Influence of Sport-Specific Physical Activity on Different Pulmonary Function Parameters and Endurance Capacity in Young Indian Female Players

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ABSTRACT

Exercises in the form of sports, aerobics or workouts, if performed regularly, have a beneficial effect on the various systems of the human body. The present study was undertaken to evaluate the influence of sports specific physical activity, on lung function and endurance power, among young Indian female athletes of different sports; and also to determine which anthropometric/ demographic characteristics correlate with lung functions and endurance power.

The present study was carried out on 19 female Football players (mean age=18.0 ± 1.55 years), 19 female Hockey players (mean age=18.8 ± 1.39 years) & 16 female long/middle distance runners (mean age= 18.1±1.33 years). All the players belonged to Sports Training Centre (STC) of Sports Authority of India (SAI), Eastern region. Selective anthropometric, pulmonary function variables and endurance power were measured following standard procedures.

The footballers were significantly ($p<0.05$) taller and heavier than long distance runners and Hockey players, respectively. Significant ($p<0.001$) differences were observed in mean values of FVC, FEV1 and FEV1% among the three groups of the female athletes. Female Footballers had significantly ($p<0.05$) lower VO_2max in comparison to the Hockey players and long distance runners. Body fat% had significant negative correlation with VO_2max ($p<0.05$); whereas fat free mass (%) had significant positive correlation with VO_2max ($p<0.05$). None of the anthropometric parameters were found to be significant predictors for the decrease or increase in FVC & VO_2max values.

Results of the present study suggest that the nature of specific sport activity and training have a significant impact in differing endurance capacity as well as pulmonary function variables among these sports disciplines.

KEYWORDS

Body fat%, Spirometry, Respiratory function, VO_2max

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INTRODUCTION

Pulmonary function is a long-term predictor for overall survival rates in both genders and could be used as a tool in general health assessment (Holger et al, 2000). Gender is one of the important factors affecting pulmonary functions. It has been found in previous study that female athletes have lower lung function values than males (Miller, 1996; Wasserman, 1999).The spirometry tests are mostly used in the respiratory status evaluation, and they have become a basic part of the routine health checks in occupational medicine, sports medicine, public health status monitoring and clinical practice (American Thoracic Society – ATS (1994). Although lung function is genetically regulated, and its function is among other influenced by the environmental and alimentary factors, previous research showed that it can be improved by specific exercise (Pathak et al, 1998; Suryawanshi et al, 2012), as well as the fact that it is influenced by the type of the sport (Doherty & Dimitriou, 1997). It has been shown that the duration, type, and intensity of exercise affect lung development and volumes (Durmic et al, 2015).

Football and Hockey both are intermittent type of sports, which need aerobic as well as anaerobic fitness depending on the playing positions. As both the sports need long running for better performance so the endurance ability (VO_2max) and the pulmonary efficiency both were asked complementary at a time; whereas, long distance runners (1500-3000m) need mostly aerobic fitness. It is assumed that although a larger lung volume may not affect endurance capacity of an athlete directly, it can provide a more alveolar capillary surface area for diffusion (Ajita & Priyanka, 2016). Optimum level of performance depends upon the improvement of these adaptations through proper training. It has been studied that pulmonary ventilation has a linear relationship with oxygen consumption at different levels of exercise (Degan et al, 2013). Studies carried out in children had projected the equations for predicting different lung functions using anthropometric measures such as height, age and weight as independent variables in India (Khosravi & Tayebi, 2013). So, specific and systemic training is required to improve the performance level of the players. Training plays a pivotal role to improve pulmonary functions and therefore, lung volumes of players tend to have larger amount of diffusion capacities at rest and exercise than non-athletes. Aerobic training helps to develop the oxygen transport system (Rampinini et al, 2007).Due to regular exercises, pulmonary parameters like tidal volume and forced vital capacity (FVC) were found significantly higher in athletes than in non-athletes (Kippelen et al, 2005).

To date, although many studies have been conducted to evaluate pulmonary function parameters and its association with anthropometric parameters among male athletes participating in different sports (Vedala et al, 2013; Mazic et al, 2015; Durmic et al, 2015), but there is scanty of research found on female athletes of different sport disciplines with this kind of objectives. To fulfill the lacunae, the aims of the present study are:i) to compare different anthropometric parameters, lung function parameters and endurance power among young Indian female footballers, Hockey players and long distance runners and ii) to evaluate the influence of sports specific physical activity on anthropometric parameters, lung volumes and capacities and as well as endurance power.

METHODOLOGY

Selection of Subjects

The present study was carried out on 19 female Football players (mean age=18.0 ± 1.55 years), 19 female Hockey players (mean age=18.8 ± 1.39 years) & 16 female long distance runners (mean age= 18.1±1.33 years). All the players belong to Sports Training Centre (STC) of Sports Authority of India (SAI), Eastern Region. The players of the present study were at least of state level performer with minimum of 2-3 years formal training history. All the subjects were evaluated for various anthropometric and physiological variables. The players belonged to almost same socio-economic status with similar dietary habits and undergone training in same kind of geographical and climatic condition. Hence, the subjects were considered as homogeneous. Before performing the tests, all the subjects were clinically examined by the physicians of SAI, who are specialized in Sports Medicine following standard procedure (SAI, National Sports Talent Contest Scheme Mannual, 1992). Prior to initial testing a complete explanation of the purposes, procedures and potential risks and benefits of the tests were explained to all the subjects and a signed consent was obtained from the players. The subject who was found to be medically fit, healthy and with no history of any hereditary and cardio respiratory diseases, were finally selected for the present study.

Training Regimen

The formulation and implementation of systematic training programme was made by the qualified coaches with the guidance of the scientific expert from Sport Science Department, SAI, Kolkata. The training regimen was almost common to all the three games of the present study except the skill training and was used to apply on an average of 4 to 5 hours every day, except Sunday; and which comes about 30 hours in a week. There were two sessions in a day i.e. morning and evening session and both of which comprised of physical training for one hour and skill training for about two hours. The physical training schedule includes different strength and endurance training programme along with flexibility exercises. Strength and Endurance training was also applied according to their sports specific requirement. Warm up and cool down session, after and before training of the main practice, were also included in the programme. Besides the technical and tactical training the players were also provided psychological or mental training session.

Anthropometric measurements

Measurements were performed with the participants barefoot and in minimal clothing. The physical characteristics of the subjects including height (cm) &

weight (kg) were measured by anthropometric rod and digital weighing machine, respectively, followed by standard procedure (Sodhi, 1991). The decimal age of all the subjects were calculated from their date of birth recorded from original birth certificate, produced by them at the time of testing. Body Mass Index (BMI) was calculated from body height and weight (WHO, 1995). Skinfold thickness was measured by Harpenden Skin fold caliper at the site of bicep, tricep, subscapular, supraspinalae and calf. Body fat (%) and fat free mass (%) were derived from the equation of Brozek et al (1963).

Evaluation of VO_2max

Maximum aerobic capacity (VO_2max) was assessed using an indirect method of multistage physical fitness test (Beep test) (Leger et al, 1982) from where VO_2max was predicted. The test is a progressive shuttle run test for the prediction of aerobic fitness as well as to estimate a person's maximum oxygen uptake capacity (VO_2max) from the standard chart. The procedures and purpose of the above test were elaborately instructed to all the players. In a typical shuttle run test, the players ran back and forth between two lines, spaced 20m apart, in time with the "beep" sounds from a compact disc (20m Shuttle Run test CD). Each successful run of the 20-m distance marks the completion of a shuttle. The frequency of the "beep" sound increases progressively with every minute of the test and correspondingly the player increases his/her running speed accordingly. The player is warned verbally if he did not reach the end line in time once. The test is terminated when he/she i) could not follow the set pace of the "beeps" for two successful shuttles and/or ii) stops voluntarily. Typically, the scores in the test are expressed as levels and shuttles, which estimate a person's maximum oxygen uptake capacity (VO2max) from the standard chart.

Pulmonary function testing

Pulmonary function tests (PFT) were carried on all these subjects with Spirometer (VM1 Wright, HS Clement Clarke International, UK). The test was carried out in a well ventilated spacious room with ambient temperature ranging from 28°C to 32°C. The spirometry examination was done at rest and with no exercise to be done for the last 3 hours in agreement with the recommendations of American Thoracic Society (ATS, 1994). In sitting position, the examinees performed three forced expiratory maneuvers with their nose plugged and the best of three was used for data analysis. The subjects were well informed about the instrument and the technique of the test by demonstrating the procedure. Pulmonary measures included: forced vital capacity (FVC), forced expiratory volume within the first second (FEV1) and peak expiratory flow (PEF).

Statistical Analysis

To assess differences between athletes according to the type of sport in which they were engaged, we used one-way analysis of variance (ANOVA), with multiple post hoc Scheffe's tests. Pearson's correlation coefficient was also used in order to test the relationships between anthropometric/ demographic and spirometric characteristics and endurance capacity. Multiple linear regression models analyzed the effects of the physical activity on different anthropometric parameters, lung functions and endurance capacity. Statistical analysis was performed using the Statistical Package for the Social Sciences, version 16.0 (SPSS Inc., Chicago, IL, USA). All the values were expressed as mean ± standard deviation (sd). Criterion alpha level of $p \leq 0.05$ was used to determined statistical significance.

RESULTS & DISCUSSION

Table 1 represents the comparison of various anthropometric parameters among the young Indian female footballers, Hockey players and middle & long distance runners. The Table reveals significant differences in body weight ($p<0.05$), height ($p<0.01$) and BMI ($p<0.001$) when compared among the three groups. Scheffe`s post hoc test for multiple comparisons (Table 1) of the following parameters reveals that footballers were significantly ($p<0.05$) taller and heavier than long distance runners and Hockey players, respectively. BMI was found to be significantly ($p<0.05$) lower among Hockey players when compared with their other counterparts.

Table-1: Comparison of various anthropometric parameters of young Indian female footballers, Hockey players and middle & long distance runners

Parameters	Footballers (n=19)	Hockey players (n=19)	Distance Runners (n=16)	Level of significance (F value)	Scheffe's Post Hoc Test
Age (yrs)	18.0 ± 1.55	18.8± 1.39	18.1±1.33	1.570(NS)	-
Height (cm)	160.0 ± 4.07	158.2 ± 3.38	156.2±2.62	5.306**	1 vs 3*
Weight (kg)	48.7 ± 5.11	44.5 ± 5.80	47.5±3.32	3.564*	1 vs 2*
BMI (kg/m^2)	19.4 ± 1.80	17.5 ± 2.34	19.5±1.26	6.692***	2 vs 1 & 3*
Fat Mass (%)	16.2 ± 2.33	16.4 ± 3.39	14.7±1.51	2.213(NS)	-
Fat Free Mass(%)	83.8 ± 3.31	83.6 ± 3.41	85.1±1.61	1.883(NS)	-

Values are (mean ± sd),* = p<0.05, **=p<0.01,***=p<0.001,NS = Not significant, 1= Footballers, 2= Hockey players 3= Long distance runners

Table 2 depicts comparative analysis of pulmonary function parameters and endurance capacity of the Indian young female footballers, Hockey players and distance runners. Significant ($p<0.001$) differences were observed in mean values of FVC, FEV1, FEV1% and VO_2max when compared among these groups. Scheffe`s post hoc test for multiple comparisons (Table 2) of the following parameters reveals that female Hockey players had significantly ($p< 0.05$) lower mean values of FVC and FEV in comparison to the female footballers and distance runners. On the other hand, the mean value of FEV1% was also found to be significantly ($p< 0.05$) more in long distance runners as compared to their Hockey and Football counterparts. Female footballers had significantly ($p< 0.05$) lower VO2max in comparison to the Hockey and distance runners.

Table-2: Comparison of selected pulmonary function parameters and endurance capacity of young Indian female footballers, Hockey players and distance runners

Parameters	Footballers (n=19)	Hockey players (n=19)	Distance Runners (n=16)	Level of significance (F value)	Scheffe's Post Hoc Test
FVC (lt.)	3.1±0.45	2.6±0.35	3.0±0.23	8.338***	2 vs 1*& 3*
FEV_1 (lt.)	2.4±0.39	2.1±0.26	2.5±0.23	9.212***	2 vs 1*& 3*
$FEV_{1\%}$	78.1±4.05	79.9±5.20	84.0±3.52	8.180***	3 vs 1*& 2*
PEFR (lt./min)	323.5±63.10	311.8±57.41	316.3±24.89	0.238(NS)	-
VO_2max (ml/kg/min)	43.9±4.93	47.9±3.59	50.0±1.46	12.705***	1 vs 2*& 3*

Values are (mean ± sd),*= p<0.05***=p<0.001 NS = Not significant,1= Footballers, 2= Hockey players & 3= Long distance runners

Table 3 represented the coefficient of correlation of different anthropometric parameters with various lung function parameters and endurance capacity of these groups of athlete (combined). Height was found to be positively and significantly correlated with PEFR ($p<0.05$), but a negative and significant correlation coefficient was observed with VO2max ($p<0.05$). Body fat% had also negative and significant relation with VO_2max ($p<0.05$); whereas, fat free mass (%) had significant and positive correlation with VO_2max ($p<0.05$).

Table-3: Correlation coefficient of different anthropometric parameters with lung function and endurance capacity (VO2 max) of all the groups (combined)

	FVC	FEV_1	FEV_1 %	PEFR	VO_2 max
Age (yrs)	-.009	-.008	.024	.115	-.120
Height (cm)	.168	.130	-.074	.339*	-.343*
Weight (kg)	-.002	.064	.157	.235	-.046
BMI (kg/m^2)	-.080	.011	-.153	.083	-.078
Fat%	-.022	-.053	-.116	.203	-.346*
FFM (%)	.021	.052	.113	.199	.336*

* = p<0.05

Table 4 depicts the multiple linear regression analysis of anthropometric parameters predicting association with FVC and VO_2max, respectively. None of the anthropometric parameters were found to be significant predictors for the decrease or increase in FVC & VO_2max values.

Table-4: Multiple linear regression analysis to evaluate the possible predictors of FVC and VO_2max of the three female athlete groups (combined)

Variables	FVC (Lit) (combined)			VO_2 max (ml/min/kg) (combined)		
	β	t	*p*-value	β	T	*p*-value
Age (yrs)	-.031	-.209	.836	-.097	-.719	.476
Height (cm)	-.342	-.595	.554	-.698	-1.349	.184
Weight (kg)	1.387	.981	.331	1.170	.918	.363
BMI (kg/m²)	-1.416	-.983	.331	-1.055	-.812	.421
Fat (%)	-.904	-.623	.536	-.518	-.396	.694
FFM (%)	-.848	-.590	.558	-.183	-.141	.889

Physique including height and weight has got vital role to excel better performance in sports (Dey et al, 2015). Height of the present female footballers was found to be significantly higher than other two groups as height has got an advantage for goalkeeper, the center-backs and to the forwards. Like height, weight of the footballers were also found higher than Hockey players and distance runners, that showed as an advantage to the footballers as muscular weight has positive relation with speed. Body composition is another important aspect of fitness for all the dynamic games. As superfluous body fat (BF) acts as dead weight in physical activities where body mass must be lifted repeatedly against gravity in movement during play. The lowest BF% and highest FFM% in distance runner than other two groups of athletes supports the fact that higher physical activity levels resulted in lower BF%, and higher in FFM (Bandyopadhyay & Chatterjee, 2003). As per literature, increased level of fat mass in general, even in athletes, are significantly associated with less low-frequency heart rate variability (Durmic et al, 2015). It has also been reported to other literature that, sport activity at early ages (independent of type of sport), unlike sport inactivity, ensures lower fat mass and greater fat free mass (Guisado et al, 2015).

In the present study, FVC was found to be significantly higher in footballers, might be due to their taller stature, than their other two counterparts (Kiefer et al, 2011). On the other hand FEV1 and FEV1% were found to be higher in distance runner than other two athletic groups. This may be due to the respiratory muscle strengthening because of proper endurance training and strength training (Willis et al, 2012). Due to strength training, there is an increase in the production of contractile proteins (such as action and myosin) which leads to an increase in the available cross bridges, area for generating force during full length muscle contraction. Previous study of muscle biopsy has shown that in aerobic games after endurance training there is a significant increase in capillary to muscle fibres ratio and as a result muscular endurance capacity may increase (Ghosh, 1985). The improved pulmonary function in athletes, in the present study, supports the findings of previous researches (Prakash, 2007; Hagberg, 1989; Ghosh, 1985).

Maximum oxygen uptake capacity (VO_2max) is the highest rate at which an individual can consume oxygen during exhausting exercise or maximum physical work, limits the capacity to perform aerobic exercise and therefore, serves as the most popular index of aerobic fitness (Faina et al, 1988; Wasserman et al, 1994). This is the maximum rate at which energy can be released from the oxidative process exclusively (Shephard, 1995). In the present study, VO_2max was found to be significantly ($P<0.05$) higher in female long distance runners than footballers and Hockey players. The higher mean value of VO_2max in female runners might be due to their aerobic training protocol which has given for the improvement in endurance capacity and respiratory functions (Divya and Madhankumar, 2015; Sjödin and Svedenhag, 1985; Aghemo et al., 1971). However, in trained runners velocity associated with VO_2max and anaerobic threshold (AT) can contribute for the success of predominantly aerobic events. According to such researches it has been found that vVO_2max has shown a close relationship with performance in short, intermediate and long distance race (Souza et al, 2014). Some studies reported that VO_2max on its own is a poor predictor of performance; but, using the velocity (vVO_2max) that an athlete can operate at their VO2max which will provide a better indication of performance. vVO_2max is the minimal running velocity which produces VO_2max i.e. causes muscular system to utilise oxygen at its highest possible rate (Billat, 1999).

VO_2max had significant and negative correlation with BF%, but significant positive correlation with FFM. According to the study of Shete et al, (2014), total body fatness and aerobic capacity are frequently used in association with each other and it is often implied that these parameters are strongly inter-related. Both body fatness and aerobic fitness have been shown to be risk factors for future health outcomes. Goran et al (2000) had reported that, BF% does not have any effect on VO_2max, but the major influence of body weight on VO2max is explained by FFM. Fatness and excess body weight do not necessarily imply a reduced ability to maximally consume oxygen, but excess fatness does have a detrimental effect on sub maximal aerobic capacity. Thus, fatness and VO_2max should be considered independent entities.

Age had insignificant negative correlation with pulmonary function parameters which revealed that with increasing age the flow rate decreases which in turn decreases the respiratory efficiency; and this may be due to the reduced capacity of lung recoiling (Khosravi and Tayebi, 2013). Height has a significant ($P<0.05$) negative relation with VO_2max which coincides with the study of Sprynarová et al (1987). Pearson's correlation analysis revealed that BF% and FFM are negatively and positively associated with the lung function parameters, respectively. As per literature, the increase in body fat can induce a decrease in lung function which can be explained by a reduction in expiratory reserve volume and functional residual capacity and as a result of decreased lung compliance, decreased chest wall volume, and increased airway resistance (Guenette et al, 2007; Paulo et al, 2013). The present results are in agreement with those of a study involving obese individuals, demonstrated that lung function, expressed as DLCO (Diffusing Capacity for Carbon Monoxide) correlates positively with lean body mass, but negatively with BF% (Pekkarinen et al, 2012).

CONCLUSION

The present study that measured spirometric values except FVC were significantly higher in long distance runners along with the endurance capacity. These observations are particularly relevant of an athlete seeks treatment for respiratory disorders such as cough, wheezing etc. Our results suggest that the category of sport has a significant impact on respiratory adaptation. Because of these sport-specific differences, there is a need for further observations investigating the specific exercise bouts; the influence of the duration, severity, and intensity of exercise; the early years of training; respiratory muscle strength; specific hereditary influences and game specific habitual activity. So, the results of the present study may act as a reference standard for future research and comparison in the relevant field particularly female athletes.

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