Original Article

Ventilatory functions as an evaluation tool in the assessment of pulmonary system adaptability in marathon runners

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Abstract

Background: There are diverse opinions about the degree of adaptability of the respiratory system in delivering the physiological needs in case of severe exercise. Role of the normal respiratory system in delivering oxygen to meet the demands of various degrees of exercise has been a topic of considerable debate. One view holds that the respiratory system is not normally the most limiting factor in the delivery of oxygen, others hold the absence of structural adaptability to physical training cause of limitation of the pulmonary system. The role of ventilator functions in evaluating the respiratory functions in marathon runners has not been studied adequately in previous studies. Hence the need for this study. **Materials and Methods:** Pulmonary Function Tests were done before and after maximal exercise testing to assess dynamic lung functions in two groups' viz., athletes and nonathletes. The athletes were marathon runners. **Results:** On studying the differences in dynamic lung functions in two groups of nonathletes and athletes, there was no difference in forced vital capacity and forced expiratory volume in 1 s, before or after exercise (AE) testing in either. The other flow rates maximum mid-expiratory flow, peak expiratory flow rate, mid expiratory flow 25-75% were on the higher side in trained subjects that were consistently maintained AE testing. A higher adaptability of the respiratory system to the training stimulus in the form of a higher elastic recoil pressure of the lungs and a lower resistance of medium to small airways is suggested as the mechanism of adaptability in this study.

Key words: Airflow limitation, dynamic lung functions, exercise testing, marathon runners, ventilatory functions

INTRODUCTION

There are diverse opinions about the degree of adaptability of the respiratory system in delivering the physiological needs in case of severe exercise. There are reports that the respiratory system is not normally the most limiting factor in the delivery of oxygen to the muscles during maximal muscle aerobic metabolism, whereas others do not subscribe to this.[1]

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Mechanical constraints on exercise hyperpnea have been studied as a factor limiting performance in endurance athletes'.[2] Others have considered the absence of structural adaptability to physical training as one of the "weaknesses" inherent in the healthy pulmonary system response to exercise.[3]

Ventilatory functions are an important part of functional diagnostics,[4] aiding selection and optimization of

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training and early diagnosis of sports pathology. Assessment of exercise response of dynamic lung functions in the healthy pulmonary system in the trained and the untrained has a role in clearing gaps in the above areas.

MATERIALS AND METHODS

The present study was conducted in the department of physiology, PES Institute of Medical Sciences, Kuppam as a part of cardio-pulmonary efficiency studies on two groups of nonathletes (n = 30) and athletes (n = 30) comparable in age and sex.

Informed consent was obtained and clinical examination to rule out any underlying disease was done. Healthy young adult males between 19 and 25 years who regularly undergo training and participate in competitive marathon running events for at least past 3 years were considered in the athlete group whereas the nonathlete group did not have any such regular exercise program. Smoking, clinical evidence of anemia, obesity, involvement of cardio-respiratory system was considered as exclusion criteria.

Detailed procedure of exercise treadmill test and a computerized spirometry was explained to the subjects.

Dynamic lung functions were measured in both groups before exercise (BE) was evaluated following standard procedure of spirometry using a computerized spirometer Spl-95. All subjects were made to undergo maximal exercise testing to VO_2 max levels on a motorized treadmill.

After exercise (AE), the assessment of dynamic lung functions was repeated. All these set of recordings were done on both the nonathlete as well as the athlete groups.

Statistical analysis was done using paired Student's t-test for comparing parameters within the group before and AE testing and unpaired t-test for comparing the two groups of subjects.

A $P < 0.01$ was considered as significant.

RESULTS

On comparing the anthropometric data of the two groups of subjects studied, it is shown in table 1 that the two groups were similar statistically. From tables 2 and 3, it is clear that there is no significant difference in dynamic lung functions within the groups after exercise. On comparing the dynamic lung functions between the two groups before exercise in table 4 it was found that MMEF, PEFR, MEF 25-75 were significantly different.

DISCUSSION

Considerable information can be obtained by studying the exercise response of dynamic lung functions in untrained and trained subjects.

Intra group comparison is helpful in noting the exercise response and inter-group comparison in evaluating adaptations of the respiratory system to training.

On comparing the anthropometric data of the two study groups it is clear that the age and sex matched subjects have no statistically significant difference in height, weight and body mass index taking a $P < 0.01$ as significant.

VO_2 max values were higher in athletes and was statistically significant ($P < 0.001$). This observation is expected in view of the training stimulus and adaptability of both the pulmonary system and the cardio vascular system. VO_2 max is an objective index of the functional capacity of the body's ability to generate power.

Forced vital capacity (FVC) is the volume expired with the greatest force and speed from total lung capacity and forced expiratory volume in 1 s (FEV1) that expired in the 1st s during the same maneuver. The FEV1 was initially used as an indirect method of estimating its predecessor as the principal pulmonary function test, the maximal breathing capacity.[5]

On comparing the response of exercise within the two study groups and in between them, there is no statistically significant difference in FVC and FEV1 under any condition.

A normal FEV1/FVC ratio is always observed.

Another way of looking at forced expiration is to measure both expiratory flow, and the volume expired. The maximum flow obtained can be measured from the flow – volume curve is the peak expiratory flow rate (PEFR). The peak flow occurs at high lung volumes and is an effort dependent. Flow at lower lung volumes is effort independent. Flow at lower lung volumes depends on the elastic recoil pressure of the lungs and the resistance of the airways upstream or distal to the point at which dynamic compression occurs. Measurements of flow at low lung volumes, mid expiratory flow (MEF 25-75%)

are often used as indices of peripheral or small airways resistance.[5]

On examining [Tables 2 and 3] it is clear that exercise *per se* does not cause a statistically significant change in dynamic

Table 1: Comparison of anthropometric data and VO_2 max of nonathletes and athletes with statistical analysis

Parameter	Nonathletes	Athletes	*P*	Remarks
Age (year)	22.48±2.62	22.45±2.89	<0.10	NS
Height (cm)	168.70±7.50	165.90±7.24	<0.10	NS
Weight (kg)	60.06±5.64	59.43±6.26	<0.10	NS
BMI (kg/m²)	22.02±2.47	21.60±1.75	<0.10	NS
VO_2 max (L/min)	2.99±0.16	3.02±0.27	<0.001	HS

P<0.01 significant, *P*<0.001 highly significant, Degree of freedom=58. NS = Not significant; BMI = Body mass index

Table 2: Comparison of dynamic lung functions of nonathletes BE testing and AE testing with statistical analysis

Parameter	Nonathletes (*n*=30)		*P*	Remarks
	BE	AE		
FVC (L)	3.58±0.52	3.34±0.56	<0.10	NS
FEV1 (L)	3.56±0.50	3.29±0.05	<0.05	NS
FEV1/FVC	0.94	0.95		
MMEF (L/S)	4.99±1.31	4.99±1.46	<0.10	NS
PEFR (L/S)	7.22±1.78	6.72±1.96	<0.10	NS
MEF 75(L/S)	6.42±1.94	5.86±1.74	<0.10	NS
MEF 50(L/S)	5.47±1.44	5.45±1.63	<0.10	NS
MEF 25(L/S)	3.47±1.16	3.71±1.47	<0.10	NS

P<0.01 is considered significant. Degree of freedom=29. NS = Not significant; BE = Before exercise; AE = After exercise; FVC = Forced vital capacity; FEV1 = Forced expiratory volume in 1 s; MMEF = Maximum mid-expiratory flow; PEFR = Peak expiratory flow rate; MEF = Mid expiratory flow

Table 3: Comparison of dynamic lung functions of athletes BE testing and AE testing with statistical analysis

Parameter	Athletes (*n*=30)		*P*	Remarks
	BE	AE		
FVC (L)	3.11±0.39	3.12±0.30	<0.05	NS
FEV1 (L)	3.17±0.30	3.09±0.30	<0.05	NS
FEV1/FVC	0.99	0.99		
MMEF (L/S)	6.09±1.21	6.44±1.07	<0.1	NS
PEFR (L/S)	8.73±1.09	8.59±0.84	<0.1	NS
MEF 75 (L/S)	8.27±1.28	8.14±1.13	<0.1	NS
MEF 50 (L/S)	6.38±1.20	6.83±0.92	<0.1	NS
MEF 25 (L/S)	4.34±1.11	5.01±1.05	<0.05	NS

P<0.01 is considered significant. Degree of freedom=29. NS = Not significant; BE = Before exercise; AE = After exercise; FVC = Forced vital capacity; FEV1 = Forced expiratory volume in 1 s; MMEF = Maximum mid-expiratory flow; PEFR = Peak expiratory flow rate; MEF = Mid expiratory flow

Table 4: Comparison of dynamic lung function of nonathletes and athletes before exercise testing with statistical analysis

Parameter	Nonathletes	Athletes	*P*	Remarks
FVC (L)	3.56±0.52	3.32±0.39	<0.05	NS
FEV1 (L)	3.52±0.51	3.27±0.35	<0.05	NS
FEV1/FVC	0.95	0.99		
MMEF (L/S)	4.93±1.31	6.02±1.21	<0.001	HS
PEFR (L/S)	7.21±1.78	8.75±1.09	<0.001	HS
MEF 75 (L/S)	6.41±1.94	8.28±1.28	<0.001	HS
MEF 50 (L/S)	5.42±1.44	6.39±1.20	<0.01	S
MEF 25 (L/S)	3.45±1.17	4.35±1.12	<0.01	S

P<0.01 significant, *P*<0.001 highly significant. Degree of freedom=58. NS = Not significant; BE = Before exercise; AE = After exercise; FVC = Forced vital capacity; FEV1 = Forced expiratory volume in 1 s; MMEF = Maximum mid-expiratory flow; PEFR = Peak expiratory flow rate; MEF = Mid expiratory flow lung function parameters maximum mid-expiratory flow (MMEF), PEFR, MEF 25-75% in either of the groups. This finding supports the hypothesis that the respiratory system is not normally the most limiting factor in the delivery of oxygen.

On comparing dynamic lung functions in terms of the above flow rates of nonathletes and athletes BE [Table 4] it is seen that athletes have higher MMEF, PEFR, MEF 25-75%. This suggests a higher adaptability of the respiratory system to the training stimulus.

These changes are consistently maintained after maximal exercise testing suggesting a higher elastic recoil pressure of the lungs and a lower resistance of medium to small airways in response to exercise as a result of adaptive mechanisms in the pulmonary system.

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