physical fitness, exercise, and environmental conditions can all influence spirometry results. Objective of this study was to find out the spirometry lung volumes among athlete children and their comparison with non-athlete children. **Methods:** A descriptive cross-sectional study was carried out with children and adolescents aged 7–18 years from April to October 2021. A modified version of The International Study of Asthma and Allergies in Childhood (ISAAC) Questionnaire 17 was used. Height, weight and body measurements were recorded. Forced Vital Capacity (FVC), Forced Expiratory Volume in 1st second (FEV_1), FEV_1/FVC, Peak Expiratory Flow Rate (PEFR), Forced Expiratory Flow between 25% and 75% expired volume ($FEF_{25-75\%}$) were measured. Data analysis was done on SPSS-20. **Results:** The FVC, FEV_1, FEV_1/FVC ratio, PEF, and $FEF_{25-75\%}$ were 2.24±0.75, 2.06±0.73, 93.01±4.62, 233.3±69.9 and 2.72±1.1 respectively. There was a direct increase in lung volumes with age from children to adolescent and were more among athletes as compared to non-athletes. Mann-Whitney U test showed normal distribution of all pulmonary functions variables including FVC, FEV_1, PEFR, and $FEF_{25-75\%}$ among athletes as well as non-athletes. The independent *t*-test reported a significant variation of all pulmonary function variables among athletes and non-athletes at a confidence interval of 95% ($p \leq 0.000$). **Conclusion:** Age and physical exercise are important factors influencing spirometry reference values and therefore, they should be considered when using spirometry. The physical exercise, particularly intensive exercise in athletes improves lung volumes and should be encouraged in young children.

Keywords: Pulmonary function tests, Athletes, Physical exercise, Spirometry, Reference values

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INTRODUCTION

A leading cause of morbidity and mortality worldwide is respiratory diseases. According to WHO, 235 million people suffer from asthma, while COPD leads to more than 3 million deaths. More than 90% of those deaths occur in low- to middle-income countries.[1] Spirometry is a simple non-invasive test to assess the pulmonary function of an individual. It is used to screen, diagnose and monitor respiratory diseases such as COPD and asthma.[2] Age, sex, height, weight, ethnicity, smoking habits, physical fitness and environmental conditions can all influence spirometry results.[3] Spirometric results are meaningless unless compared against reference values. Therefore, it is essential that predictive values be obtained for specific populations.[4]

Professional athletes are trained such that they may achieve relatively high minute ventilation.[5] Athletes tend to show greater cardiac outputs, larger stroke volume and overall, significantly better cardiovascular function.[6] Spirometry performed in Greek athletes and compared to the European Community of Steel and Coal predicted Spirometric values revealed underestimated lung volumes and FEV_1/FVC ratio.[7] Another study compared pulmonary function amongst athletes, yogis and non-athletes; Yogis had the highest mean FEV_1 and Peak Expiratory Flow Rate (PEFR), followed by athletes when compared to those with a sedentary lifestyle.[8] Given this, we can infer that they would also present higher spirometric values compared to the general population. Nonetheless, very few studies have been done to discern the effects of physical activity on pulmonary function tests.[9,10]

To the best of our knowledge, none of such studies have been done on our population. This leads to decreased usefulness of spirometry and under-diagnosis of respiratory conditions, especially amongst younger athletes. The current study aims to find out the spirometry lung volumes among athlete children and their comparison with the general non-athlete children.

SUBJECTS AND METHODS

This descriptive, cross-sectional study was carried out with children and adolescents aged 7–18 years from April to October 2021. The Ethics Review Committee of Ziauddin University and Hospital, Karachi approved the study. OpenEpi was used to calculate the sample size. For the selection of schools and subjects, a multistage sampling technique was used. First and foremost, 8 schools were randomly selected from different socio-economic strata of Karachi. Next, students corresponding to the particular ages were selected for data collection; entire sections were chosen conveniently. Consent was taken from parents and school authorities. Those children/adolescents either not in the 7–18 year age limit, or those with a history of trauma that can affect the respiratory system, those who were diagnosed cases of wheezing, allergic rhinitis, asthma, any significant respiratory tract disease or of congenital heart diseases, or had muscular disorders like Duchene muscular dystrophy, those on bronchodilator therapy, those with chest wall deformity, and smokers were excluded.

Before performing the test, a modified version of the International Study of Asthma and Allergies in Childhood (ISAAC) Questionnaire17 was used.[11] Height, weight and body measurements were recorded. General physical and systemic examination was carried out on all subjects. Spirometry was done using a Vitalograph-alpha™ which was calibrated before the test. American Thoracic Society/European Respiratory Society (ATS/ERS) Task Force 2005 standardization guidelines18 were used to assess lung volumes.[12] Forced vital capacity (FVC), forced expiratory volume in 1st second (FEV_1), FEV_1/FVC, peak expiratory flow rate (PEFR), forced expiratory flow between 25% and 75% expired volume ($FEF_{25–75\%}$) were measured.

Spirometry was performed in the sitting position, and a nose clip was applied on the nose of the subjects. A minimum of 3 manoeuvres were recorded, and the best value was taken for statistical analysis.

SPSS-20 was used for data analysis. The quantitative variables were presented as Mean±SD, reference values established, and Mean±2 SD was taken as significant through the normal distribution curve. Mann-Whitney U-test was applied for the distribution of data among the subjects. The independent *t*-test was applied to compare pulmonary function variables among athletes and non-athletes at a confidence interval of 95% with $p<0.05$ considered statistically significant.

RESULTS

A total of 1,400 participants were included in the study and spirometry was performed, and 1250 records were selected who met the ATS/ERS task force 2005 acceptability criteria. The mean and standard deviation of demographic variables including age, height, weight and BMI among study participants along with variations among athletes and non-athletes are mentioned in Table-1. Pulmonary function variables including FVC, FEV_1, FEV_1/FVC ratio, PEFR, and $FEF_{25–75\%}$ were 2.24±0.75 L, 2.06±0.73 L, 93.01±4.62%, 233.3±69.9 L/Sec, and 2.72±1.1 L/Sec respectively.

Table-1: Demographic and pulmonary function variables of the subjects (Mean±SD)

Quantitative variables	Total (n=1250)	Athletes (n=638)	Non-athletes (n=612)
Age	13.01±2.9	12.77±2.7	13.15±2.8
Height (Cm)	152.2±15.9	152.2±16.1	150.1±15.6
Weight (Kg)	43.5±15.6	43.5±17.1	43.2 ± 16.1
BMI	19.7±4.4	19.9±4.6	19.4±4.2
FVC (L)	2.24±0.75	2.26±0.77	2.18±0.73
FEV_1 (L)	2.06±0.73	2.11±0.75	2.04±0.71
FEV_1/FVC (%)	93.01±4.62	93.16±4.47	92.66±4.88
PEFR (L/Sec)	233.3±69.9	235.88±71.3	226.84±69.5
$FEF_{25–75\%}$ (L/Sec)	2.72±1.1	2.76±1.3	2.61±1.0

There is a direct increase in lung volumes with age from children to adolescent as presented in Table-2. The Table is also an evident of increase in pulmonary function variables more among athletes as compared to non-athletes so beside other factors that affect the pulmonary function normative values including age, height, weight, socioeconomic status and cultural factors, the physical exercise should also be consider into an account.

Table-2: Mean pulmonary function variables with reference to age among athletes and non-athletes

Age	Variables	Mean±SD	
		Athletes	**Non-athletes**
7 Years	FVC (L)	1.0±0.12	0.89±0.12
	FEV_1 (L)	0.95±0.14	0.83±0.13
	FEV_1/FVC (%)	95.29±5.28	93.0±2.89
	PEFR (L/Sec)	128.7±7.2	135.1±21.3
	$FEF_{25–75\%}$ (L/Sec)	1.10±0.05	1.08±0.06
8 Years	FVC (L)	1.17±0.22	1.08±0.14
	FEV_1 (L)	1.07±0.19	0.98±0.14
	FEV_1/FVC (%)	91.88±4.62	91.10±5.68
	PEFR (L/Sec)	147.6±12.55	150.6±14.83
	$FEF_{25–75\%}$ (L/Sec)	1.27±0.23	1.27±0.09
9 Years	FVC (L)	1.27±0.11	1.26±0.15
	FEV_1 (L)	1.16±0.12	1.15±0.16
	FEV_1/FVC (%)	91.83±4.79	90.28±5.05
	PEFR (L/Sec)	150.6±20.72	151.3±14.48
	$FEF_{25–75\%}$ (L/Sec)	1.36±0.192	1.35±0.11
10 Years	FVC (L)	1.44±0.14	1.39±0.33
	FEV_1 (L)	1.27±0.16	1.34±0.32
	FEV_1/FVC (%)	90.74±4.76	92.32±3.38
	PEFR (L/Sec)	156.1±13.34	165.9±18.19
	$FEF_{25–75\%}$ (L/Sec)	1.62±0.19	1.49±0.18
11 Years	FVC (L)	1.68±0.18	1.59±0.14
	FEV_1 (L)	1.56±0.20	1.45±0.15
	FEV_1/FVC (%)	92.02±5.01	90.61±5.31
	PEFR (L/Sec)	171.2±33.01	171.16±18.09
	$FEF_{25–75\%}$ (L/Sec)	1.77±0.29	1.73±0.26
12 Years	FVC (L)	1.91±0.23	1.89±0.21
	FEV_1 (L)	1.78±0.24	1.78±0.22
	FEV_1/FVC (%)	93.38±4.48	93.04±4.43
	PEFR (L/Sec)	195.6±22.34	195.4±19.8
	$FEF_{25–75\%}$ (L/Sec)	2.15±0.42	2.05±0.39
13 Years	FVC (L)	2.11±0.22	2.06±0.16
	FEV_1 (L)	1.97±0.24	1.91±0.21
	FEV_1/FVC (%)	93.0±4.13	92.79±5.34
	PEFR (L/Sec)	218.9±20.27	213.0±17.85
	$FEF_{25–75\%}$ (L/Sec)	2.41±0.26	2.35±0.13
14 Years	FVC (L)	2.46±0.25	2.38±0.21
	FEV_1 (L)	2.30±0.28	2.21±0.27
	FEV_1/FVC (%)	93.39±4.76	92.68±5.0
	PEFR (L/Sec)	250.8±20.02	248.5±20.9
	$FEF_{25–75\%}$ (L/Sec)	2.89±0.39	2.76±0.25
15 Years	FVC (L)	2.81±0.26	2.78±0.19
	FEV_1 (L)	2.65±0.25	2.60±0.22
	FEV_1/FVC (%)	94.16±3.86	93.13±5.08
	PEFR (L/Sec)	277.9±20.08	279.1±15.46
	$FEF_{25–75\%}$ (L/Sec)	3.32±0.33	3.41±0.36
16 Years	FVC (L)	3.09±0.24	3.02±0.23
	FEV_1 (L)	2.94±0.26	2.87±0.28
	FEV_1/FVC (%)	94.84±3.22	94.09±4.36
	PEFR (L/Sec)	310.3±30.32	309.7±32.79
	$FEF_{25–75\%}$ (L/Sec)	3.86±0.56	3.88±0.52
17 Years	FVC (L)	3.44±0.27	3.32±0.26
	FEV_1 (L)	3.18±0.22	3.26±0.23
	FEV_1/FVC (%)	94.20±3.93	94.29±4.48
	PEFR (L/Sec)	350.5±45.04	342.7±38.26
	$FEF_{25–75\%}$ (L/Sec)	4.82±0.61	4.97±0.82
18 Years	FVC (L)	3.58±0.22	3.47±0.42
	FEV_1 (L)	3.39±0.26	3.21±0.33
	FEV_1/FVC (%)	94.50±4.31	91.60±5.10
	PEFR (L/Sec)	376.0±73.28	336.9±42.96
	$FEF_{25–75\%}$ (L/Sec)	5.14±0.61	5.19±0.65

Mann-Whitney U test showed normal distribution of all the pulmonary functions variables including FVC, FEV_1, PEFR, and $FEF_{25–75\%}$ among athletes as well as non-athletes. The independent *t*-test was applied which reported a significant variation of all pulmonary function variables among athletes and non-athletes at confidence interval of 95% with $p \leq 0.000$ Table-3.

Table-3: Comparison of pulmonary function variables among athletes and non-athletes

Variables	*t*	95% CI		*p*
		Lower	Upper	
FVC	80.84	2.16	2.27	0.000
FEV_1	77.67	2.02	2.13	0.000
PEFR	89.87	226.2	236.4	0.000
$FEF_{25–75\%}$	61.30	2.59	2.77	0.000

DISCUSSION

Spirometry is an important diagnostic tool for evaluating several different respiratory diseases such as chronic bronchitis, emphysema, and asthma etc.[13,14] It is routinely used to check lung function in the out-patient setting therefore; we need population specific reference values for comparison.[15] The variables measured using spirometry are influenced by age, gender, height, weight, ethnicity and socioeconomic status.[16] Multiple factors affecting the reference values have made it difficult to decide that which one can be kept as an independent variable in creating the predictive equation.[17] In this survey, we checked the influence of age and physical exercise on spirometry reference values.

Several studies have supported the idea that when age is kept as the independent variable there is a linear correlation in case of children and adolescents.[18,19] Current research has also deduced a positive relationship of age and spirometry variables like FVC, FEV_1, PEFR and $FEF_{25–75\%}$. The plausible explanation of this correlation could be that the ability of the lung to stretch increases with increasing age as there is growth of musculature and increase in the thoracic diameter.[19] However, in adults there is a negative correlation between lung function and age as there is a decrease in elasticity of lungs and constriction of airways.[20] The Current study shows that there is progressive increase in lung volumes from the age of 7–18 years although there are some researches which have reported that lung volumes decrease from 4–10 years of age and then increase up to 20 years of age.[21,22]

There are a number of benefits of physical exercise, one of them is improved pulmonary function variables. There is a positive correlation of physical exercise and spirometry variables like FVC, FEV_1, PEFR and $FEF_{25–75\%}$. Athletes are often given Inspiratory Muscle training and Inspiratory Muscle training leads to increased strength of musculature and stamina along with better lung function and diaphragm thickness.[23] These results were consistent with another research where lung function, diaphragm thickness and stamina increased after IMT in patients with Cystic Fibrosis.[24] Yoga is also one of the exercises which improves chest wall expansion and lung function according to a research carried out in Thailand.[25] According to Mandanmohan, Yoga improves lung volumes particularly in children.[26] Another research carried out in India revealed that people who played sports had increased lung volumes compared to normal population particularly swimmers.[27] A possible explanation for better lung volumes in exercising people could be increased diameter of thoracic cavity and increases number of alveoli.[28] This mechanism is especially important in development of increased lung volumes in children.[29]

CONCLUSION

Age and physical exercise are important factors influencing spirometry reference values, and therefore, they should be considered when interpreting spirometry results. Physical exercise, particularly intensive exercise in athletes improves lung volumes and should be encouraged in young children.

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Address for Correspondence:

Dr Sara Sadiq, Noon house, Dilawar Colony, Airport/Yazman Road, Bahawalpur, Pakistan. **Cell:** +92-335-2127642
Email: dr.sarabhatti@gmail.com

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