ORIGINAL RESEARCH PAPER

Physiology

ASSESSMENT OF CARDIO-RESPIRATORY FITNESS IN SPORTS WOMEN

KEY WORDS: swimmers, runners, VO2max, PFT

Lagare Amruta	Assistant professor, Dept of Physiology, RCSM GMC, Kolhapur.
Zingade U.S	Professor and HOD, Dept of Physiology, RCSM GMC, Kolhapur.

ABSTRACT

Various research studies have been conducted exclusively in sports men however, very few research studies are available in sportswomen, especially in India. Present study was conducted in sports women who are swimmers and runners. The following parameters were studied in them: Maximal oxygen uptake (VO2 max), Pulmonary function tests (PFT) mainly Forced Vital Capacity (FVC), Forced Expiratory Volume in one second (FEV1), Peak Expiratory Flow Rate (PEFR) and maximum Ventilatory Volume (MVV). The present study was aimed to find out effect of exercise on cardio-respiratory fitness. The study included comparison of above mentioned parameters among swimmers, runners and age matched non exercising women. Methods: 30 runners, 30 swimmers and height-weight matched, 30 healthy female subjects of the same age group were studied. VO2max was estimated by Queen College Step test (QCT). FVC, FEV1, PEFR and MVV were measured. All mentioned parameters were compared among three groups using ANOVA and post hoc Bonferroni's test. Results: Mean values of VO2max and PFTs were significantly higher in sportswomen than control group ($p<0.001$). Mean VO2max was significantly higher in runners than swimmers ($p<0.05$) and mean Values of lung volumes were significantly higher in swimmers than runners ($p<0.001$).Conclusion: The result of this study revealed that the running and swimming have a definite beneficial effect as far as the cardio-respiratory fitness is concerned. Our study strongly recommends regular physical exercise or involvement in sports activity for the control group females. Regular physical exercise will definitely improve their cardio-respiratory fitness, which will help them to lead a better quality of life.

INTRODUCTION:

Physical fitness is defined as "the ability to carry out daily tasks with vigor and alertness, without undue fatigue, and with ample energy to enjoy leisure-time pursuits and to meet unforeseen emergencies."[1]

The most important component of physical fitness is Cardio-respiratory fitness, refers to the ability of the circulatory and respiratory system to supply oxygen during sustained physical activity. It is related to the ability to perform large muscle dynamic exercise, moderate to high intensity for prolonged period.[2] Presently, maximal oxygen uptake (VO2max) has been recognized as the best index of cardio-respiratory fitness.[3] This index can be applied to the endurance athletes as well as to the sedentary individuals.[4] n general VO2max is determined by cardiac output and the amount of oxygen utilized by the exercising muscles (A-VO2: arterial-venous oxygen difference). The term cardio-respiratory fitness best describes the close interaction between heart and lungs in determining overall fitness. VO2max assesses the cardiac component of cardio-respiratory fitness. Respiratory component can be evaluated quantitatively and qualitatively by pulmonary function tests (PFTs). Lung volumes reflect the individual's ability to increase the depth of breathing according to the need.

The cardio-respiratory fitness testing is used to gather the information about person's current status of fitness. The scientific data thus collected has been used to improve the performance of athletes. Cardio respiratory fitness is a sensitive, reliable measure of habitual physical activity. It is a relatively low-cost and useful health indicator for both symptomatic and asymptomatic patients in clinical practice. Cardio-respiratory fitness testing helps in rehabilitation of patients.

Various research studies have been conducted exclusively in sports men (5 6 7) however, very few research studies are available in sportswomen, especially in India. With this background the present study was conducted in sports women who are swimmers and runners. The following parameters were studied in them: VO2 max, PFT mainly FVC, FEV1, PEFR and MVV. The present study was aimed to find out effect of exercise on cardio-respiratory fitness.

MATERIAL AND METHODS:

The synopsis of study protocol was submitted to the Institutional Ethics Committee and approval was obtained. Study was conducted in 90 subjects out of them 30 were control group, 30 were runners and 30 were swimmers. Inclusion criteria: sports women: 1) age: 18-25 years 2) experience: 3 years and participated in various sports competitions 3) practice: minimum of 2 hours daily. Control group: Age, height and weight matched females who were not involved in regular sports activities. Exclusion criteria: Subjects with history of acute and chronic lung disease, cardiac disease, neuro-muscular disorder, metabolic disorders and obstetric disease cardiothoracic surgery, and any major surgery, H/O trauma.

The study protocol was explained in detail to the subjects. All subjects who gave their consent for the study and fulfilled selection criteria were included.

Determination of VO2 max [8]

Queen College Step test (QCT) was used to predict maximal oxygen uptake. It is a standard method to measure one's maximal oxygen uptake using sub maximal exercise in the form of bench stepping, suitable for adults.

1. A wooden stepping bench of 16.25 inch was used along with metronome and stop watch.
2. Step test began after a brief demonstration and practice period.
3. The subjects were asked to perform each stepping cycle to four-steps condense up-up-down-down continuously for 3 minute.
4. Frequency of stepping was 22 stepping cycle per minute so metronome was set at 88 beats per minute.
5. After completion of test, subject remained standing while recovery pulse rate (radial pulse) was measured for 15 seconds, starting from 5th to 20th second of recovery period. 15 seconds recovery heart rate was converted to be expressed as beats per minute (15 second HR x 4).

Following equation was used to calculate Vo2max,

VO_2max (ml/kg/min) = 65.81- (0.1847 x HR)
(Where, HR is full one minute recovery heart rate)

Determination of pulmonary function: The pulmonary function parameters were measured using a computerized portable RMS Helios 702(Chandigarh) spirometer. The tests were conducted according to the American Thoracic Society/ European Respiratory Society (ATS/ERS) task force guidelines. 9 FVC, FEV1, and PEFR were recorded by FVC maneuver and MVV recorded by asking subject to breathe in and out as rapidly and deeply as they can for a period of 15 seconds through the mouthpiece. Three acceptable readings were taken and their mean values were calculated and analyzed.

Statistical analysis – The data was analyzed using Graph pad prism5 software. Statistical difference between the data obtained in various groups was evaluated by one way ANOVA (Analysis of Variance) test followed by Bonferroni's post-hoc test and p value <0.05 was considered as statistically significant.

RESULTS:

There were no significant differences in mean ages, heights and weights of the control group, runners and swimmers ($p>0.05$). Therefore, three groups were comparable with respect to age, height, weight and BMI (Table 1). Applying ANOVA, we observed highly significant difference ($p< 0.001$) in mean values of VO2max, FVC, FEV1, PEFR and MVV among 3 groups. By applying Bonferroni's post hoc test, we found significant increase in VO2max in runners compared to swimmers and control group and pulmonary function tests were significantly increased in swimmers than runners and control group (Table 2)

Table 1: Mean values of demographic characteristics in control, runner and swimmer

parameters	Control n= 30 mean±SD	Runners n= 30 mean±SD	Swimmer n= 30 mean±SD	p value
Age (years)	21.4 ± 2.27	21.87±3.55	22.13±3.37	0.657
Height (cm)	159.43±6.54	158.67±4.18	158.17±3.92	0.617
Weight (kg)	54.13±5.37	54.17±3.63	56.3±4.01	0.167
BMI (kg/m2)	21.39±1.45	21.51±1.19	21.75±1.25	0.55

Non-significant at $p>0.05$

Table 2- Comparison of mean values of different parameters recorded among control, runner and swimmer

Parameter	Control (n=30) mean±SD	Runner (n=30) mean±SD	Swimmer (n=30) mean±SD	Control v/s runner p value	Control v/s swimmer p value	Runner v/s swimmer p value
Vo2 max (ml/kg/min)	30±0.94	47.76±1.56	46.64±1.81	<0.001**	<0.001**	<0.05*
FVC (liters)	2.61±0.31	2.84±0.03	3.10±0.18	<0.001**	<0.001**	<0.001**
FEV1 (liters)	2.33±0.30	2.53±0.20	2.78±0.40	<0.05*	<0.001**	<0.001**
PEFR (liters/sec)	4.87±0.93	5.4±0.39	5.93±0.53	<0.05*	<0.001**	<0.05*
MVV (liters/min)	100.97±7.65	106.53±7.46	110.93±4.61	<0.001**	<0.001**	<0.05*

Significant at $p<0.05$* and Highly significant at $p< 0.001$**

DISCUSSION:

In present study, mean values of VO2max in runners and in swimmers were highly significantly increased than in control group ($p<0.001$). VO2max was significantly higher in runners than in swimmers ($p<0.05$).

VO2max also called as aerobic capacity is defined as the level of O2 consumption beyond which no further increase in O2 consumption occurs in spite of further increase in severity of exercise.

Present study revealed that there is a higher value of VO2max in sportswomen as compared to control group. Our findings coincide with the study of Das Gupta PK et al 6 They observed higher values of VO2 max in runners (48.42±4.72 ml/kg/min) than non athletes (37.42±4.92 ml/kg/min). Verma SK et al7 observed statistically significant difference in mean VO2max of sedentary group and that of active athletes (48.4±5.1 ml/kg/min) in India. They observed runners had higher VO2max than football, volleyball and hockey players. Saltin B and Astrand PO.10 observed higher VO2max in runners and cross country skiers as compared to swimmers they commented that difference in VO2max was due to the effect of endurance nature of running and cross country skiing.

The increase in VO2max in sports women compared to control group in the present study can probably explained by various physiological mechanisms discussed below In general VO2max is determined by cardiac output and oxygen extraction by muscle i.e. A-V O2 difference. Cardiac output is the most important limiting factor for VO2max. Cardiac output depends upon stroke volume and heart rate.11 Endurance training is associated with increase in stroke volume. Increase in stroke volume is because of two factors: dilatation of ventricles and ventricular hypertrophy. Exercise training causes vagal dominance which leads to decrease in the heart rate. lower heart rate, allows more time for ventricular filling which causes stretching of myocardial fibers; increasing end-diastolic diameter of the ventricles. Increase in the size of left ventricular chamber increases the reserve capacity of chambers and force of contraction of left ventricle to pump out more volume of blood during each stroke.(12,13) Mild to moderate increase in left ventricular wall thickness in athletes is because of endurance training. Enlarged ventricular volume due to chamber dilatation and powerful ventricular contraction of hypertrophied heart ejects larger volume of blood with each systole i.e. increases stroke volume thus, increases cardiac output in athletes.

Second factor affecting VO2max is increase in oxygen extraction by muscles. Two distinct types of skeletal muscle fibers are identified in our body. Slow twitch or type I fibers and fast twitch or type II muscle fiber. Slow twitch fibers possess more number of mitochondria and increase capillary density. There is a selective hypertrophy of slow twitch and fast twitch muscle fibers depending upon the type of training and activity.14 Thayer R and Collins J found that endurance training may promote a transition from type II to type I muscle fiber types and occurs at the expense of the type II fibre population15 With exercise training there is increased capillarization of muscle. It increases the blood supply to muscle and more extraction of oxygen. Increased density of capillary is correlated with increase in VO2max.16 Within the muscle fibers, the mitochondria are the sites where O2 is consumed in the final step of the electron transport chain. Increase in size and number of mitochondria in muscle increases the concentration of enzymes and transfer agents involved in aerobic metabolism by two to three folds enhancing the capacity to generate ATP aerobically by oxidative phosphorylation. All these changes in muscle in athletes leads to more extraction of O2 by active muscle and thus increases Vo2max.

Possible reason for the difference in VO2max in runners and swimmers could be, the effect of mode of activity in exercise testing on VO2max. Running uses lower extremity muscles primarily in the gravity dependent environment, while swimming uses upper and lower body in an environment of less influenced by gravity.17In the present study mode of exercise testing for VO2max was bench stepping (Queen College step test- QCT), which uses muscles of lower extremity. This mode of activity was more accustomed to runners than swimmers. Therefore, response of swimmers to the QCT may have been influenced by lower limb muscle limitation in oxygen extraction, which was not evident in runners. Therefore, runners had higher VO2max than in swimmers. Roles B, Schmitt L et al18also found that the exercise testing mode affects the VO2 max value.

Present study revealed that pulmonary function parameters were highly significant in swimmers than control group and runners. However, values of these parameters were significantly higher in runners than control group. Our study coincides with study of Mehrotra PK et al5 they reported increased values of FVC, FEV1 and PEFR in Indian sportsmen playing football, volleyball, basketball and swimmers as compared to the control group. They observed significantly higher lung volumes in swimmers than other sportsmen. Das Gupta PK et al6 showed significant increase in breathing reserve in Indian athletes than non athletes. Sabale M et al19 compared the pulmonary function tests in runners and swimmers. They observed TV, FVC, FEV1 and MVV were higher in swimmers than runners. Doherty M et al20 compared lung volume in Greek swimmers, land based athletes and sedentary controls. They found that the male and female swimming groups had larger FEV1 than both land based athletes and sedentary controls.

In the present study sports women had improved pulmonary functions than control group. The possible explanation for this could be that exercise involves increase in rate and depth of respiration so there is forceful inspiration and expiration which for prolonged period during training; leads to strengthening of respiratory muscles. This helps the lungs to inflate and deflate maximally which is stimulus for the release of surfactant and prostaglandins in the alveolar spaces5. This decreases surface tension in alveoli and physiological dead space leading to increase in lung volumes and capacities.(5,21,22) Swimming differs from the other sports in the following aspects: During swimming the external pressure is higher, as the density of the surrounding water medium is higher than that of air which is the usual external medium in other sports. Therefore, the respiratory muscles along with diaphragm develop greater pressure for respiration which leads to improvement in the functional capacity of these muscles. Sternocleidomastoid, trapezius and diaphragm are being constantly exercised. So there is strengthening of thoracic and abdominal muscle.(5,19,23) Swimming is performed in the horizontal position compared to the vertical position in other sports. Swimming involves keeping the head extended which is constant exercise to erector spinae muscles which increases anterior-posterior diameter of lungs. Swimmers have large thoracic cavity or broader chest.(5,20) Regular swimming practice may tend to alter the elasticity of lungs and chest wall which leads to improvement in lung function of swimmers.24

CONCLUSION: Present study shows that runners had more improvement in VO2max while, swimmers had more improvement in lung functions. However, overall cardio-respiratory was better in sports women than control group, because of regular exercise and training in sports women. The result of this study revealed that the running and swimming have a definite beneficial effect as far as the cardio-respiratory functions are concerned. Our study strongly recommends regular physical exercise or involvement in sports activity for the control group females. Regular physical exercise will definitely improve their cardio-respiratory fitness, which will help them to lead a better quality of life. Secondly, awareness can be created by explaining the importance of beneficial effects of exercise and sports on health.

A study with larger sample size along with varying categories of running and swimming would be a better indicator of this relationship. Further studies will be required to evaluate the duration of sports and exercise intensity on cardiorespiratory fitness.

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