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ORIGINAL ARTICLE

Pulmonary Functions in Volleyball and Basketball Players of Kolkata, India

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Abstract

Background: Assessment of lung function is an indispensable tool for determination of the health status in case of the athletes. Present study focused on evaluating the lung function parameters for the state-level male basketball players and male volleyball players of West Bengal, India apart from comparing the data with their age-matched healthy, sedentary male counterparts.

Methods: State-level young male basketball (n = 40) and volleyball (n = 40) players being involved in athletic training for a minimum of 5 years were employed in the study from several sports clubs in Kolkata. Sedentary group subjects (n = 30) who were non-smokers and belonging to similar socio-economic background served as the control group for the study. Standard procedures were followed for measurement of the physical parameters and pulmonary functions.

Results: Physical parameters like body height, body weight were significantly ($p < 0.05$) lower in case of the sedentary male control subjects when compared against both basketball and volleyball players. Vital capacity (VC), forced vital capacity (FVC), forced expiratory volume in 1 second (FEV_1), end expiratory flow ($FEF_{75\%-85\%}$) and peak expiratory flow rates (PEFR) were significantly ($p < 0.05$) higher for both the basketball and volleyball players in contrast to their age-matched, healthy sedentary counterparts. Body height and body weight were found to be correlated significantly with the lung function parameters. For prediction of the pulmonary function parameters in the studied population, both simple as well as multiple linear regression equations were computed.

Conclusion: Data from the study revealed that participation in court sports like Basketball and Volleyball lead to improvement of the pulmonary functions status of the athletes possibly due to their training pattern and game demands. Prediction of the pulmonary function in the studied population may be done by employing the regression equations.

Keywords

Lung function, FVC, VC, PEFR

Introduction

Fitness of an individual may be adjudged by employing a battery of physiological test manoeuvres, and lung function test is one such suitable method [1]. For an athlete to excel in a particular sport, it is imperative to have both strength of the respiratory muscles and good pulmonary capacities [2]. Various studies have highlighted that regular participation in physical activity or sport has beneficial effects on health due to attainment of better pulmonary function [2]. In this context, measurement of the lung volumes and capacities is efficient for determining the functional state of the respiratory system. Training exerts a significant change in breathing volumes and frequency [3].

Gaseous exchange in the human body occurs through diffusion of huge amount of oxygen into the blood at the time of performing physical activity [4]. Lifestyle plays a major role in influencing the lung function parameters, as there is a keen association between pulmonary capacities and volume of regular exercise performed by an individual [5]. Pertinent studies have revealed that exercise has beneficial effects in terms of enhancing the pulmonary functions [6,7]. Hence, lung function tests appear as crucial tools whereby both qualitative and quantitative evaluation of pulmonary function is carried out in an attempt to understand the diagnostic and

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therapeutic effects in a particular population or in the concerned individuals [8].

This, pulmonary function testing is considered as a crucial and commonly used diagnostic procedure considering its simplicity in terms of application [9]. Movement of air between the atmosphere and lung alveoli is tested through this lung function tests through measurement of both static and dynamic lung volumes and capacities [9]. Thus, volumes of air inhaled or exhaled by an individual, as a function of time is determined by virtue of employing the test that in turn serves as a tool of health evaluation not only in case of sedentary people but also in case of sportspersons.

Lung function is essentially dependent on certain unchangeable factors such as that of genetic endowment of the individual and ethnic background [10]. Moreover, efficient breathing capacity of an individual has also been found to rely on some important factors such as width of the rib cage and strength of the respiratory muscles [10]. However, lung volumes greater than the predicted values has been repeatedly noted in case of athletes in contrast to their control counterparts who are not associated with any sort of regular exercise regime [11,12].

High intensity court sports like that of volleyball and basketball which require repeated maximum exertion (e.g., dashing, jumping, etc) potential agile power with muscular strength and aerobic fitness have evolved among world's popular sports that are being played in almost every nation at varying levels of competence [13,14]. Volleyball player's fitness relies on their force, power output and jumping ability [15]. Main features of general physical fitness involved in basketball are anaerobic endurance and speed of movement. Other authors have added agility as a key factor in this sport [16].

Pulmonary functions in athletes playing various sports have been extensively studied across the globe [10,17]. Studies conducted in the Indian context is however limited. The present study was therefore aimed to evaluate the lung functions in male volleyball and basketball players of Kolkata, India and to compare the data not only between the groups but also with their sedentary and overseas counterparts. Further, it was attempted to propose regression equations for the prediction of lung volumes and capacities in the studied groups.

Materials and Methods

Study design

The Sports and Exercise Physiology Laboratory, Department of Physiology, University of Calcutta was the place where the entire study was undertaken. Participants visited the laboratory for two occasions which were further categorized as Familiarization Trial and Experimental Trial, respectively. The subjects were demonstrated and familiarized with the experimental protocols during the familiarization trial for the sake of allaying their apprehensions. On their second visit, i.e., during the Experimental Trial, the experiments were conducted for data collection. Ethical approval was obtained from the Human Ethical Committee, Department of Physiology, University of Calcutta and all the subjects volunteered to participate in the study through written informed consent.

Selection of subjects

Healthy, male volleyball (n = 40) and basketball (n = 40) players with age ranging between 18 and 30 years were recruited from various Sports Associations and eminent clubs of Kolkata, India and their sedentary control counterparts (n = 30) were recruited from the residential area where the players reside. All the subjects were non-smokers and had similar socio-economic background. The athletes were into regular athletic training schedule for an average of 6 years and 8 years for the volleyball and basketball players, respectively. Personal demographic data, health status in addition to consent for participation in the study was obtained through filling up of questionnaire by each subject. The sedentary control individuals were not connected with any physical conditioning programme and did not have a regular exercise regime. Individuals having history of any chronic ailments or major diseases and undergoing treatment for the same were excluded from taking part in the study.

Preparation of subjects

Calculation for the age of each subject was done in nearest year from the date of birth as procured from the Photo ID issued by the Government of India. Prior to the experiment the subjects were requested to take breakfast at least 2 hrs before the trial and were asked not to undertake any strenuous physical work. They reported to the laboratory at 10 AM in the morning and were allowed to take rest for half an hour. Measurements of body height and body mass were taken with the subject standing barefoot and wearing minimum clothing on a weighing machine built-in with height measuring rod (Avery India Ltd, India) having an accuracy of ± 0.50 cm and ± 0.1 kg, respectively.

Determination of Pulmonary Function Tests (PFTs)

PFTs were performed at the same time of the day to avoid any chance of diurnal variation. A 9-L closed-circuit-type expirograph (Toshniwal Technologies Pvt. Ltd., India) was used to record the PFTs. The parameters taken into account in this study to evaluate static lung function measurements were Tidal Volume (TV) and Vital Capacity (VC) while Forced Vital Capacity (FVC), Forced Expiratory Volume in first sec (FEV_1), FEV_1 expressed as a percentage of FVC ($FEV_1\%$), Mid-Expiratory Flow Rate ($FEF_{25\%-75\%}$) and End Expiratory Flow Rate ($FEF_{75\%-85\%}$)

were recorded to evaluate the dynamic lung function measurements. Moreover, Peak Expiratory Flow Rate (PEFR), another significant measure of dynamic lung function was also measured with the help of Wright's peak flow meter [18]. Calibration of the expirograph was done daily by using a Palmer respiratory hand pump. All the measurements were done by using standard procedure [19]. Participants were motivated and encouraged to attain maximum inspiratory and expiratory efforts. In accordance with the convention, for each volunteer, recordings of three satisfactory efforts were considered with at least 5 minutes rest between the consecutive trials [20]. After a couple of practice runs, at least three trials were conducted of which the highest value was accepted [20]. Expressions of all pulmonary function measurements were done at body temperature and pressure saturated with water vapour (BTPS).

Statistical analysis

The data were expressed as Mean ± Standard Deviation (SD). One way analysis of variance (ANOVA) was resorted for comparing the measured variables among different groups. After a significant main effect was detected, Tukey's post-hoc analyses were employed to locate where specific mean differences were laid. Pearson's product-moment correlation coefficient (r) was computed for evaluation of the relationship between pulmonary function measurements and physical parameters. Simple and multiple regression analysis were also performed for computation of the prediction norms for different pulmonary function variables from the physical parameters. The level of significance was set at $p < 0.05$. Data were analyzed by using Statistical Package for Social Sciences (SPSS), Version 21.

Results

Values of the physical parameters of all the studied groups have been presented in Table 1. ANOVA revealed that body height and body weight of both basketball and volleyball groups were significantly ($p < 0.05$) differ-

Table 1: Physical parameters and values of different pulmonary function parameters of the Sedentary, Basketball and Volleyball groups.

	Group		
	Sedentary (n = 30)	**Basketball (n = 40)**	**Volleyball (n = 40)**
Age (years)	22.70 ± 0.67	22.70 ± 3.02	20.80 ± 3.39
Body height (cm)	167.55 ± 4.53	185.61 ± 5.39*	183.74 ± 6.65*
Body weight (kg)	60.05 ± 4.60	70.61 ± 6.97*	70.10 ± 6.87*
TV (l)	0.492 ± 0.03	0.543 ± 0.05	0.545 ± 0.07
VC (l)	4.09 ± 0.20	4.69 ± 0.16*	4.48 ± 0.35*
FVC (l)	4.00 ± 0.23	4.65 ± 0.16*	4.65 ± 0.19*
FEV_1 (l)	3.35 ± 0.22	3.86 ± 0.11*	3.91 ± 0.04*
FEV_1% (%)	83.89 ± 4.74	83.01 ± 1.07	84.09 ± 2.98
PEFR ($l.min^{-1}$)	611.30 ± 37.37	690.30 ± 20.08*	688.90 ± 15.69*
$FEF_{25\% - 75\%}$ ($l.min^{-1}$)	182.70 ± 63.28	228.79 ± 17.40*	205.38 ± 12.59
$FEF_{75\% - 85\%}$ ($l.min^{-1}$)	92.43 ± 12.53	126.70 ± 17.02*	132.90 ± 13.37*

Values are mean ± SD, *p < 0.05 (When compared with the sedentary group).

Table 2: Values of Pearson's product moment correlation coefficient (r) between physical parameters (viz, age, height and weight) and lung function measurements and the simple regression equations for the prediction of VC, FVC, FEV_1, $FEFR_{25\% - 75\%}$, $FEF_{75\% - 85\%}$ and PEFR from age, height and weight in the studied groups.

Pulmonary function measurement	**Group**	**Physical parameter**	**Correlation Coefficient (r)**	**Regression equation**	**SEE (l)**
VC (l)	Sedentary	H	r = 0.78	VC = 0.04H - 1.83	0.13
		W	r = 0.64	VC = 0.03W + 2.38	0.17
	Basketball	H	r = 0.86	VC = 0.03H - 0.08	0.09
		W	r = 0.69	VC = 0.02W + 3.57	0.12
	Volleyball	H	r = 0.85	VC = 0.04H - 3.63	0.19
		W	r = 0.79	VC = 0.04W + 1.67	0.22
FVC (l)	Sedentary	H	r = 0.82	FVC = 0.04H - 2.94	0.14
		W	r = 0.88	FVC = 0.04W + 1.38	0.11
	Basketball	H	r = 0.88	FVC = 0.03H - 0.17	0.08
		W	r = 0.70	FVC = 0.02W + 3.52	0.12
	Volleyball	H	r = 0.76	FVC = 0.02H + 0.71	0.13
		W	r = 0.74	FVC = 0.02W + 3.24	0.13
FEV_1 (l)	Sedentary	H	r = 0.72	FEV_1 = 0.03H - 2.44	0.16
		W	r = 0.82	FEV_1 = 0.04W + 1.02	0.13
	Basketball	H	r = 0.81	FEV_1= 0.02H + 0.89	0.07
	Volleyball	H	r = 0.85	FEV_1= 0.005H + 3.04	0.02
		W	r = 0.92	FEV_1 = 0.005W + 3.56	0.02

$FEF_{25\% - 75\%}$ ($l.min^{-1}$)	Sedentary	H	r = 0.72	$FEF_{25\% - 75\%}$ = 10.10H - 1508.82	46.44
	Basketball	H	r = 0.80	$FEF_{25\% - 75\%}$ = 2.58H - 250.85	11.05
		W	r = 0.74	$FEF_{25\% - 75\%}$ = 1.85W + 98.51	12.44
	Volleyball	H	r = 0.83	$FEF_{25\% - 75\%}$ = 1.57H - 82.72	7.49
		W	r = 0.71	$FEF_{25\% - 75\%}$ = 1.31W + 113.62	9.35
$FEF_{75\% - 85\%}$ ($l.min^{-1}$)	Basketball	H	r = 0.74	$FEF_{75\% - 85\%}$ = 2.33H - 305.92	12.18
		W	r = 0.68	$FEF_{75\% - 85\%}$ = 1.66W + 9.43	13.24
	Volleyball	H	r = 0.81	$FEF_{75\% - 85\%}$ = 1.64H - 167.96	8.23
		W	r = 0.81	$FEF_{75\% - 85\%}$ = 1.58W + 22.02	8.26
PEFR ($l.min^{-1}$)	Sedentary	H	r = 0.66	PEFR = 5.46H - 303.99	29.72
	Basketball	H	r = 0.87	PEFR = 3.23H + 90.31	10.58
		W	r = 0.80	PEFR = 2.31W + 527.29	12.76
	Volleyball	H	r = 0.86	PEFR = 2.03H + 315.76	8.49
		W	r = 0.70	PEFR = 1.59W + 577.27	11.93

H = Body height, W = Body weight, SEE = Standard error of estimate. All values of correlation coefficient (r) are significant at the level $p < 0.001$.

Table 3: Multiple regression norms for the prediction of pulmonary function measurements in the studied population.

Pulmonary function measurement	**Group**	**Regression equation**	**R**	**R^2**	**SEE (l)**
VC (l)	Sedentary	VC = 0.056H - 0.022W - 3.938	0.81	0.65	0.14
	Basketball	VC = 0.028H - 0.002W - 0.372	0.86	0.74	0.09
	Volleyball	VC = 0.038H + 0.006W - 2.985	0.85	0.72	0.21
FVC (l)	Sedentary	FVC = 0.005H + 0.039W + 0.854	0.88	0.78	0.12
	Basketball	FVC = 0.029H - 0.002W - 0.488	0.89	0.78	0.08
	Volleyball	FVC = 0.015H + 0.007W + 1.468	0.77	0.59	0.14
FEV_1 (l)	Sedentary	FEV_1 = - 0.011H + 0.048W + 2.212	0.82	0.68	0.14
	Volleyball	FEV_1 = 0.000217H + 0.005W + 3.530	0.92	0.85	0.02
$FEF_{25\% - 75\%}$ ($l.min^{-1}$)	Basketball	$FEF_{25\% - 75\%}$ = 1.957H + 0.582W - 175.608	0.81	0.66	11.54
	Volleyball	$FEF_{25\% - 75\%}$ = 1.973H - 0.430W - 126.970	0.83	0.70	7.89
$FEF_{75\% - 85\%}$ ($l.min^{-1}$)	Basketball	$FEF_{75\% - 85\%}$ = 1.778H + 0.513W - 239.518	0.75	0.56	12.82
	Volleyball	$FEF_{75\% - 85\%}$ = 0.872H + 0.814W - 84.261	0.83	0.69	8.40
PEFR ($l.min^{-1}$)	Basketball	PEFR = 2.447H + 0.729W + 184.655	0.88	0.77	10.85
	Volleyball	PEFR = 3.126H - 1.163W + 196.083	0.89	0.78	8.27

H = Body height, W = Body weight SEE = standard error of estimate. All values of multiple correlation coefficient (R) are significant at the level $p < 0.001$.

ent from the sedentary group (Table 1). VC, FVC, FEV_1, $FEF_{75\%-85\%}$ and PEFR showed significant ($p < 0.05$) differences for both the basketball players and volleyball players when compared to the sedentary group. Additionally, $FEF_{25\%-75\%}$ was significantly ($p < 0.05$) different only in case of the basketball players in contrast to the sedentary group (Table 2). However, ANOVA did not depict any significant intra-group variation in case of the basketball players and volleyball players for any of the studied parameters.

Values of Pearson's product moment correlation coefficient (r) between physical parameters (height and weight) and lung function measurements and the simple regression equations for the prediction of VC, FVC, FEV_1, $FEF_{25\%-75\%}$, $FEF_{75\%-85\%}$ and PEFR from height and weight in the studied groups have been tabulated in Table 2.

Multiple regression equations have been computed on the basis of significant correlation of PFTs with physical parameters in the studied groups (Table 3).

Discussion

The primary focus of the study was laid on assessment and comparison of selected lung function parameters of the volleyball and basketball players in addition to comparison of the data with their age-matched healthy, sedentary control group and overseas counterparts.

Assessment of the physical parameters of the subjects showed that there was a significant difference in terms of the body height and body weight of both the volleyball and basketball groups when compared with their sedentary counterparts ($p < 0.05$). Previous study reported that only the body height of the basketball players significantly varied when compared against the sedentary controls while the volleyball players did not show any significant difference in height and weight when compared with the sedentary counterparts [21]. Similar studies with respect to significant differences of body height and body weight in volleyball players and basketball players compared to sedentary control was observed in Caucasian athletes [17].

TV of volleyball and basketball players did not show any significant variation in comparison with the sedentary group. This finding was contrary to what has been documented in earlier study where significantly higher values of both TV and FVC was reported in the Nigerian male athletes in comparison with the male non-athletes of Nigeria [22].

FVC is the volume of air expired after maximum inspiration, expiration being as forceful, as rapid and as complete as possible. However, both VC and FVC in case of the basketball players and volleyball players varied significantly ($p < 0.05$) in comparison to the sedentary counterparts. In the Indian context, it has been reported that FVC of the Indian University volleyball players from the North Indian state of Haryana was significantly different in contrast to their sedentary counterparts [23]. However, the results of our study related to TV was in agreement with the report where it has been mentioned that in case of accomplished marathoners as well as other endurance trained athletes, the static lung volumes did not vary from the untrained individuals of comparable body size [24].

Additionally, it was observed that FEV_1 was significantly ($p < 0.05$) higher in case of both the basketball and volleyball players when compared against the sedentary group. Further, for the basketball and volleyball players no significant difference in terms of the $FEV_1\%$ was observed when compared against their age-matched healthy sedentary control group. This $FEV_1\%$ is the ratio between FEV_1 and FVC and expressed as percentage that is used as a valid marker in the diagnosis of obstructive or restrictive lung diseases [4]. The finding was contradictory to the observation of the study which reported that $FEV_1\%$ of the volleyball players differed significantly with that of the sedentary control group [21]. It is generally assumed that exercise has the capacity to reduce the predisposition or exacerbation of any obstructive or restrictive lung disease in concerned persons [22]. However, the values for $FEV_1\%$ for the volleyball players and basketball players in our study was lower than what has been reported in earlier study [21]. The reason for such difference might be attributed to the ethnic variation of the players where the athletes in our study hailed from Eastern part of India while players from the study mentioned belonged to North India.

On assessment of the dynamic lung function parameters of the subjects, it was found that all the parameters ($FEF_{25\%-75\%}$, $FEF_{75\%-85\%}$ and PEFR) had significant ($p < 0.05$) difference in case of the basketball players with respect to the sedentary control group. The volleyball players exhibited significant ($p < 0.05$) differences in $FEF_{75\%-85\%}$ and PEFR, but not in $FEF_{25\%-75\%}$ when compared with their sedentary counterparts. However, no such significant intra-group variation was observed when the data were compared between the two experimental groups concerning the volleyball players and basketball players.

Such enhanced values of the dynamic lung function parameters in case of the trained sportspersons might be attributed to their regular participation in event specific training activities that in turn might have exerted a facilitating effect on the lungs. Maximum inflation and deflation of the lungs might have resulted due to strengthening of both the voluntary and involuntary respiratory muscles [12]. Thus, this maximal inflation and deflation act as a crucial physiological stimuli that triggers the release of prostaglandins and lung surfactants inside the alveolar space leading to reduction in the tone of the bronchial smooth muscles and increase of the compliance of the lungs respectively [25,26].

Moreover, the significant differences in the volleyball players may be further attributed to the relative contribution of the energy systems during the game. Volleyball has been identified as an interval sport requiring both anaerobic and aerobic energy systems, but anaerobic component predominates over the aerobic one [15]. Now, this anaerobic type exercises have been found to lead to cause betterment of the dynamic ventilation parameters [15]. Similarly, basketball game has been described as a high intensity sport where anaerobic endurance and speed of movement are vital criteria for determining the physical fitness of the player [27]. Hence, these intrinsic differences in their game patterns might have contributed to the significant differences in their lung function parameters in contrast to their age-matched, healthy sedentary counterparts.

The study further highlighted that in case of dynamic lung function measurement, PEFR is considered as an important indicator [18]. It stands for maximal flow, which can be sustained for a period of 10 milliseconds during a forced expiration starting from total lung capacity [18]. Body height and bodyweight are among other factors which have been demarcated as chief determinants of PEFR as far as the physical parameters are concerned. Thus, the significant differences in PEFR values for the volleyball players as well as the basketball players might be affixed to their significantly higher values of body height compared to the sedentary individuals [28].

In the sedentary group, body height had significant correlation with VC [$r = 0.78$], FVC [$r = 0.82$], FEV_1 [$r = 0.72$], $FEF_{25\%-75\%}$ [$r = 0.72$] and PEFR [$r = 0.66$]. On the other hand body weight for the sedentary individuals showed significant correlation with VC [$r = 0.64$], FVC, [$r = 0.88$], FEV_1 [$r = 0.82$]. All values of correlation coefficient (r) are significant at the level of $p < 0.001$.

For the basketball group, body height had significant correlation with VC [$r = 0.86$], FVC [$r = 0.88$], FEV_1 [$r = 0.81$], $FEF_{25\%-75\%}$ [$r = 0.80$], $FEF_{75\%-85\%}$ [$r = 0.74$] and PEFR [$r = 0.87$]. Further, for the basketball players body weight showed significant correlation with VC [$r = 0.69$], FVC [$r = 0.70$], $FEF_{25\%-75\%}$ [$r = 0.74$], $FEF_{75\%-85\%}$ [$r = 0.68$] and PEFR [$r = 0.80$]. All values of correlation coefficient (r) are significant at the level of $p < 0.001$.

Moreover, for the volleyball group it was found that body height had significant correlation with VC [r = 0.85], FVC [r = 0.76], FEV_1 [r = 0.85], $FEF_{25\%-75\%}$ [r = 0.83], $FEF_{75\%-85\%}$ [r = 0.81], and PEFR [r = 0.86]. Further, in case of the volleyball players body weight also showed significant correlation with VC [r = 0.79], FVC [r = 0.74], FEV_1 [r = 0.92], $FEF_{25\%-75\%}$ [r = 0.71], $FEF_{75\%-85\%}$ [r = 0.81] and PEFR [r = 0.70]. All values of correlation coefficient (r) are significant at the level of $p < 0.001$.

Therefore, it is evident that body height and body weight were significantly correlated with majority of the pulmonary function parameters in the studied populations. However, age did not depict any significant correlation with the PFTs probably be due to the narrow age range.

For prediction of VC, FVC, FEV_1, $FEFR_{25\%-75\%}$, $FEF_{75\%-85\%}$ and PEFR from different physical parameters in all the three studied groups, simple and multiple regression equations were computed (Table 2 and Table 3). Standard errors of estimate (SEE) of the computed regression equations were substantially small enough to recommend them for prediction of PFTs in the respective population.

Conclusion

The findings of the present study revealed that there were significant differences in terms of the lung function parameters especially with respect to the dynamic lung function variables for both the volleyball and basketball players when compared against their age-matched healthy sedentary counterparts. However, no such intra-group variation for the measured lung function parameters was observed in case of the two experimental groups. Therefore, it may be concluded that regular involvement in training for volleyball and basketball helps to develop lung function capacities perhaps due to their training induced pulmonary adaptation. Nevertheless, the findings of this study might act as a reference database for the sport coaches and allied professionals to devise exercise regime for the respective athletes accordingly, so that performance may be enhanced. Detailed analysis of the lung function parameters for the volleyball and basketball players is essentially required to reach onto a conclusive deduction about the specific training induced physiological mechanism that improves the pulmonary function.

Conflict of Interest

The authors declare that there is no conflict of interest.

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