Aerobic Capacity in Endurance Trained and Resistance Trained Athletes

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Abstract

The study was aimed at comparing the aerobic capacity in endurance trained and resistance trained athletes. Thirty male athletes who received endurance training and thirty male athletes who received resistance training for a period of more than 1 year were chosen for the study. Physical parameters were measured and exercise stress testing was done on a cycle ergometer with a portable gas analyzing system. Functional capacity (FC) as percentage of predicted $\dot{V}O_2max$ was measured to study the aerobic capacity. Highly significant ($P<0.001$) differences existed in values of FC for endurance trained and resistance trained athletes. The higher aerobic capacity displayed by the endurance trained when compared to resistance trained athletes could be due to variations in adaptations that happen in them due to different types of training protocols. The levels of aerobic capacity reported from athletes abroad are higher compared to our athletes and this could prove to be a potential area of improvement for their much awaited superior performance in international arena.

Key words: Endurance training, Resistance training, Functional capacity, $\dot{V}O_2$max.

Introduction

Primary interest in fitness research has traditionally centered upon cardio respiratory endurance (*Mead et al, 1981).* As there are not many studies conducted in the field of exercise physiology in India, this study was conducted to analyze the variations in aerobic energy capacities of South Indian male athletes who underwent two different forms of training. The athletes were divided into two groups based on their training. In one group there were athletes who predominantly received endurance training which involved continuous steady paced prolonged exercise in moderate intensities for long distances. On the other hand, the athletes in the other group received resistance training in the form of weight lifting. With this method, exercises were designed to strengthen specific muscles by causing them to overcome a fixed resistance, usually in the form of a dumbbell or weight plates on a pulley – or cam-type machine *(McArdle et al, 1996).* The endurance trained athletes were mainly long distance and marathon runners; while the resistance trained athletes were predominantly sprinters but included hurdlers, long jumpers and volley ball players. This would result in various adaptations (*Mead et al, 1981).* Measurement of aerobic energy transfer in these individuals required the evaluation of long term energy system and it was done by assessing the Functional Capacity (FC). FC was considered as the percentage of predicted $\dot{V}O_2max$ ($\dot{V}O_2max$ is the maximal amount of oxygen a person could take in per unit time).

Material and Methods

Selection and preparation of Participants

Sixty elite male athletes were selected from Prime Sports Academy - Chennai. Thirty of these were undergoing endurance training and the other thirty were undergoing resistance training (apart from event specific training and muscle stretching) for more than one year at the college grounds of Madras Medical College. All the subjects were between 19-25 years and procedures followed were in accordance with the ethical standards set by the institution and as per the "Joint Statement of the *American Thoracic Society (2003)* and the American College of Chest Physicians (ACCP) on Cardiopulmonary Exercise Testing". Every individual was informed about the objective of the study and his consent was obtained. Respiratory or cardiovascular disabilities and intake of medications contraindicating their participation in the exercise stress test were ruled out. A detailed clinical examination was also done to exclude any systemic pathology. All the participants did not involve in any kind of exercise for 6 hours before the test. The subjects were instructed about the importance of the test and proper technique was demonstrated. Precautions like loosening of tight clothing, usage of nose clips and keeping the pneumotach clip in the upright (12 'O' clock) position were adequately taken care of.

Determination of Aerobic Capacity:

The athlete's physical parameters were recorded and predicted $\dot{V}O_2max$ was calculated using the following formula given by *Froelicher and Myers (2006).*

$$\textbf{Pred. } \dot{V}O_2\textbf{ max = wt (kg) x (50.72 - 0.372 x age)}$$

Exercise stress testing was done on a cycle ergometer in the CPX EXPRESS system, which is a portable breath-by-breath gas analyzing system. It analysed the gas concentration and determined the FC. The gas analyzer module of the CPX express system contains O_2 and the CO_2 breath-by-breath analyzers. The O_2 sensor consisted of a zirconium cell and CO_2 sensor was a dual path infra red (IR) analyzer. The system was calibrated and made ready for use.

An incremental protocol where the wattage changed in discrete steps was selected for the bike (cycle ergometer). The time increment was specified as 30 seconds and a work increment of 15 Watts, allowing a work rate increase by a single 15 Watt step every 30 seconds. The subjects were completely familiarized with the test procedures before the experimental data collection. Before administration of each test, the seat handle bars and toe clips of the cycle ergometer were adjusted to the needs of each subject. Resting data for O_2 production per unit time ($\dot{V}O_2$) was collected for 3 minutes of rest, followed by 3 minutes of unloaded pedaling, followed by the incremental phase of exercise (with a single 15 Watt step every 30 seconds) during which the subject maintained the bike revolutions anywhere between 40-60 revolutions/min. The $\dot{V}O_2$ was displayed on the LCD screen of the CPX system. As the wattage increased the subject found it more and more difficult to maintain revolutions between 40-60 revolutions/min. Subjects were required to remain seated throughout the test and verbally encouraged to pedal maximally. Exercise was continued to his supra maximal limit, a stage after which he could not continue to exercise. This was considered as the subject's point of peak exercise and a leveling-off or peaking-over in oxygen uptake was considered as $\dot{V}O_2max$. Then the subjects were allowed to recover from exercise by continuing to pedal the bike without any resistance and the recovery data was colleted for 5-10 min.

The mean and standard deviation of FC for both the groups were first calculated and the data was subjected to Student-t test with a significance level of 0.05.

Results & Discussion

The mean of FC (as % of predicted $\dot{V}O_2max$) in endurance trained athletes was found to be 108.82 ± 7.85. This was significantly higher ($P<0.001$) when compared with the resistance trained athletes, where it was found to be 94.64 ± 5.05.

The higher values of FC seen in endurance trained athletes were consistent with previous reports *(Barnard et al, 1979; Niemelä et al, 1980; Boileau et al, 1982; Svedenhag & Sjödin, 1984; Draper & Wood, 2005)*. Earlier studies have investigated the reasons for these elevated levels of FC and found that it lies in the various adaptations to training *(McArdle et al, 1996)*. Pulmonary adaptations include an increase in tidal volume, respiratory rate, and pulmonary ventilation for better O_2 exchange by the lungs. Cardiovascular changes like an increase in heart size and plasma volume raises the cardiac output so that O_2 per pulse is increased. According to *Rywik et al (1999)* a reduction in cardiac after load to increase the cardiac output may occur by increasing the arterial compliance by endothelium derived dilation (EDD) or non –EDD. Adaptations at the motor unit level include the predominance of slow twitch, low tension and fatigue resistant (type I) fibers which makes them perform physical activity for long durations (*Coggan et al, 1992)*. These slow twitch fibers are the so called red muscle fibers which have high capillary density for better O_2 storage and increased mitochondrial size and number for better O_2 extraction *(Magel et al, 1978)*. These adaptations at the cellular level favors the aerobic machinery. Enzymes involved in aerobic production of ATP like pyruvic acid dehydrogenase and other enzymes in the Krebs cycle were also shown to be elevated (*Coggan et al, 1992)*.

Metabolic adaptations include the enhanced capacity to mobilize, deliver and oxidize lipid and this allows carbohydrate storage for intense exercise and prevents lactic acid accumulation *(Crampes et al, 1989)*. The number of beta receptors on the leukocytes of endurance trained athletes has been reported to be less *(Fujii et al, 1998)*. If similar changes occur in the muscle fiber then the epinephrine induced glycolysis and production of lactic acid would be less in them. Alterations in carbohydrate metabolism include a greater ability to oxidize carbohydrates. This allows large quantities of pyruvate to move through aerobic pathways and again prevents lactic acid accumulation *(Holloszy & Coyle, 1984)*. Although it is known that during exercise, blood borne glucose can enter the muscles without the aid of insulin, *Takala et al (1999)* have identified that aerobic and not resistance training is associated with enhanced insulin sensitivity in skeletal muscle.

Possible changes that occur at the genetic level include genetic variation at the Na^+K^+ATP-ase alpha 2 locus which influences the trainability of $\dot{V}O_2max$ in sedentary Caucasian subjects. *Rankinen et al, (2000)* reported that Na^+K^+ATP-ase play an important role in maintaining the electrolyte balance in working muscles and may contribute to endurance performance). Studies have also linked the alpha 2 adrenoceptor DRA2A gene variability with elite endurance status *(Wolfarth et al, 2000).*

Dasgupta et al (2000) demonstrated that long distance runners and middle distance runners had a significantly higher $\dot{V}O_2max$ (51.03 ± 1.96 and 52.26 ± 2.8 ml/kg/min respectively) than the short distance runners (46.34 ± 5.18 ml/kg/min) when they were subjected to graded exercise on a treadmill. In our study, conducted on athletes from South India, the mean value for $\dot{V}O_2max$ recorded on cycle ergometer in the endurance athletes was 46.66 ml/kg/min with SD ± 3.36 (10.7% lower). The resistance trained athletes of our study demonstrated a mean $\dot{V}O_2max$ of 40.69 ml/kg/min with SD ± 2.17 (12.1% lower). The values achieved by endurance athletes were was also 26% lower than the mean values recorded from long distance runners of eastern India *(Das & Bhattacharya, 1995).* But, the authors of this study have measured $\dot{V}O_2$ max with Queens College Test.

An assessment of Aerobic capacity of Indian senior and junior female hockey players by *Laroia et al (1998)* revealed that the relative $\dot{V}O_2$ max of the senior and junior players were 47.0 and 40.9 ml/kg/min respectively and were observed to be much lower than their international counterparts. An evaluation of maximal oxygen uptake capacity as a measure of cardio respiratory fitness in Indian air force personnel by *Banerjee et al (1988)* showed that their mean absolute $\dot{V}O_2$ max values were found to be around 2.5 and 2.4 l/min in 21-29 and 30-39 years age group respectively. $\dot{V}O_2$ max per Kg body weight values, viz. 38.6 and 35.2 ml/min/Kg in the aircrew and 40.8 and 35.5 ml/min/Kg in the ground duty subjects, in the age group 21-29 and 30-39 years respectively. Interestingly, *Raju et al (1986)* studied oxygen consumption in sportsmen of different events and reported that there were no significant differences seen in VO_2 max, blood pyruvate and blood lactate in sportsmen of different events.

Svedenhag & Sjödin B (1984) measured maximal oxygen uptake on the treadmill and the $\dot{V}O_2max$ values were 72.1 ml/kg/min in 800-1500-m group and 78.7 ml ml/kg/min in 5000-10,000-m group. These values were a staggering 54% and 68% higher than the current studies. *Boileau et al (1982)* too reported high mean $\dot{V}O_2max$ values (76.9 ml/kg/min) in the long distance runners. These wide differences could possibly be due to the variations in race, nutrition and level of training. Our study results are in line with the results of *Niemelä et al (1980)* who reported significantly higher $\dot{V}O_2max$ values in endurance runners (75.3 ml/kg/min) in comparison to the sprinters (46.0 ml/min/kg). The sprinters of this study had on an average 13% higher value of $\dot{V}O_2max$ as compared to the resistance trained athletes of the present study.

Kilding AE, et al (2006) measured actual $\dot{V}O_2max$ during the multi-stage fitness test in international-level intermittent sport athletes and compared these with the predicted values. Their predicted values (53.6+/-3.9 & 51.3+/-4 ml/kg/min) were reported to be significantly lower (9.3% and 13.2%, respectively) than the actually measured

VO_2max (59.1+/-6.6 ml/kg/min). In our study the predicted values were 8.1% lower and 5.3% higher than the measured values in endurance and resistance trained athletes respectively.

Conclusion

Endurance trained athletes' exhibit higher aerobic capacity as compared to the resistance trained athletes and possibly due to the variations in adaptations that happen in them due to different types of training. The levels of aerobic capacity reported on foreign athletes are higher as compared to the endurance athletes of the present study and seems to be a possible potential area for improvement.

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