Effect of Interval Training on Hematocrit and Hemoglobin Levels of Sprinters

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ABSTRACT

Background & Objective – This study aims to investigate the effects of interval training on the blood hemoglobin level and hematocrit (Hct) of sprinters.

Method – This experimental research used a repeated measure ANOVA design. For the study, 40 male sprinters were selected using a purposive sampling technique and they were further randomly assigned to two groups named the control group and the experimental. The experimental group received interval training 3 times a week for a duration of 6 weeks. To examine the effect of interval training on hemoglobin levels and hematocrit blood samples were taken at three different levels - before training (pre-test), after 2 weeks of training (mid-test), and after completion of training (post-test), Hemocue Hb 201 devices were used to measure hemoglobin levels. The result of the study was analyzed using repeated measures-ANOVA. The findings of the study indicated that average hemoglobin and hematocrit levels significantly increased among the experimental group. It can be concluded that 6 weeks of interval training can significantly raise increase hemoglobin levels and hematocrit among sprinters.

Keywords*: Hematocrit; Hemoglobin; Interval Training; Plasma Volume; Red Blood Cells; Sprinter*

INTRODUCTION

Interval training includes running for a specific duration with intensity and recovery. The duration and intensity of running are pre-decided as per the demand of the event and individual fitness. Interval training work is based on load and recovery, the load is given for some duration and followed by recovery in between the load, load, and recovery time depends on the requirement desirable performance outcome and based on the energy system utilization during the Competition (McArdle, katch & katch). Correct spacing of exercise and rest intervals allows one to perform an extraordinary amount of intense physical activity. The interval training for sprinters is lower in volume and higher in intensity with incomplete recovery between each repetition. Whenever athletes perform any training, enormous

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physiological changes occur to increase the oxygen supply to working muscles, here blood plays a vital role that transporting essential gases and nutrients.

Blood is composed of Plasma volume the fluid part, red blood cells, platelets, and white blood cells. The total blood volume in healthy males is 5 to 6 L, and in healthy females is 4-5 L, which consists of plasma volume and formed elements. Plasma volume is the fluid part that constitutes about 55% to 60 % of total blood volume, and about 90 % of plasma volume is water, 7 % consists of plasma protein and the remaining 3% includes cellular nutrients, electrolytes, enzymes, hormones, antibodies, and waste. (Wilmore et al., 2008). The other 40% to 45% of total blood constitutes formed elements which include red blood cells (erythrocytes), white blood cells (leukocytes), and platelets (thrombocytes). Red blood cells are a major part of formed elements and consist of 99% of total formed elements & the remaining 1% of formed element is white blood cells and platelets. The percentage of total blood volume consisting of formed elements is called hematocrit, which is almost indicative of the percentage of red blood cells (RBC) present in the blood (Wilmore et al., 2008) Therefore any changes in RBC and plasma volume will influence the Hematocrit percentage.

Normally males possess hematocrit (Hct) of range 41% to 50% and adult females possess an average of approximately 38% of hematocrit. (Kenney et al., 2012)

One of the major contributors to viscosity is the concentration of RBCs found in the blood. Therefore, during periods of anemia (decreased RBCs), the viscosity of blood is lowered. While an increase in hematocrit results in an elevation in blood viscosity. There is a potential influence of changing blood viscosity on performance (Power & Howley). Increasing RBC may contribute to oxygen transport but if RBC increases in their number without increasing plasma volume, the blood viscosity increases if the hematocrit percentage increases. For a good level of performance, a low-normal hematocrit with an optimum or slightly raised number of RBCs is required. It influences oxygen transport positively. (Kenney et al., 2012) As the red blood cell concentration increases, so do the blood per unit hemoglobin content increases. This substantially increases the blood's oxygen-carrying capacity, which is advantageous during exercise and provides a distinct advantage at altitude (Kenny, Wilmore & Costill)

Therefore, mainly these two factors- plasma volume and RBC count influences are responsible for hematocrit percentage.

EFFECT OF EXERCISE ON PLASMA VOLUME

Plasma normally constitutes about 55% to 60% of total blood volume but can decrease by 10% of its normal amount or more with intense exercise in the heat or can increase by 10% or more with endurance training or acclimation to heat, when plasma volume reduced, hemoconcentration occurs. When the fluid portion of the blood is reduced, the RBCs and cellular portions represent a larger fraction of the total blood volume; that is, they become more concentrated in the blood while when the plasma increases it results in a decrease in the concentration of red blood cells.

According to (Krip B et., al 1997) Endurance training especially continues cycling and running results in an increase in Plasma volume (PV), hematocrit (Hct), and hemoglobin (Hb) both at rest and in response to exercise, these changes depend on intensities, frequencies, durations, and mode of exercise.

Several other studies have shown that a short training period involving intermittent exercises (especially cycling) may result in significant changes in PV. It also found that training-induced high blood volume accounts for approximately 47% of changes in VO_2 max after continuous and interval training among untrained individuals. (Warburton et al ,2000)

The increase in plasma volume due to training is possible through a higher renal sodium reabsorption rate due to aldosterone (Milledge et., al), higher plasma protein production, and the shifting of plasma protein into the intravascular space. (Haskell A et.,al 1997). It is important to have a balance hemoglobin and plasma volume ratio.

HOW DOES EXERCISE INFLUENCE THE HEMOGLOBIN LEVEL?

The function of hemoglobin is to regulate the exchange of gases in the body. (Sepriadi *et*., al 2020) Each molecule of hemoglobin contains four atoms of iron, and each iron can loosely bind with one molecule of oxygen, so a total of four molecules of oxygen can be transported through each molecule of hemoglobin. (Hall & Guyton, 2011).

Red blood cells (RBC) are produced in bone marrow during the last month of birth and after birth, up to the age of five years bone marrow of all bone produces red blood cells, but after this age only some bone produces RBC, pluripotential hematopoietic stem cells are the type of cells that begin the lives of red blood cells in bone marrow, different circulating cells are formed by the successive division of pluripotential hematopoietic stem cells. Developmental stage these stem cells are called Committed stem cells. Growth Inducers are the multiple proteins called Growth Inducers that control the Growth & reproduction of different stem cells. One of these is Interleukin-3, which is responsible for the growth and development of all types of committed stem cells, another set of proteins that is responsible for differentiating the committed cells toward the step of adult blood cells is called Differentiation inducers (Hall & Guyton, 2011)

The controlling of each protein depends on the other factors, for example, in the case of erythropoiesis, hypoxia causes growth induction, differentiation, and production of erythrocytes. The erythropoietin is the main stimulus for red blood cell production, erythropoietin increases in response to hypoxia which increases red blood cell production until the oxygen level becomes normal. (Hall & Guyton, 2011)

Bone marrow serves as the core site of human hematopoiesis. There are specific microenvironment exits in which the hematopoietic stem cells (HSCs) survive, self-renew, and differentiate, and constant replenishment of mature hematopoietic cells. Evidence shows that exercise training might improve the hematopoietic microenvironment (Taichman RS 2005)

One of the important components and regulators of the HSC microenvironment are osteoblasts, the bone-forming cells derived from mesenchymal stem cells. Osteoblasts play a main role in hematopoiesis. It has been seen that osteoblasts generate many elements which important for the survival, renewal, and maturation of HSCs (Taichman RS 2005) Signals from osteoblasts can directly initiate and modulate HSC proliferation in the context of mobilization (Mayack SR and Wagers AJ 2008),

In various research, it has been shown that exercise training can modulate bone marrow activity. It has been concluded that 20 weeks of strength training induces the higher activity of osteoblasts and is associated with larger red blood cell formation. (Hu M 2011), While in the case of endurance athlete hyperplasia of hemopoietic bone marrow stimulate erythropoiesis would resulting in large cell volume. (Vogt Set., al 2018), Alterations in the hematopoietic bone marrow suggestive of stimulated hematopoiesis have been observed in endurance athletes using MRI, and the stimulated erythropoiesis with hyperplasia of the hematopoietic bone marrow in endurance athletes could explain their large red cell volume (Hu, Min et.al 2012).

Some of the other studies have shown the opposite results, one of the studies shows that the hemoglobin concentration decreases during the training period, because the regular training increases the gas transport capacity of erythrocytes, which results in a decrease in the need for hemoglobin which in response reduces in hemoglobin (Agricola N.A et.al 2016).

Another study by (DellaValle DM &Haas JD 2011) shows that Athletes may face exercise-induced anemia, the transient decrease in red blood cells and hemoglobin due to intense exercise. Intense and rigorous exercise transiently results in hemodilution due to increased plasma volume which culminates in transitory lowering of hemoglobin (Hb) levels. Often mistaken for anemia, this transient response is corrected gradually by the end of the ensuing exercise. (DellaValle DM &Haas JD 2011).

As per Eichner ER.et., al study outcome RBCs level can also be decreased due to considerable quantities of iron could be lost by athletes due to bleeding from the gastrointestinal tract because of stress inflicting damage to gut linings, and the side effects of medication (pain killers, anti-inflammatory drugs (Eichner ER.et., al 2012).

Other sources of loss of RBCs include injuries and wounds such as foot strike hemolysis, a condition that develops from red blood cell destruction in the feet because of frequent striking on hard surfaces (Janakiraman K 2011)

While (Schmidt., et al) Reported that erythropoietin is stimulated due to exercise dominion over the hemolysis due to foot strikes, The findings of large-scale studies show that the athletes have higher red blood cell counts than controls.

According to some evidence, the increase in hemolysis stimulates erythropoiesis and increases iron absorption, Hepcidin is a peptide hormone that maintains iron homeostasis, Exercise, and physical activity present scenarios depicting increased physiological demands and inflammatory conditions in the regulation of hepcidin expression. Exercise-induced anemia, like anemia of chronic diseases is characterized by increased hepcidin expression. On the other hand, glycoprotein erythropoietin (EPO) controls the production of red blood cells in the bone marrow, The degree of oxygen availability that is sensed in the kidney is stimulation for erythropoietic (Vaz., et al 2013).

The main role of hemoglobin is the transport of oxygen from the blood to whole body tissues. Oxygen-carrying capacity is an important factor for performance, enough hemoglobin level must be maintained to bring the desired performance outcome, it is important to monitor the blood hemoglobin level and Hematocrit during the training period. A lot of studies have been done so far to see the effect of exercise on hemoglobin and hematocrit having endurance training as an intervention. Therefore, the study was conducted to determine the effect of interval training on Hemoglobin and hematocrit among sprinters over the three different stages of the training period that's before training (pretest), after 2 weeks of training (mid-test), and after the completion of training (post-test).

MATERIAL & METHODS

Participants

A total of 40 male sprinters were selected from Lakshmibai National Institute of Physical Education, (LNIPE) NERC, Guwahati (Assam), and their age range was between 18-23 years who were regularly trained. The criteria for subject selection were age, gender, good physical fitness, and active participation in sports. The sprinters were involved in training at least for three years and specialized in sprinting events. Before data collection and intervention, all the processes of training were explained, and all the athletes provided a consent form to the researcher.

Training Protocol

The interval training was given 3 times a week for a total duration of 6 weeks to the experimental group. The training session was scheduled on Monday, Wednesday, and Friday. The training was carried out on the 400m track of LNIPE.

The training session begins with 10 min of a general and 5 min of specific warm-up with the objective to prepare the participants for interval training and the session ends with cooling down.

The training load increases progressively per week, and the training load was pre-decided for each session according to the training plan, the recovery time given between the repetition was decided by monitoring the heart rate.

Data collection.

To measure hemoglobin level, the Hemocue Hb 201 device was used. The hemoglobin data were used to convert into hematocrit values. To test the hemoglobin the blood sample was taken at three different stages, first- before training (pre-test), second – after 2 weeks of training(mid-test), and after the competition of 6 weeks of training (post-test). All the tests were taken during resting conditions in the early morning.

Statistical analysis

To analyze, the effect of interval training on hematocrit Repeated measure design applied, SPSS version 26 was used for the formal statistical Analysis. The descriptive statistics were reported in the form of mean ± standard deviation (SD).

To find out the changes in blood hemoglobin and hematocrit between the pre-phase of treatment to six weeks of the training period. a repeated measure ANOVA was used between pre, mid, and post score, and the level of significance was set at 0.05.

Mauchly's Test of Sphericity was used to test the assumption of sphericity.

RESULTS

The mean value and standard deviation (sd) of hemoglobin in grams per deciliter (g/dl) and hematocrit in percent (%) assessed are given in table 1 and table 2 respectively.

In the given table 1. Based on the result it is indicated that the mean ±SD of pre, mid, and post-hemoglobin test in the experimental group was 13.07 ± 1.47, 14.03 ±1, 15.02 ±0.77 respectively and in the control group the mean ±sd was 12.39 ±1.50, 13.43 ±1.35, 13.91 ±1.11 for pre, mid and post-test respectively.

Table 1. Assessment of Hemoglobin(g/dl)

	Experimental Group		Control Group	
	Mean	**SD**	**Mean**	**SD**
Hemoglobin Pre-test	**13.07**	**1.47**	**12.39**	**1.50**
Hemoglobin Mid-Test	**14.03**	**1.00**	**13.43**	**1.35**
Hemoglobin Post Test.	**15.02**	**0.77**	**13.91**	**1.11**

In table 2. Based on the Hematocrit assessment the mean ±SD of pre, mid and post-hematocrit in the experimental group was 39.22 ±4.41, 42.09 ±3.20, and 145.12 ±2.35 respectively and in the control group the mean ±sd was 37.17 ±4.45, 40.26 ±4.04, 41.76 ±3.34 for pre, mid and post-test respectively.

Table 2. Assessment of Hemoglobin (%)

	Experimental Group		Control Group	
	Mean	**SD**	**Mean**	**SD**
Hematocrit Pre-test	**39.22**	**4.41**	**37.17**	**4.45**
Hematocrit Mid- Test	**42.09**	**3.20**	**40.26**	**4.04**
Hematocrit Post Test.	**45.12**	**2.35**	**41.76**	**3.34**

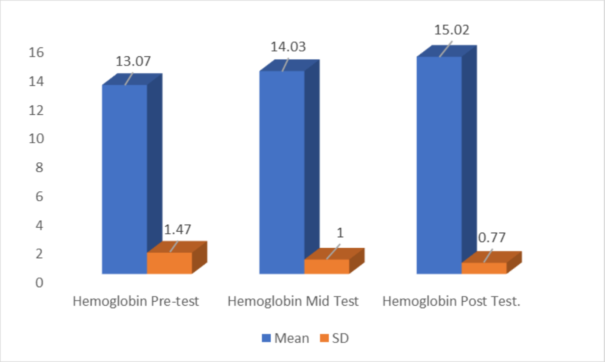

Figure 5. Histogram of Hemoglobin level (g/dl) of Experimental Group

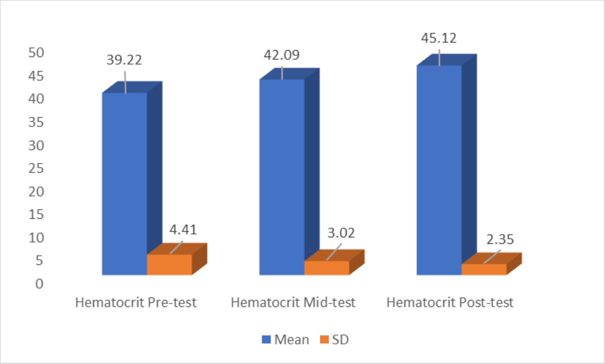

Figure 5. Histogram of Hematocrit (%) of Experimental Group

The test sphericity was checked with help of Mauchly's Test of Sphericity for both groups for hemoglobin and hematocrit scores.

In the Hemoglobin data of the experimental group Mauchly's test of sphericity showed that this assumption was met, $\chi 2$ (2) =2.975, p = .226, and the Hematocrit score of the experimental group Mauchly's test of sphericity showed that this assumption was met, $\chi 2$ (2) =3.06, p = .201

While the Hemoglobin score of the control group Mauchly's test of sphericity showed that this assumption was not met, $\chi 2$ (2) =28.926, p =.000 and also the Hematocrit score of the control group Mauchly's test of sphericity showed that this assumption was not met, $\chi 2$ (2) =28.333, p = .000

Therefore, the sphericity assumed in the main ANOVA was applied to the Experimental Group only.

In given table 3. The results of the one-way repeated-measures ANOVA for hemoglobin level in the experimental group show ($p< 0.05$), F (2, 38) = 26.601, p = .000, η^2p = .583) so, there is a significant mean difference in hemoglobin level due to interval training

Table 3. Mean, Standard Deviation, and Repeated Analysis of variance for hemoglobin level in the Experimental group

	Pre-data		Mid-data		Post-data			η^2	Sig.
Variables	*M*	*SD*	*M*	*SD*	*M*	*SD*	*F* (2,38)	.583	.000
Hemoglobin	13.07	1.47	14.03	1.00	15.02	.077	26.01		

In table 4, The results of the one-way repeated-measures ANOVA for hematocrit in the experimental group show ($p< 0.05$), F (2, 38) = 27.493, p = .000, η^2p = .591). so, there was a significant mean difference in hematocrit percent during the interval training period.

Table 4. Mean, Standard Deviation, and Repeated Analysis of variance for hematocrit in the Experimental Group

	Pre-data		Mid-data		Post-data			η^2	Sig.
Variables	*M*	*SD*	*M*	*SD*	*M*	*SD*	*F* (2,38)	.591	.004
Hemoglobin	39.225	4.41	42.09	3.023	45.12	2.35	27.493		

DISCUSSION

The researcher conducted a study on the effect of interval training on Blood Hematocrit and Hemoglobin in Male sprinters. The manipulative interval training was more anaerobic in nature. The observation for blood hemoglobin was made before the beginning of treatment, after the training of two weeks, and at end of the six-week training period. The experimental group statistics show that there was an alternation in blood hemoglobin and hematocrit value as training progresses. The result of the study revealed that there was a significant increase in blood hemoglobin and hematocrit level in response to manipulative interval training.

The magnitude of hemoglobin level and hematocrit depends on the total number of red blood cells, plasma volume, and its ratio. Blood hemoglobin and hematocrit change in response to interval training. Interval training-induced erythropoiesis, because intense exercise leads to hypoxia, hypoxia causes growth induction, differentiation, and production of erythrocytes. The erythropoietin is the main stimulus for red blood cell production, erythropoietin increases in response to hypoxia which results in an increase in red blood cell production until the oxygen level becomes normal. (Hall & Guyton, 2011),

Exercise training also improves the hematopoietic microenvironment and osteoblast plays an important role in this process. Exercise-induced osteoblast and hyperplasia of hemopoietic bone marrow stimulate erythropoiesis.

The change in hemoglobin level and hematocrit in response to exercise also depends on several factors like weather conditions, intensity, and duration of exercise. Performing interval training in hot and humid weather would increase the rate of sweating, which further decreases blood plasma volume and results in an increase in the concentration of red blood cells in the blood, in this way even without an increase in the total number of red blood cells, the hemoglobin level would increase. jogging significantly improve hemoglobin level (Sepriadi et al 2020)

Hepcidin is a peptide hormone that maintains iron homeostasis, Exercise and physical activity present scenarios depicting increased physiological demands and inflammatory conditions in the regulation of hepcidin expression. Glycoprotein erythropoietin (EPO) controls the production of red blood cells in the bone marrow, The degree of oxygen availability that is sensed in the kidney is stimulation for erythropoietic (Vaz et al., 2013)

Mild intensification of exercise facilitates inflammation and erythropoiesis, and the net effect is to lower hepcidin concentration. (Diego Moretti et,.al 2018), So, various studies and present studies indicate that exercise as well as interval training improves the production of red blood cells, so Exercise can be a useful and safe way to treat anemia. (Hu, Min & Lin, Wentao 2012).

While Findings of some other studies have shown a decrease in blood hemoglobin and hematocrit level, one of the reasons for the decrease in hemoglobin is hemodilution, it is due to an increase in total blood plasma volume which results in a decrease in blood hemoglobin concentration without a decrease in total red blood cells count, which is generally known as exercise-induced anemia. (DellaValle DM &Haas JD 2011).

Interval training influence significant increase of estimated plasma volume at rest for training group. High-intensity training may improve plasma volume values and decreases the effect of age on the decrease in PV (Jabbour, G et.al (2018)

Agricola N.A et.al (2016) revealed that Hemoglobin concentration decreases during the training period because regular training increases the gas transport capacity of erythrocytes, which results in a decrease in the need for hemoglobin which in response reduces hemoglobin.

Hemolysis could also be the reason for the decrease in hemoglobin levels, during running the foot strike over a hard surface would cause the destruction of red blood cells in the feet. (Janakiraman.K et al.,2011)

It was concluded that interval training sessions in highly polluted air will be associated with more hemolysis of RBCs, s (Bahrami, F.et., al 2013) Moderate stimulation of erythropoiesis during altitude served as compensation for exercise-induced destruction of red cells (Dehnert et al., 2002)

CONCLUSIONS

Based on the findings of a study it can be concluded that Interval training brings a significant mean difference in blood hemoglobin and hematocrit. Physical training can be a good intervention for stimulating erythropoiesis. Thus, it can be exercise training can be a good way to increase

RECOMMENDATIONS AND FUTURE PERSPECTIVES

A similar study may be undertaken with interventions such as endurance training, circuit training, or hill training. Hemoglobin alternation can be studied in response to different weather conditions and can be done with a large sample and a Similar study can be done with longer period treatment

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