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# A Crossectional Study of VO2max and Plasma Lactate Values in Football Players

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***Research Article***

***Abstract:*** **Introduction:** Football is the most popular sport played all over world. There is scarce published data on football players from India, although there are numerous published reports for American, European and Australian players. Study was conducted to determine $VO_2max$ and plasma lactate values of football players. **Objective:** To evaluate aerobic capacity (VO2max) and anaerobic capacity (lactate) in professional football players and compare it with controls. **Methods:** 60 males, aged 21 to 24 years were included. Thirty were professional football players and thirty were controls with sedentary lifestyle. Queens College Step Test was used to determine predicted VO2max. An all-out effort of running for 60 seconds was performed by both groups and immediately after that; venous sample was collected for plasma lactate estimation. Unpaired t test was used to test statistical significance. **Results and Conclusion:** Mean predicted VO2max was 59.53 ± 2.96 ml/kg/min in players, and 42.61 ± 3.45 ml/kg/min in controls, mean plasma lactate 104.03 ± 9.55 mg/dl in players and 65.13 ± 7.6 mg/dl in controls. The difference in VO2max and lactate is statistically highly significant with 'p' value less than 0.001. Thus, football players showed superior aerobic and anaerobic capacity. VO2max of local professional players fall in the range reported for elite soccer players from various countries. The coaches may get help in improving performance of players by proper designing of training programs in accordance with research studies. Maybe, this will contribute to put India ahead in international Soccer rankings.

***Keywords:*** $VO_2max$, plasma lactate, soccer.

## Introduction:

Football is the most popular sport played all over the world. It is the game that leads in the field of sports. It's not a miracle, but it promotes passion and love. Football encompasses millions of players, coaches, scientists, administrators, physical education teachers, politicians and inevitably parents of young players. The profound beauty of football in any of its codes lies in the fact that football requires power, accuracy and coordination. Unlimited options are assessed, decisions are taken and action is conducted in less than seconds during the course of every game. The scale of association of football, for example, is evident in more than 200 nations; *Federation Internationale de Football Association* (FIFA) has 207 members as of 2006 whereas United Nations has 191 members: Involvement of a natural instinct! [1]

The passion for football is evident in the famous statement by Bill Shankly, English soccer manager. "Some people believe football is a matter of life and death. I'm very disappointed with that attitude. I can assure you it is much, much more important than that".

Football, also known as Soccer, is considered a physically demanding sport. [2] The energy demands of football involve all the three systems for production of energy.

There are three major systems available for production of energy in muscles: Adenosine Triphosphate- phosphocreatine (ATP- PC) system for high-intensity short bursts; the anaerobic glycolysis system for intermediate bursts of relatively high intensity and finally, there is aerobic system for long efforts of low to moderate intensity. [3]

A game of football could be represented as an exercise protocol of running about 150 metres every minute for 90 minutes, with a 15 minute rest period after the first 45 minutes. In order to achieve this, even at moderate intensity, a high demand is placed on the player's aerobic energy system. [4] It is well documented that there is a significant relationship between aerobic capacity i.e. $VO_{2max}$ (V- Volume consumed, $O_2$- Oxygen, max- maximum) and the total distance covered, frequency of sprints made in a match, as well as the number of involvements with the ball by the football player. [5]

The high intensity bursts of football are fuelled by anaerobic glycolysis system. These activities require rapid energy transfer that exceeds that supplied by stored phosphagens (ATP-phosphocreatine). [3] It has been suggested that a high anaerobic power is a required characteristic of elite soccer players and "the main difference between players of different quality is not the distance covered during the game but the percentage of overall fast-speed distance

during the game and the absolute values of maximal speed play during the game". [2]
Blood lactate levels more than likely reflect the capacity of the anaerobic glycolysis system. Capacity to generate high lactate levels during exercise enhances maximal power output for short durations. [3]
There is scarcity of published data on physiological profile of football players from India, although there are numerous published reports for North American, European and Australian soccer players. With this perspective, this study is an attempt to evaluate the aerobic capacity ($VO_{2max}$) and the anaerobic capacity (lactate values) in local professional football players.

## Aims and Objectives:

1) To determine $VO_{2max}$ values in professional footballers of the city.
2) To determine plasma lactate values in professional football players of the city.
3) To compare $VO_{2max}$ values of professional football players of city with that of controls.
4) To compare plasma lactate values of professional football players of city with that of controls.

## Material and Methods:

The ethics committee of the institution was informed about the nature of the study. The approval of the study protocol was obtained from the Institutional Ethics Committee.
**Study Design:** Crossectional study
**Selection of the Subjects:** Thirty players were included in this group.
Inclusion Criteria:

- Professional male football players in the age group of 21 to 24 years who were playing regularly and have participated in club level football games for more than five years.
- Apparently healthy – not having any chronic disease.
- Subjects who gave their consent for the study.

Exclusion criteria:

- Subjects having symptoms of cardiopulmonary disease, or history of any chronic disease.
- History of smoking, trauma or injury
- Subjects not ready to participate voluntarily in the study.

**Selection of the Controls:** Thirty individuals were included in this group.
Inclusion Criteria:

- Males in the age group of 21 to 24 years who were having a sedentary lifestyle with no involvement in any athletic activity or yoga
- Apparently healthy – not having any chronic disease.
- Individuals who gave their consent for the study.

Exclusion criteria:

- Individuals having symptoms of cardiopulmonary disease, or history of any chronic disease.
- History of smoking, trauma or injury
- Individuals not ready to participate voluntarily in the study.

**Basic Data Collection:**
The subjects and controls were called early in the morning. Following measurements were done in a well-lit room of the Department of Physiology in the Government Medical College, Aurangabad, Maharashtra.

- Body Weight: measured by standard weighing machine.
- Standard Height: taken by measuring tape
- Body Mass Index: (BMI) = Weight in kilograms (kg)/ (Height in metre)$^2$

**Determination of $VO_{2max}$:**
Subjects were asked to come 3 hours after their meal. They were asked not to indulge in any kind of vigorous exercise within 48 hours prior to the test. They were asked to wear comfortable clothing.
Queens College Step Test was used to predict maximal aerobic capacity. It is a standard method to measure one's maximal oxygen uptake using submaximal exercise in the form of bench stepping, suitable for adults. Prior to the test, subjects were asked to warm up for 5-7 minutes consisting of brisk walking and stretching of lower limb muscles. A wooden stepping bench of 16¼ inch was used along with metronome and stop watch. Metronome was used to monitor the stepping cadence, which was set at 96 beats per minute (24 complete steps per minute). The step test began after a brief demonstration and practice period. The subjects were asked to perform each stepping cycle to a four-step cadence, up-up-down-down continuously for 3 minutes. After completion of test, subjects remained standing while pulse rate (carotid or radial artery) was measured for 15 seconds, from 5$^{th}$ to 20$^{th}$ second of the recovery period. Fifteen second Recovery heart rate was converted to be expressed as beats per minute (15 second Heart Rate x 4).
Following equation is used:

$VO_{2max}$ (ml/ kg/min) = 111.33 – (0.42 × step test pulse rate in beats per minutes). [6]

**Estimation of Plasma Lactate:**

Subjects were asked to come 3 hours after their meal. They were asked not to indulge in any kind of vigorous exercise within 48 hours prior to the test. They were asked to wear comfortable clothing. They were asked to perform an all-out effort of running for 60 seconds. Immediately after this, under aseptic precautions, 2 ml of venous blood sample was taken in a Gray Top (Sodium Fluoride) vacutainer. Venous specimen was obtained without use of a tourniquet. The blood was then mixed with the anticoagulant (Sodium Fluoride) by gently inverting the tubes 8-10 times and blood was centrifuged. Plasma was separated from cellular material within 15 minutes of collection. It was then transferred into appropriate plastic transport vial containing ice packs to maintain temperature. Sample was sent to laboratory for analysis by Spectrophotometry. Lactate is analysed by lactate calibrator kit-1 of Ortho-Clinical Diagnostics by VITROS 250 Analyser. Values assigned to the VITROS chemistry products calibrator kit-1 for lactate are traceable to gravimetrically prepared standards using reagent grade lactic acid. Results expressed in milligrams/decilitre (mg/dl). By this method, the normal range of resting plasma lactate is 4.8-19.8mg/dl.

## Observations and Results:

In the present study, $VO_{2max}$ and plasma lactate values of football players and controls were estimated and compared. For each parameter, the mean value and standard deviation were calculated. ‘Unpaired t test’ was applied to test whether the differences in means were statistically significant. All the calculations and statistics were done using Microsoft Excel 2007. A ‘p’ value of less than 0.05($p < 0.05$) was considered to be statistically significant. A ‘p’ value of less than 0.001($p < 0.001$) was considered to be statistically highly significant.

**Table 1:** Comparison of the Baseline characteristics of the Study Groups.

| **Parameter (Mean ± SD)** | **Subjects** | **Controls** |
|---|---|---|
| Age (years) | 22.9 ± 0.99 | 22.46 ± 1.04 |
| Weight(kilograms) | 60.13 ± 2.68 | 60.16 ± 2.5 |
| Height(centimetres) | 174.7 ± 2.73 | 174.77 ± 3.26 |
| Body Mass Index | 19.71 ± 1.1 | 19.71 ± 0.97 |

SD: Standard Deviation.

**Table 2:** Comparison of $VO_2$ max in the Study Groups.

| **Parameter (Mean ± SD)** | **Subjects** | **Controls** | **‘p’ value** |
|---|---|---|---|
| Recovery Heart Rate (per minute) | 123.33** ± 7.05 | 163.6 ± 8.22 | <0.001 |
| $VO_2$ max (ml/kg/min) | 59.53** ± 2.96 | 42.61 ± 3.45 | <0.001 |

** $p < 0.001$: statistically highly significant. SD: Standard Deviation.

**Table 3:** Comparison of Plasma lactate values in the Study Groups.

| **Parameter (Mean ± SD)** | **Subjects** | **Controls** | **‘p’ value** |
|---|---|---|---|
| Plasma lactate values (mg/dl) | 104.03** ± 9.55 | 65.13 ± 7.6 | <0.001 |

** $p < 0.001$: statistically highly significant. SD: Standard Deviation.

## Discussion:

The mean $VO_2$ max of elite soccer players has typically reported to be in the region of 55 to 65 ml/kg/min. However, these values are relatively modest in comparison with elite endurance athletes in other sports such as rowing, cycling or running. To some extent, this may be explained by the high volume of matches completed over the competitive season that reduce the opportunities for aerobic fitness training. It is also likely that elite soccer players are successful because they have good, but not exceptional, all round physical strengths and are thus able to effectively respond to the diverse demands of the game. [7]

Several researchers have proposed that a $VO_{2max}$ of about 60 ml/kg/min is a minimal threshold for elite professional male soccer players. Aerobic endurance training has the potential to optimize soccer performance by enhancing recovery from high intensity intermittent bouts during match play, thereby contributing to the ability to sustain a high work rate throughout a full competitive match.[5]

Thus; it is of importance to monitor the aerobic endurance performance of professional soccer players.

The increase in aerobic capacity can probably be explained by the various physiological mechanisms discussed below [3]:

1. Two distinct fiber types have been identified in skeletal muscle: fast twitch and slow twitch. Slow twitch fibers also called as Type I fibers have a contraction speed about one half as fast as its fast twitch counterpart. Slow twitch fibers possess numerous mitochondria and high enzyme concentration to sustain aerobic metabolism. They demonstrate a much greater capacity to generate ATP aerobically than fast twitch fibers. As such, slow twitch muscle fiber activation predominates in endurance activities that depend almost exclusively on aerobic metabolism. Fast twitch fibers also called as Type II fibers, have a rapid contraction speed and become activated in sprint activities that depend entirely on anaerobic metabolism for energy. Football requires a blend of both aerobic and anaerobic capacities. Both types of muscle fibers are activated in it. Specific exercise training improves the metabolic capacity of both the fiber types.

2. Training significantly increases capillary density and mitochondria size and number. The concentrations of enzymes and transfer agents involved in aerobic metabolism also increase two to three fold, enhancing the capacity to generate ATP aerobically, particularly via fatty acid breakdown.

3. Resting heart rate in untrained individuals' averages about 70 beats per minute, resting cardiac output averages 5 litres per minute. Resting heart rate in trained athletes' averages about 50 beats per minute, resting cardiac output is 5 litres per minute. Thus, blood circulates with a proportionately larger stroke volume of 100 millilitres per beat. The two factors probably interact as aerobic fitness improves:

- Increased vagal tone slows the heart, allowing more time for ventricular filling.
- Enlarged ventricular volume and a more powerful myocardium eject a larger volume of blood with each systole.

In sedentary, college-age men, cardiac output in strenuous exercise increases about four times the resting level to an average maximum of 22 litres per minute. Maximum heart rate for these young adults averages 195 beats per minute. Consequently, stroke volume averages 113 millilitres per beat during maximal exercise. In contrast world class endurance athletes generate maximum cardiac output of 35 litres per minute, with a similar or slightly lower heart rate than untrained counterparts. The difference between maximum cardiac outputs of both individuals relates solely to the stroke volume.

A modest increase in heart size (cardiac hypertrophy) represents a fundamental adjustment of the healthy heart to exercise training. It is called "Athlete's Heart". Regular aerobic exercise stimulates myocardial protein synthesis; individual muscle fibers thicken; and a fiber's contractile elements increase in number. When exercise overload ceases, heart size returns to pre-training levels.

4. The following equation shows an important relationship between maximum cardiac output, maximum a-v$O_2$ difference (extraction of Oxygen), and $VO_2$ max:

$$VO_{2max} = \text{maximum cardiac output} \times \text{maximum a-v}O_2\text{ difference}$$

Two mechanisms for Oxygen supply can increase a person's oxygen uptake capacity:

1. Increased tissue blood flow
2. Use of relatively large quantity of oxygen that remains unused by tissues at rest (i.e. expand the a-v$O_2$ difference). [3]

In accordance with the present study, following studies have been carried out in relation to aerobic capacity of football players:

Al-Hazzaa H.M. et al (2001) found that $VO_{2max}$ of Saudi elite soccer players was more than Saudi college males but less than Saudi distance runners. There was no difference in $VO_{2max}$ of players based on playing positions. The aerobic power and anaerobic power parameters of Saudi players were in the lower range of values normally reported in literatures of elite soccer players. [2]

K McMillan et al (2005) found that performing for high intensity 4 minute intervals, dribbling a soccer ball, around a specially designed track, together with regular soccer training is effective for improving the $VO_{2max}$ of soccer players, with no negative interference effects on strength, jumping ability, and sprinting performance. [8]

Da Silva CD, Bloomfield J and Carlos JBM (2008) found physical and physiological differences between Brazilian and European soccer players in terms of anthropometric values & $VO_{2max}$ profiles of players. They suggested that coaches and physical trainers should give special attention towards improving the $VO_{2max}$ values for Brazilian players, which could provide the players with an even greater ability to become more involved in the match. [9]

The increased plasma lactate values in professional football players may be explained by the following physiological mechanisms: [3]

1. Improvement in the metabolic capacity of Fast twitch i.e. Type II fibers, which have a rapid contraction speed and become activated in sprint

activities that depend entirely on anaerobic metabolism for energy.

2. Increased intramuscular glycogen stores with training contribute a greater amount of energy via anaerobic glycolysis.

3. Increase in glycolytic enzyme activity, particularly phosphofructokinase.

4. Differences in training level, capacity to buffer acid metabolites produced in heavy exercise, and motivation contribute to individual differences in capacity to generate short-term anaerobic energy. [3]

Edwards A.M., Clark N, and Macfadyen A.M. ( 2002) study found that Lactate and ventilatory thresholds reflect the training status of professional soccer players where maximum aerobic power is unchanged. [7]

## Conclusion:

The the football players showed a superior aerobic capacity ($VO_{2max}$) as well as anaerobic capacity (plasma lactate values). The $VO_{2max}$ values of the local professional football players' fall in the range reported for elite soccer players from various countries. Further research on Indian soccer players across the country and different age groups will be needed to substantiate this claim.

Although, the "parameters for success cannot be measured", further research is needed to study the physical and physiological characteristics of Indian Soccer players and compare it with international standards. The coaches may get help in improving the performance of players by proper designing of aerobic and anaerobic training programs in accordance with the research studies. Maybe, this will contribute to put India ahead in the international rankings of Soccer.

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