AEROBIC CAPACITY IN RUNNERS AND CONTROLS, ITS CORRELATION WITH AUDIO VISUAL REACTION TIME.

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Abstract: Background & objective: The main purpose of this study was to analyze the effects of training and specificity on the oxygen uptake using bicycle ergometry and to see if aerobic exercise can increase cognitive processing speed by using reaction time. **Methods**: VO_{2max} and Reaction time of 31 national level runners was compared with that of 31 controls. Runners were subdivided into two groups, group A (>2yrs & < 3yrs of training) and group B (>3yrs & < 10yrs of training).Correlation of VO_{2max} with Audio Visual Reaction Time was done. **Results**: VO_{2max} was found to be higher for runners and was statistically significant. Among runners VO_{2max} was higher for group B players (seniors) and was statistically significant. Correlation analysis has shown negative correlation of VO_{2max} with reaction time with statistically significant value for Click (Audio), Red and Green color in runners, Click (Audio) and Yellow color in controls. **Interpretation & conclusion:** Improvement in VO_{2max} by regular practice will ultimately improve reaction time in turn improving the cognitive processing, speed and sports performance.

Keywords : Reaction time, VO_{2max}, Runners.

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Introduction:

Sports are organized at competitive levels since ancient times. In India the scientific community has recently started contributing towards upliftment of an athlete. But still looking at the vast sporting population, this contribution appears to be meager.

VO_{2max} refers to the highest rate that tribute to success at the elite level [1] Aerobic power is the maximum capacity of an individual's body to transport and utilize oxygen during incremental exercise, which reflects the physical fitness of the individual. Aerobic power depends on the ability of tissues to use oxygen to breakdown metabolic fuels and the combined abilities of various systems (pulmonary, cardiac, vascular, and cellular) to transport oxygen from the air to mitochondria [2]. VO_{2max} has been interpreted as a measure of the maximal capacity of the cardiorespiratory system to acquire oxygen, circulate it to working muscle, where muscle can extract and utilize oxygen in mitochondrial respiration to meet the energy needs of muscle contraction. The measure of VO_{2max} has therefore been invaluable in quantifying endurance fitness and the status of the cardio-respiratory and muscular systems for all individuals ranging from the athlete to the sedentary and diseased [3]. Maximal oxygen uptake (VO_{2max}) is widely accepted as the single best measure of cardiovascular fitness and maximal aerobic power. The major physical fitness components which have greater influence on the performance of runners are cardiorespiratory endurance, body composition, flexibility, agility, quickness and muscular strength. The VO_{2max} estimation is an important component of cardiorespiratory endurance which is useful in determining a person's capacity to sustain high-intensity exercise for longer than 4 to 5 minutes [4].The best indicator of aerobic work potential is the maximal oxygen consumption Aerobic adaptation is highly dependent on training characteristics (sports specificity) [5].

Reaction time is defined as interval of time between presentation of stimulus and appearance of appropriate voluntary response in a subject[6] the reaction time is often overlooked and usually underestimated element in the selection of athletes for different sports. In sports and games, in which movements of a participant are conditioned by signals, by movements of opponents, or by motion of the ball, reaction time is of great importance. A sprinter who can start faster than other contestants; a baseball catcher who can react faster to the change in the direction of the motion of the ball; a ping pong player who is always in the right place at the right time- all have a definite advantage over slower reacting men[7]. Since performance of an athlete is directly linked with duration of reaction time, athletes and coaches are starting to realize importance of reaction time in sports performance. Because of this realization, research is necessary to scientifically show athletes and coaches the effect of reaction time on their sports performance so that it will be useful to screen a large population for physical fitness. The study of relation of the reaction time to motor skill performance in sport is not new, but in the past not much attention was given to elite athletes [7]. Reaction time measurement is an indirect index of processing capability of central nervous system and simple means of determining sensory motor association and performance of an individual [8].

This study is aimed to know the effect of training on aerobic capacity, there are number of published articles on circulatory & ventilatory response to exercise and effect of training on improvement of performance, but the number of studies directed towards influence of physical fitness on performance appears sparse. Further there are no studies conducted in this region with respect to VO_{2max} measurement amongst runners. Moreover none of the researchers have done any study on the correlation of VO_{2max} with reaction time in runners. Hence, this study was undertaken to define and interpret the possible aerobic endurance status, quickness, and finding out the fitness levels and to help them out with some valuable suggestions to improve the performance and prepare runners to international levels. Also to encourage those who are already endowed with these capabilities.

This research is the most comprehensive and systematic of its kind, identifying the minimum set of variables that holistically and meaningfully assess VO_{2max} and reaction time in runners of Indian scenario.

Methods :

The present study was conducted between January 2010 and December 2010.

Study Design: Cross-sectional study.

Method of Data collection

Source of Data: In the present study the data was collected from the runners (National & State level players) practicing regularly at district stadium.

Sample size : Based on universal sample size all the runners aged 16-25 yrs of Belgaum city who are eligible were enrolled at the time of data collection and available number of players who fit into the inclusion criteria were 31. For comparison, age (16 – 25 yrs) and sex matched individuals were enrolled. Selection was done using random number table. Data collection was done from the month of July to December 2010.

Inclusion Criteria:

1. All the runners practicing for a minimum period of 2 years and who were in the age group of 16-25yrs.
2. Individuals of age and sex matched participants coming from same region who have not undergone any sort of athletic training or carrying out regular

exercise were selected randomly in comparative group.

Exclusion Criteria:

1. Subjects with respiratory, neuromuscular, cardiac, endocrine disorders in study subjects & comparative group.
2. Comparative group who were doing regular physical exercise, meditation and undergoing physical training.

List of runners was obtained from the stadium and the coach information about their practice schedule, number of players, and their availability was taken from the coaches. Permission was obtained from the Assistant Director, District stadium, Belgaum to carry out the intended study on the players. The study was approved by the Ethical and Research Committee of the institution.

After finding the suitability as per selection criteria, the players were selected for the study and briefed about the nature of the study and written informed consent was obtained from them.

Descriptive data of the participant's age, medical history, training schedule regarding number of years of practice, number of days in a week, number of hours per day, etc were obtained by interviewing the participants.

The sports participants were subdivided into two groups depending on number of years of training. Group A consisted of runners with >2yrs and ≤ 3 years of practice and Group B consisted of the senior players with > 3 years and < 10 yrs of training [9,10]. All the players participated in consistent training. On an average practices were held for four to five hours per day, six times per week. Throughout the year, apart from running practices, all participants were involved in additional sessions of strength training and conditioning, speed, and stretching both pre-season and during the competitive season. Both groups had been exposed to similar training regimens.

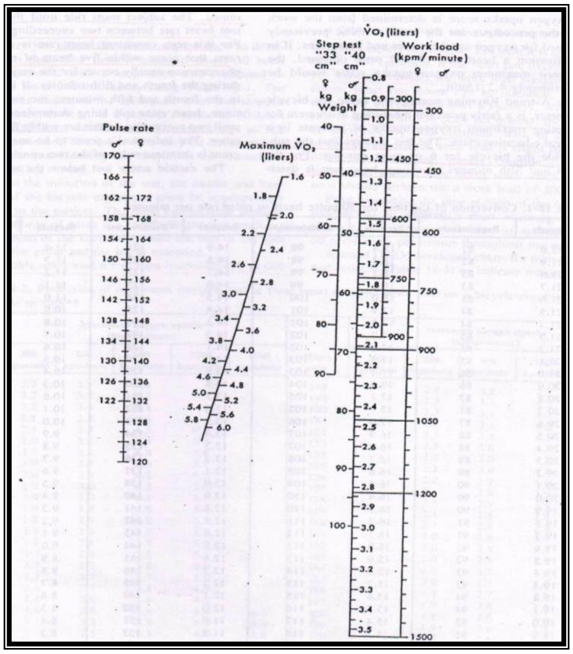
Cardiorespiratory endurance [11,12]

This test was done on Bicycle ergometer to calculate the most accepted criterion- VO_{2max} (maximum oxygen uptake) by using Astrand Nomogram which is commonly used Bicycle ergometer exercise stress test used to estimate cardiovascular fitness.

After recording the resting pulse rate the player was given a warm up ride for 1 to 2 min without any load, performers were then asked to pedal the bicycle at a constant speed of 50 revolutions per minute with a load of 2kgs. At the end of every min pulse rate was noted using pulse oxymeter. The subjects were asked to continue the work for a minimum of 6mins. If the subject was able to perform this exercise then the load was gradually increased by half kg and so on. The steady pulse rate which was achieved at 5th and 6th min is noted, if the pulse rate differed by more than 5 beats/min at the end of 5th and 6th min then the exercise was prolonged for 1-2mins more until steady state was achieved. The average of last 2mins was designated as maximum heart rate at that load.

VO_{2max} was estimated by using Astrand's nomogram. Correction of age factor was done according to the table and multiplied by VO_{2max} score which gave us the value of VO_{2max} (L/min).

$$VO_{2max}\ (ml/kg/min) = \frac{VO_{2max}\ (L/min) \times 1000}{\text{Body weight}}$$



Astrand nomogram

Reaction time: The apparatus used in this study was the portable research reaction timer with two response choices latest manufactured in March 2010 and was purchased from Anand agencies, Pune, which can measure Auditory Reaction Time (ART) and Visual Reaction Time (VRT)

Specifications of reaction timer:

1. Inbuilt chronoscope – 4 digit chronoscope with least count of 1/1000 seconds.
2. It works on – 230 volts AC [13]

After familiarizing the subject with the instrument and after repeated practice, Auditory Reaction Time (in msec) for Beep tone and Click was determined for both right and left hand. The procedure was repeated for three times and three readings which appeared on the display were noted. The least reading of the three was taken as subject's best auditory reaction time and was recorded in the subject's right hand as it was the dominant hand. The inter stimulus interval was randomly adjusted between 5-10 seconds. The same procedure was followed for determination of visual reaction time (in msec) for Red and Green stimuli using both hands.

Statistical analysis was done using SPSS 16.0. Mean and standard deviation for VO_{2max} was calculated and difference between mean of the two groups was tested using unpaired 't' test, where significance of the P value was < 0.05. Pearson Correlation analysis was done for reaction time with VO_{2max} and is significant at the 0.05 level.

Results:

Table 1 and graph 1 shows the comparison of cardiorespiratory fitness between runners and controls. VO_{2max} – maximum oxygen uptake mean was higher for group runners and was statistically significant.

Table 2 and graph 2 shows the comparison of cardiorespiratory fitness among the two player groups. VO_{2max} – maximum oxygen uptake mean was higher for group B players (seniors) and was statistically significant.

Table 3 and graph 3 shows correlation between VO_{2max} and Reaction time where correlation is significant with Click, White and red color at the level of 0.05 & 0.01 respectively.

Graph 4 shows correlation between VO_{2max} and Reaction time where correlation is significant with Click and Yellow color at the level of 0.05 respectively.

Table 1; Comparison of Cardiorespiratory fitness between runners & controls

	Runners	**Controls**	**p**
VO_{2max} **(ml/kg/min)**	59.3±12.47	30±5.92	0.000*

(*) p value significance<0.05

Table 2; Comparison of Cardiorespiratory fitness between two groups:

	Group A	**Group B**	**p**
VO_{2max} **(ml/kg/min)**	48.3±7.71	66.3±9.57	0.00*

(*) p value significance<0.05

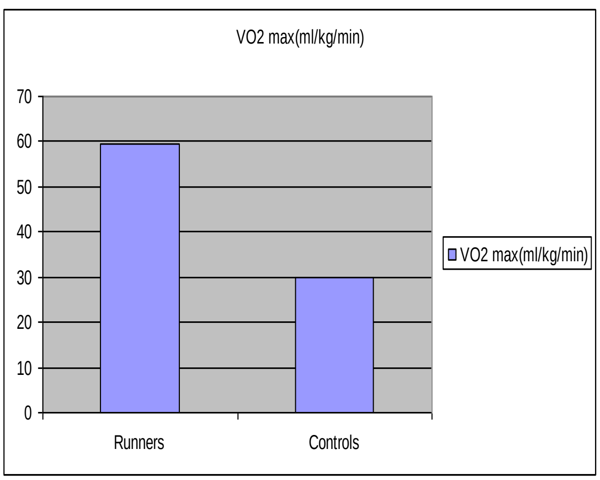
Table 3; Correlation of VO $_{2max}$ with reaction time of runners and controls

	VO $_{2max}$ with reaction time of runners	VO $_{2max}$ with reaction time of Controls
Click (ms)	-.497**	-.405*
Tone (ms)	-.268	-.220
White(ms)	-.404*	-.310
Red(ms)	-.500**	-.258
Yellow(ms)	-.342	-.408*
Green(ms)	-.270	-.327

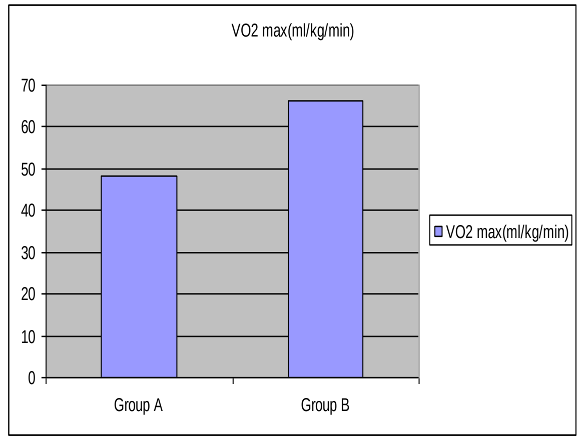
**. Correlation is significant at the 0.01 level

*. Correlation is significant at the 0.05 level

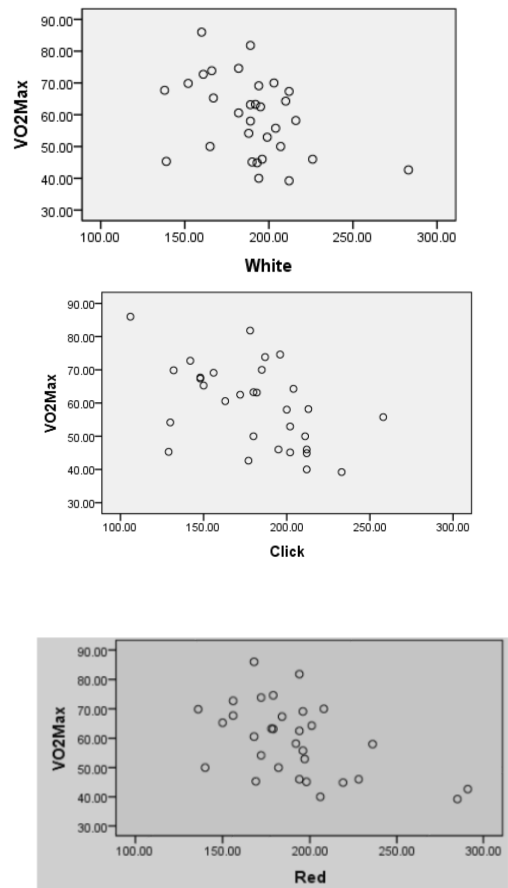
Graph No: 1, Comparison of Cardiorespiratory fitness b/w runners & controls



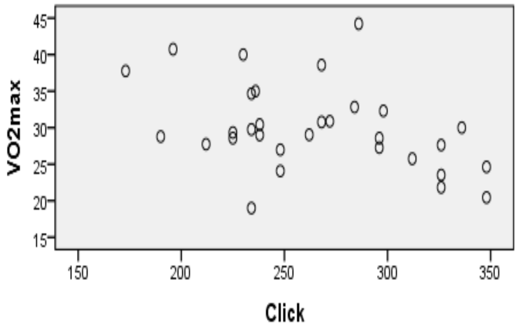
Graph No: 2, Comparison of Cardiorespiratory fitness b/w two groups

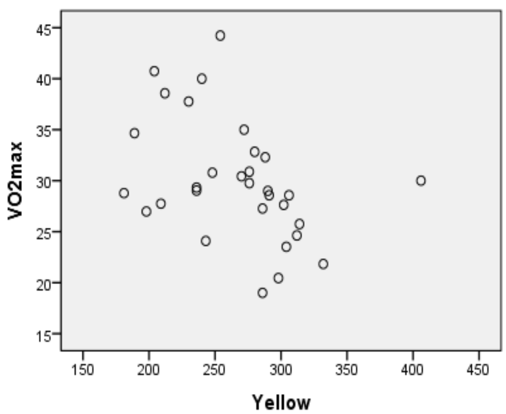


Graph no : 3, Correlation of VO_{2max} **with Click, red and white in Runners.**



Graph no : 4 Correlation of VO_{2max} with Click and yellow in controls.





Discussion:

We have, first, to underline that we have focused this investigation on national and internationally elite runners which are, by definition, few in number and we have got significantly higher VO_{2max} in more trained runners and in comparison with controls the mean value is greater for runners.

Capability of an organism to release higher quantities of energy during the period of time allows elaborating more intensive physical activities. This seems very important to majority of athletes and, what is more, it could be even decisive for one's championship level. It is generally agreed that aerobic capability is best reflected on the cardiopulmonary function and other components of oxygen transport capacity[14] Persons possessing higher values of maximal oxygen uptake (VO_{2max}) have the capacity to yield larger amounts of energy and are capable of performing better in athletic and other field activities. Determination of VO_{2max} is thus one of the important criteria to assess the oxygen transport system, or the cardiopulmonary efficiency [15] The physical limitations that restrict the rate at which energy can be released aerobically depend upon the chemical ability of the muscular tissue system to use O_2 in breaking down fuels and the combined ability of cardiovascular and pulmonary systems to transport the oxygen to the muscular tissue system. Therefore measurement of O_2 consumption is actually a measure of aerobic fitness [16]

Rise in aerobic power with training is just as rapid as its fall without it, and most of the Improvements in VO_{2max} occur within three weeks of beginning intense (3-4 times a week, moderate to high intensity) cardiorespiratory training. In addition, once the desired VO_{2max} is achieved, it is possible to maintain it by reducing the frequency and maintaining the intensity of training [3]. It is reported by many investigators that the magnitude of work done determines the rate of decrease of heart rate during recovery and the recovery heart rate at the beginning of recovery is strongly influenced by the heart rate during work and VO_{2max} but the influence of these parameters on recovery heart rate decreases as the recovery progress[(17)] It was assumed that if some benefit could occur as a result of resistance training, one of the following areas known to influence endurance performance would likely be affected: VO_{2max}, Lactate threshold, running economy, or anaerobic factors/neuromuscular characteristics[1] In world class athletes, lactate threshold typically occurs at 70-80% VO2 max. In untrained individuals it occurs much sooner, at 50-60% VO2 max. In general, if two athletes have the same VO2max value but one has a higher lactate threshold, the one with the higher lactate threshold will more than likely perform better than the other in endurance events. Therefore, the speed at which an athlete reaches their lactate threshold is an additional important training indicator versus

VO2max value alone [18] Research indicates that aerobic training can increase VO_{2max} 15-20 % with training. The biochemical and metabolic adaptations that occur with endurance training are an increase in glycolytic enzymes (LDH, PDH, PFK), beta oxidation enzymes (acyl carnitine transferase), as well as increases in citrate synthetase in the TCA cycle. The primary benefit of these physiological changes is due to a greater use of fatty acids via beta oxidation for metabolic energy, thus reducing the demand for glycogen via glycolysis. This in turn will provide a "glycogen sparring" effect, therefore prolonging the time it takes to fatigue during strenuous exercise. Aerobic group has a different recovery pattern because with aerobic training concentrations of aerobic enzymes increases, mitochondrial number, size and surface area and myoglobin content increases all contributing to improved oxygen extraction by muscle Aerobic training also results in increased muscle blood flow, which is accomplished through elevated cardiac output, increased capillarisation of muscle tissue and an improved ability to vasodilate. Oxygen delivery in the endurance trained athlete is further improved by increases in blood volume and total hemoglobin volume. Together these enhancements results in an increased rate of VO_2 during high intensity exercise and decreased time to reach peak VO_2 during exercise. Moreover, the enhanced ATP/PCr stores and elevated myokinase and creatine concentration, results in an ability to supply more energy through the phosphagen and aerobic systems, thus decreasing the reliance on anaerobic glycolysis. With reduced anaerobic glycolysis during exercise, less energy is required during the recovery period to rid the muscle of H^+ and lactate, potentially hastening the recovery process. Other training effect seen in aerobically trained individuals may improve temperature regulation during and after exercise. Thus it appears that the metabolic and circulatory adaptations associated with high levels of aerobic power should facilitate faster recovery from high intensity exercise [19, 20, 21]

Audio-visual reaction time is the time taken by an individual to react to an auditory or visual stimulus respectively. It can be of crucial value in activities like driving and is an important quality of a sportspersons.[22] In the present study Auditory and visual reaction times were significantly less in runners than in controls. These changes are due to the effect of training in the runners. Also among senior players there was a significantly lower reaction time. Reaction time is a crucial factor in deciding success in many sports. The quickness of response depends on the integrity of cell communication, sensory perception, central processing and motor response. The significant decrease in reaction time (auditory and visual) in athletes can be explained on the following basis: improved concentration and alertness, arousal induced as a result of exercise which supports alertness to external environmental stimuli in highly trained athletes. The effects of exercise on arousal could be linked to neurophysiological changes such as level of plasma catecholamines with exercise duration or intensity.[23]

Increased amount of blood flow in the brain results in improvements in cognitive functioning due to increased supply of necessary nutrients, such as oxygen and glucose. [24] Improvement in VRT (Visual reaction time) over a period of time with practice was displayed in this study and supported the hypothesis. Reaction time in specific movements improves as a result of extensive practice of those concerned movements.[24] Tripp claims that practice reduces decision time by eliminating incorrect decisions and enables the correct decision to be made more efficiently.[25]

Due to increase in level of participation in specific events the reaction time tends to decrease. If an act is practiced enough a conditioned reflex may develop. For example, a sprinter may develop conditioned reflex to a pistol shot. Similar examples could be given in connection with numerous other performances and skills of different games and sports. Therefore reaction timeimproving training sessions have to be held for athletes to develop their fine motor skills [24, 25]

Reaction times are widely used to evaluate neuromuscular-physiological responses in sports.[26] Reaction time is an important parameter for sports person's quickness and their performance. Improvement in reaction time will ultimately improve sports person's performance. Hence sports persons have to practice regularly to improve their reaction time and sports performance.[27]

In a study done by Kaur et al they concluded that the reaction time is a good indicator of performance in sports as the athletes performed better with reaction time tasks.[28] This study goes in hand with the study done by Brisswalter et al which states that physical exercise will decrease the reaction time. [29] As exercise physiologists, our main aim is to improve the speed, skill and performance of the athlete. The above evidences suggest that speed and performance of an activity can be improved with faster reaction time to a stimulus. From the above findings of the study, faster reaction times can be achieved by providing repeated auditory stimuli and with adequate periods of rest between the stimuli. A performance enhancing program can look like this: - Exposure to adequate auditory stimuli, repeated exposure to stimuli during practice, adequate periods of rest between practices.[24] It can thus be concluded that RT is related to sprinters' mental activity and must be considered evidence of their racing strategy.[30]

None of the studies directly gives the relationship of VO_{2max} with reaction time. In our study there is a negative correlation with click, red and white reaction time and is statistically significant for runners and same way for click and yellow color in controls, which suggests the higher aerobic capacity with lesser reaction time after the training. Right handed reaction time was better than left hand even tough very slight difference was there between right and left hand.

Study done by M. Collardeau et al suggests that an increase in arousal induced by a prolonged exercise improves simple reaction time performance.[31] Few studies conclude that improvements in neuromuscular parameters were achieved without impairment in maximal oxygen uptake, showing no changes in VO_{2max}, although the volume of the endurance training was somewhat reduced [32, 33, 34] Study done by Peiffer tells that recent evidence proposes increase in aerobic fitness through regular physical activity which are essential to sustain cognition and acute aerobic exercise of moderate and vigorous intensities can improve executive function processes in older women who possess a high level of fitness.[35]

Conclusion:

In the current study, endurance training has improved the aerobic capacity in runners as compared to controls. As an effect of training there is an increase in VO_{2max} and whoever has got more VO_{2max} they have got less reaction time.

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