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*Research article*

# SPORTS ANAEMIA IN ENDURANCE ATHLETES: A PHYSIOLOGICAL PHENOMENON.

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**ABSTRACT:** Endurance athletes require a very efficient oxygen transport system for maximal aerobic power during physical work performance. Many studies carried on endurance athletes suggested low levels of red blood cell markers leading to misconception of existence of so called sports anaemia in athletes. Sometimes athletes are on needless iron supplementation and are concern about anaemia. The main objectives of the study were to investigate the red cell population markers and to study the sports anaemia phenomenon in endurance athletes and the underlying responses responsible for ot. 60 male endurance track and field runners age group 18-21 were selected from the local city based club named Vasant Desai Krida Sangh Akola and were compared with the age, height sex matched non athletes students of Govt. Medical College Akola. The seven red blood cell markers were studied from the blood samples taken from the cubital vein under standard conditions. The blood variables for both the groups were analyzed with an automatic cell counter. The mean values of Hb(12.27 gm% +/- 0.782), RBC count in(3.64millions per cu mm+/-0.52), hematocrit ( 41.58 % +/- 1.32), mean corpuscular Hb conc (MCHC 29.49% +/- 1.198) were all very significantly lower ( $p<0.0001$) as compare to controls. Whereas the plasma volume (58.412% +/- 1.32), Mean Corpuscular volume (MCV 115.06 cu microns+/- 11.54)), Mean Hb conc (MCH 33.998 picogms+/- 2.608), were significantly increased in endurance athletes. Though decrease in Hb conc, Low RBC count and less hematocrit in endurance athletes indicate presence of anaemia in them but it's not a true anaemia as it is also confirmed by MCV, MCH, MCHC values between the two groups. The significant differences between the groups are due to the response to endurance training leading to hemo dilutional anaemia caused by plasma volume expansion which increases the blood volume in endurance athletes helping them for better oxygen supply and aerobic power needed during physical work.
**Key words:** Endurance athletes, Sports Anaemia, Red blood cell markers

## INTRODUCTION

Efficient transport of oxygen within the body is of particular importance for physical work performance, maximal aerobic power and resistance to fatigue, especially in endurance disciplines such as cycling, long distance running or cross-country skilling. The oxygen supply to tissues is influenced mainly by the oxygen-carrying capacity of blood, which is determined primarily by blood's haemoglobin concentration (Zbigniew Szygula, 2010). One can expect that exercise training aimed at an increase in the physical performance should bring about an elevation of the oxygen carrying capacity of blood by increasing, among others, the values of haematological parameters such as erythrocyte count, haematocrit and haemoglobin concentration. Many authors, however, have observed that under resting conditions, the parameters of the erythrocyte system are lower in some well-trained athletes, particularly those performing in endurance disciplines (Lindsay M Weight, 1993). This kind of anaemia has been termed as sports anaemia, athlete's anaemia, post exercise anaemia, runner's anaemia or swimmer's anaemia (Bell, J, Cowan, G.S.M, 1978).Technically, anaemia is a condition in which one has a reduced amount of haemoglobin or low number of red blood cells. The most common symptoms of this disorder are fatigue, weakness and, in extreme cases, shortness of breath or palpitations, or one may have no symptoms at all. Athlete's anaemia or sports anaemia is well recognized and there have been many suggestions for its aetiology some leading to unnecessary anxiety as well as needless investigation and treatment (Eric Watts, 1989). There is an ongoing, unsolved debate as to whether iron supplementation, often used by elite athletes, is really necessary or not (Cosimo Ottomono, Massimo Franchini, 2012). A preliminary question that needs an answer is whether the existence of sports anaemia is supported by facts or whether it is fiction. Whether iron should be prescribed to athletes depends on the answer to this preliminary question. Therefore the study intended with given objectives.

Aims and Objectives:-

1. To find out the values of Hematological parameters like, Hb%, RBC count, Hematocrit, MCV, MCH & MCHC in endurance athletes & compare with non athletes.
2. To study the whether any true anemia exist in endurance athletes.
3. To study the underlying various physiological mechanisms for this phenomenon in athletes.

## MATERIAL AND METHODS

### Selection of Subject

**1. Athletes**: A group of 60 male Athletes consisting of track and field runners were selected from Vasant Desai Krida Sangh Akola, (M.S.) .The criteria for selection of the group was that, they should have at least 4 – 5 years of Athletes activities for a minimum period of 5-6 hours daily in morning & evening. They should be participant in Athletes activities at District, State or National level.

**2. Non- Athletes**: The control group consists of 60 medical students of GMC, Akola. They were non-Athletes means did not participate in regular running, jogging, swimming, or in any other sports.

Both the groups were age (18-22 years), height and sex matched with slight variation in their weight. They were selected after complete medical examination. Detail family history was obtained to rule out the risk factors like hypertension, diabetes mellitus, cardiovascular disorder or any other ailment. Special care was taken to see that none of them was on drug therapy or having history of chest pain, palpitations or breathlessness. Informed consent was obtained in every case and the study was carried out by taking prior permission from Institutional ethical committee. All the subjects voluntarily participated in the study.

**3. Measures and Procedure:** Height and weight were measured for both the groups according to standard procedures and formulas. Body mass index (BMI) was calculated as weight in Kg upon height in metres. The blood markers of the red blood system were also determined (Bozo D, 2014).

Blood sampling took place in the morning under standard procedure with all aseptic precautions with an empty stomach of overnight fasting. The blood was collected from antecubital vein in EDTA bulbs. 2 ml of blood was collected from every subject in groups and the process was completed within 2 hrours of collection. The concentration of haemoglobin (Hb) in gm%, RBC count in millions per cu mm, Hematocrit or Packed Cell Volume (PCV%), erythrocyte indices MCV in cu micron, MCH in picogram & MCHC in % were determined with an fully Automated haematology Analyzer (Automatic Cell Counetr) Nihon Koden, MEK 6420 ( Japan). Plasma volume (PV) was calculated from PCV as %.

**Analysis:** Standard statistical methods (SPSS version 15) were used for the data analysis. The results were tabulated.

## RESULTS

Both the groups of the study were age, height, body mass index and sex matched with little differences in their body weights, as shown in Table No. 1. The Athletes have lower body weights as compared to non Athletes. The figures and data related to red blood cells of the groups under investigation are shown in Table No. 2. As, it can be seen a very significant differences are seen in the haematological parameters of both the groups. The RBC count have mean value 3.647 millions per cu mm +/- 0.5203,in athletes and 5.006millions per cu mm, +/- 0.4421in non athletes, mean values of Hb conc were 12.27gm%, +/- 0.782 & 13.845gm%, +/- 0.829, in athletes & non athletes respectively , and hematocrite with group average 41.58% +/- 1.324 & 44.521% +/-, 0.6932 respectively. Similarly the plasma volumes were 58.412%, +/- 1.324, +/- & 55.48%+/- 0.6932 in athletes and non athletes. The blood indices in an athletes and non athletes were MCV 115.06cu microns, +/- 11.544 & 89.497 cu microns +/- 6.838, MCH 33.998 picograms, +/- 2.608 & 27.763 picograms, +/- 1.7066, MCHC 29.497%, +/- 1.198 & 31.091%, +/- 1.556 respectively. (Fig 1 to 7).

**Table No-1: Physical Characterstics**

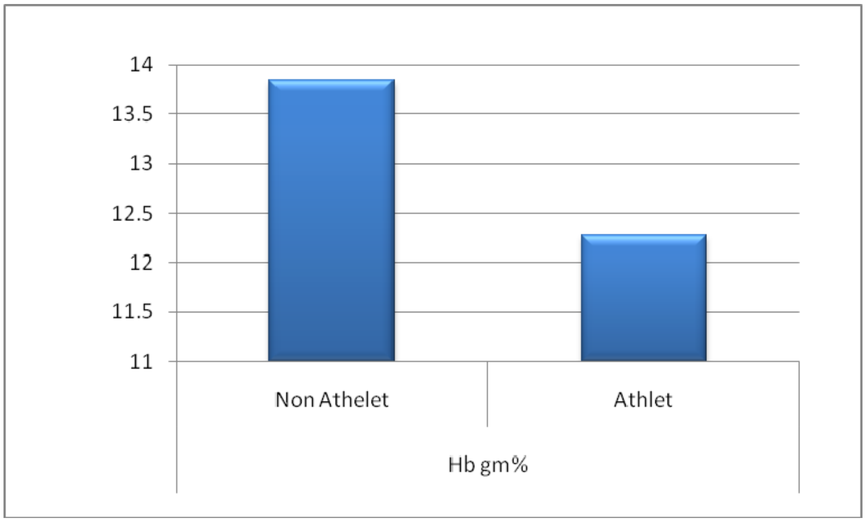
| Parameters | Non Athelets Mean/SD | Athelets Mean/SD | P Value |
|---|---|---|---|
| Age( years) | 20.45/1.06 | 20.32/1.32 | > 0.50 |
| Height (Meters | 1.66/0.04 | 1.67/0.035 | > 0.25 |
| Weight Kg | 61.6/7.33 | 55/8.86 | < 0.001* |
| BSA Sq. Mts | 1.67/0.05 | 1.59/0.045 | > 0.40 |

*-- significant

**Table No-2: Haematological Parameters**

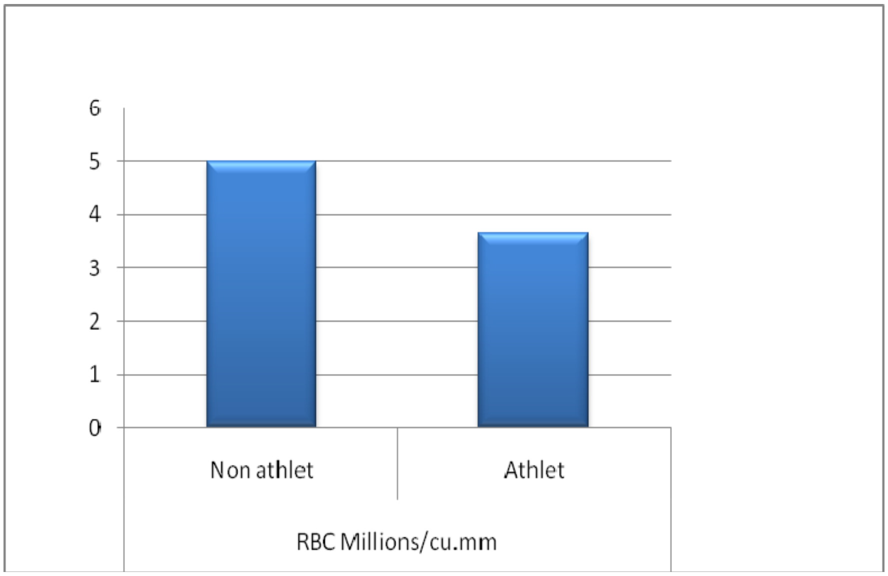
| Parameters | Non Athelets Mean/SD | Athelets Mean/SD | P Value |
|---|---|---|---|
| Hb gm % | 13.84/0.829 | 12.27/0.782 | <0.0001**** |
| RBC million/cu mm | 5.006/0.442 | 3.647/0.5203 | <0.0001**** |
| PCV % | 44.5120.693 | 41.5871.324 | <0.0001**** |
| PV % | 55.487/0.693 | 58.412/1.324 | <0.0001**** |
| MCV | 89.497/6.838 | 115.06/11.544 | <0.0001**** |
| MCH | 27.763/1.7066 | 33.998/2.608 | <0.0001**** |
| MCHC | 31.091/1.556 | 29.497/1.198 | <0.0001**** |

****----- very highly significant



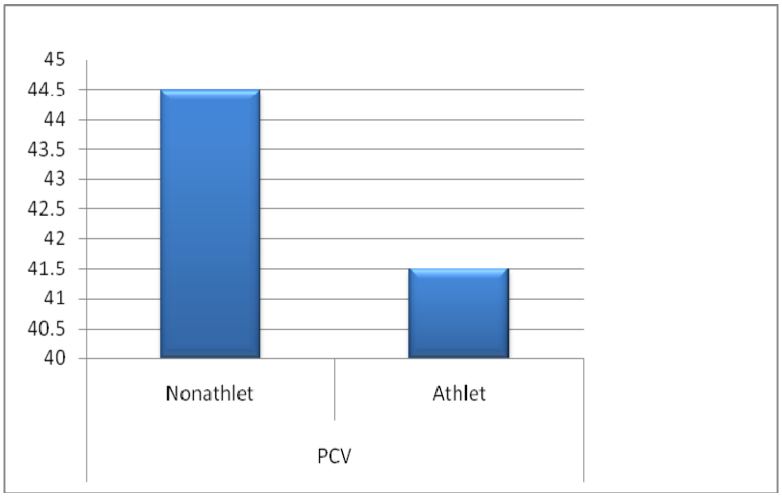

Non Athletes- 13.84 gm % Athletes- 12.27 gm %

**Fig-No 1. Showing Hb cotent in gm%**



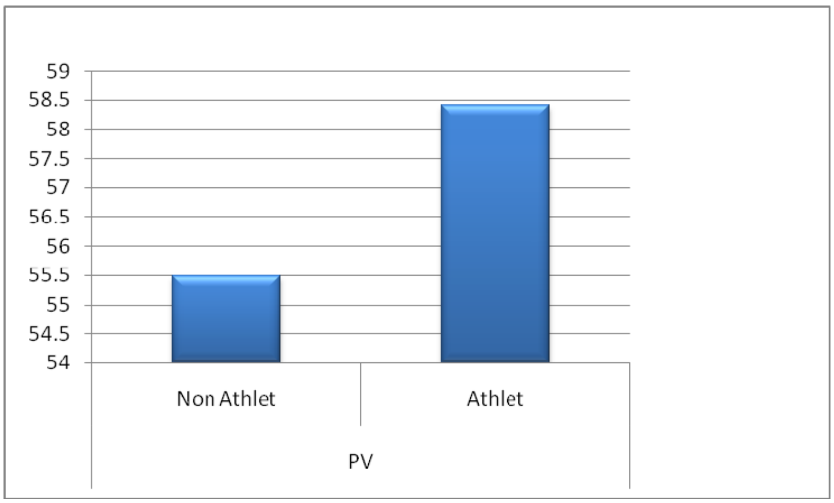

Non Athletes- 5.006 millions/ cu mm Athletes- 3.64 millions/ cu mm.

**Fig-No 2.Showing RBC count in millions per cu mm.**



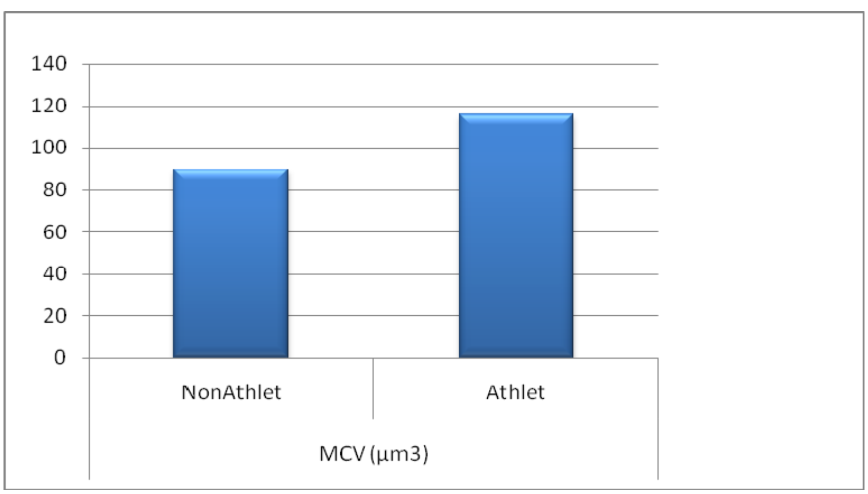

Non Athletes- 44.51 % Athletes- 41.58%

**Fig-No 3. Showing PCV in %**



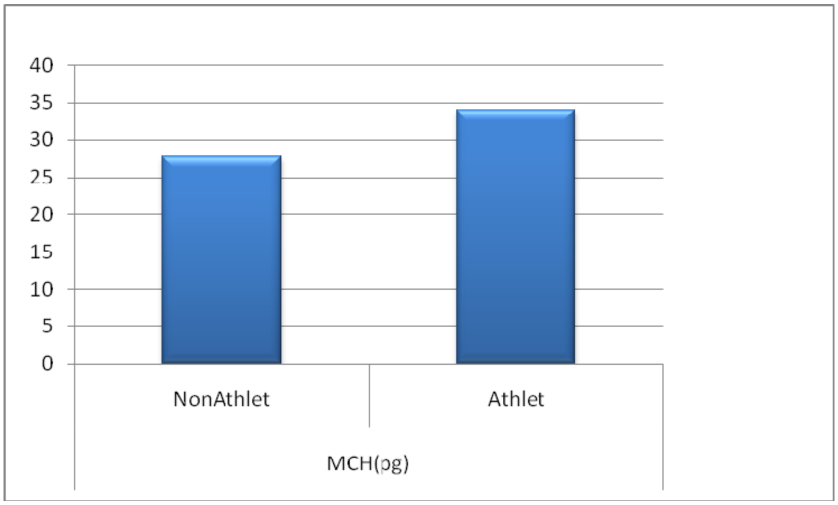

Non Athletes- 55.487% Athletes- 58.412%

**Fig-No 4. Showing PV in %**



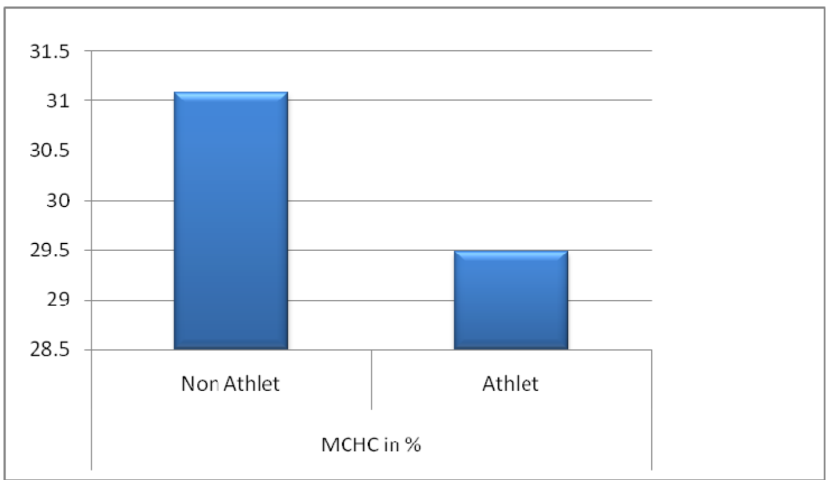

Non Athletes- 89.49 cu microns Athletes- 115.06 cu microns

**Fig-No 5. Showing MCV in Cu microns.**




Non Athletes- 27.76 picogms Athletes- 33.99 picogms

**Fig-No 6. Showing MCH in pg (picograms)**




Non Athletes- 31.09% Athletes- 29.49 %

**Fig-No 7. Showing MCHC in %**

## DISCUSSION

Our study reported a very significant decrease in RBC count, Hb conc, & Hematocrit (p< 0.0001) in endurance athletes as compared to the non athletes group shown in Bar diagrams 1,2, 3.Similarly very significant increase in Plasma volume, MCV, MCH & MCHC (p<0.0001) as shown in Figures 4,5,6,7.The following are the facts in relation with the changes in blood markers seen as a result of endurance training in athletes.

Regular aerobic exercise "expands the baseline plasma volume, diluting the red blood cells, and thus, the haemoglobin concentrations". That is why athletes tend to have higher blood volume levels and lower haemoglobin concentration that sedentary individuals (Convertino, V.A et al, 1980). Similar findings of low Hb conc, decrease Red blood cell mass and increased plasma volume were also reported in other studies (Bell, J., Cowan, G.S.M 1978, Naokes T. D 1979, Brotherhood, J et al, 1975, Weight, L.M et al, 1992). Despite this decline in haemoglobin concentration, it may be advantageous for the endurance athlete. (Krip, Gledhill, et al 1997), concluded that increase in blood volume could impact stroke volume, as well as cardiac output (Dill et al, 1974), reported in the studies. The untrained individuals had immediate increase in maximal diastolic filling rate of over twenty-two percent while the endurance trained athletes had immediate decrease in the maximal diastolic filling rate of twenty-seven percent. These results showed that increase in blood volume occur with any immediate change in physical activity, thus, initiating instant changes in stroke volumes. These changes in stroke volume subsequently caused alterations in blood volume, which are primarily attributed to the changes in higher diastolic filling rate of trained athletes (Krip, B et al, 1997, Clausen, J.P (1977). These adaptive events account for the larger blood volume in endurance trained athletes and augments blood flow through the arteriole walls (Krip, B et al, 1997).

As noted in the study by Erric Watts (Eric Watts, 1989), the other adaptive changes in includes increase in muscular bed and ventricular volume in trained athletes. Mean blood pressure and Peripheral resistance are reduced i.e. it leads to vasodilations. Increased stroke volume and blood volume reflect this (Uddin, D.E. Paliganda, B 1978). One might expect that the lower haemoglobin concentration per unit of blood in the system would hinder performance. In fact what actually results, is an increase in cardiac stroke volume produced by the greater tidal volume. Hence, the dilution of blood produces an enhanced delivery of oxygen to active muscle; thus, increased blood volume lowers the blood's viscosity, improves the blood's flow and increase oxygen diffusion (Clausen, J.P 1977, Dressendorfer, R.H et al, 1981).

Furthermore, there must be consideration for the possibility that 'sports anaemia' may just be pseudo anaemia or false anaemia, although athletes may also develop a true anaemia caused by iron deficiency. But true anaemia can curb an athletic performance whereas, pseudo anaemia does not. The most important information is obtained from red cell indices in our study, reported a significant increase in MCV, MCH & MCHC which are the primary indicator for mean Hb conc in erythrocyte. In a study by Lippi (Lippi G, Schena F, 2012) and Gauidin (Gaudin C, Zerath E, 1990) found significant increase in MCHC. Banfi G and et al also reported an increase in MCH & MCHC in trained endurance athletes. Iron deficiency anaemia would be likely if MCV is below 75 cu microns (normal range 77-93 cu micron), and the MCH below 25 pg (normal range 27-34 pg) (Eric Watts, 1989). Red blood cells in circulation are normally determined by observing the ratio of blood cells to total blood volume. Regular exercise and aerobic training increase the total blood volume by ten to twenty percent[19]. Thus, there is a reduction in the percentage of blood that is composed of red blood cells. The result is a decrease in red blood cells in circulation- a false anaemia. This false anaemia has lead to higher demand for dietary iron in athletes. Many of these athletes are unaware that the declines in iron are short lived and are caused by the increased blood volume (Cosimo Ottomono, Massimo Franchini, 2012).

A significant increase in mean corpuscular volume (MCV) observed in the study. Our findings are in consistent with the study by Giovanni et al. Increases in Red cell volume with endurance training also contributs to the overall increases in blood volume (Jack, A Willmore. David L Costill, 2008). Increase MCV in endurance athletes can be attributed to again an adaptive change in endurance athletes as a fluid storage so that during muscular exercise more blood volume is available for circulation. It is advantageous for oxygen delivery mechanism (Boyadiev N, Taralov Z, 2000). Further more normal hemodilution happens when the body adds water to the blood and increases the plasma, the fluid part of the blood. The amount of formed elements RBCs, WBCs & platelets stays the same. A very moderate but regular jogging programme can boost blood plasma by 5 per cent, and the training schedule of a top-level endurance athletes can augment blood plasma by 20 percent (Brotherhood, J et al, 1975, Dill, et al, 1974). Importantly a laboratory test shows less haemoglobin per unit of blood, but it doesn't note the overall increase in blood volume. Athlete's blood has normal amount of haemoglobin, but more plasma, so they have fewer red blood cells per unit of volume. Because the amount of haemoglobin remains constant, hemodiluton isn't an anaemic condition and has none of the symptoms of one.

The cause of this condition remains unknown. However, one reasonable explanation, favoured by most researchers, holds that hemodilution is related to athlete's body's cooling mechanism[7]. When they exercise, their body dumps water onto skin in the form of perspiration. Blood brings fluid to the skin's surface through the capillaries, tiny, semi-permeable vessels. A great loss of fluid would cause blood to become too concentrated and sticky to flow easily through the capillaries in athletes. So their body prevents this problem by storing extra water in the bloodstream leading to increase blood volume (Milledge, J.S et al, 1982).

## CONCLUSION

Although there is a reduction in the Hb concentration, lower RBC count in endurance athletes there is an increase in the blood volume and the apparent anaemia is actually an artefact of training adaptations. Hemo dilution is a normal function of body in response to the demands of heavy training. Elite athletes, particularly those in endurance sports, are the most likely candidates for hemodilution. Low haemoglobin and haematocrit don't represent real anaemia. That's because one of the key physiological adaptations produced by physical training is an expansion of blood volume. This upswing in blood volume although beneficial to the endurance athletes, artificially lowers haemoglobin and haematocrit readings, misinterpreting some physicians as true anaemia. However, this 'pseudo anaemia' is unlike true anaemia because iron levels are normal. In addition, pseudo anaemia does not respond to iron supplementation. Endurance Athletes should not be advised regarding iron supplementation for low haematological parameters. Physicians must consider these ranges as normal in endurance athletes.

**Limitations:** The study is done on a small group. Study did not investigated the iron status of the athletes.

**Recommendations:** The endurance athletes should not take iron supplementation for low Hb, & RBC count. Further investigations of anaemia that occurs in athletes needs to be done to clarify the epidemiology as well as patho physiology specially in cases of iron deficiency.

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**Conflict of interest:** Authors hereby declare that there is no Conflict of interest among the Authors.

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