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Red Blood Cell Variables in Volleyball Players of Kolkata, India

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Abstract

Intensive physical exercise often leads to suboptimal hematological status in humans as well as in animals. In some cases it may lead to anemia. Studies on training induced changes in red blood cell variables in Indian sportspersons are lacking, especially among volleyball players. The present cross-sectional study was conducted to measure the basic red blood cell variables in trained male (n=20) and female (n=16) state level volleyball players (18–25 years) of Kolkata, India, and to compare the data not only between two sexes but also with their sedentary (male = 20, female = 20) counterparts. Venous blood sample was drawn from the cubital vein and the red blood cell count (TC), packed cell volume (PCV), hemoglobin (Hb) concentration/, MCV and MCHC were determined by standard methods. The volleyball players of both sexes had significantly lower values of TC, PCV and Hb concentration than their control counterparts but MCV and MCHC depicted insignificant variation, indicating a probable effect of hemodilution among the players. The reduction in TC, PCV and Hb concentration among the volleyball players was significantly correlated with the duration of the training, except in case of PCV in the female group. The decrement in TC and PCV among the female players was less probably because of their significantly ($P<0.01$) lower training duration than the male players. It can be concluded that the high intensity endurance training resulted a decrease in TC, Hb concentration and PCV among the volleyball players and such decrement is significantly correlated with the training duration.

Key Words: **Hemoglobin, Red Blood Cell, PCV, MCV, MCHC, Volleyball, Training**

Introduction

There have been reports of suboptimal hematological status and even anemia resulting from intensive physical exercise in humans *(Biancotti et al. 1992; Hasilbeder et al. 1987; Magazanik et al. 1988; Radomski et al. 1980)* as well as in experimental animals *(Szygula et al. 1986).* These studies have investigated the acute effects of different types of intensive exercise as well as training on the red blood cell variables and reported a decrease in red blood cell count, hemoglobin concentration, packed cell volume, mean corpuscular volume and mean hemoglobin concentration *(Brodthagen et al. 1985; Gimenez et al. 1986; Cordova and Escanero, 1992; Laub et al. 1993) or an increase in red blood cell count (Schwandt, 1991; Cordova et al. 1993;).* There are other reports *(Hasilbeder et al. 1987; Magazanik et al. 1988; Schmidt et al. 1988; Schobersberger et al. 1990; Biancotti et al. 1992)* which concentrated on the effects of chronic high intensity training on these variables reported almost similar kind of observation as found in case of acute training or exercise. However, similar and contemporary studies are lacking in Indian sportspersons.

Volleyball is one of the popular sports in India and any kind of hematological deficiency may cause serious trouble among the volleyball players who come across a vigorous exercise protocol during their training session. Data on the hematological profiles, especially on red blood cell variables are not available on trained Indian volleyball players. The present study was therefore conducted to measure the basic red blood cell variables in trained male and female volleyball players and to compare the data not only between two sexes but also with their sedentary counterparts.

Material and Method

Selection of participants:

The highly trained state level volleyball players (male= 20, female=16) belonging to 18-25 years of age with at least 3 years' participation in sports and intensive training *(Hasilbeder et al., 1987; Biancotti et al., 1992)* were selected for the study. The untrained or sedentary control counterparts (male = 20, female = 20) matched for age, height, weight and socio-economic background were selected from the post-graduate section of the University of Calcutta. They were explained about the entire experimental protocol to allay apprehension and their body height and body mass were measured by standard weighing machine fitted with a height measuring rod (Avery India Ltd., India). Body mass was measured to an accuracy of $\pm$ 0.250 kg and height to an accuracy of $\pm$ 0.50 cm. Subjects provided written informed consent and the entire study was approved by the ethical committee.

Collection of blood sample:

Venous blood samples were drawn from the cubital vein between 0700 and 0900 in accordance with the guidelines of the International Federation of Clinical Chemistry or IFCC *(IFCC 1984),* 48 hours after the last training bout. The blood samples were placed in tubes containing EDTA (tripotassium salt) and were analyzed on the same day.

Measurement of red blood cell variables:

Total count of red blood cells (TC), packed cell volume (PCV) and hemoglobin (Hb) concentration were measured by using Neubauer hemocytometer *(Dacie and Lewis, 1985),* hematocrit or Wintrobe's method *(Dacie and Lewis, 1985)* and cyanomethemoglobin method *(Drabkin, 1984),* respectively. The mean corpuscular volume (MCV) and mean corpuscular hemoglobin concentration (MCHC) were determined by the following equations *(Sembulingam and Sembulingam, 2006):*

$$\textbf{MCV (cu µ)} = \frac{\text{PCV(ml.L}^{1}\text{ of blood)}}{\text{RBC Count (millions/cu mm of blood)}}$$

$$\textbf{MCHC (\%)} = \frac{\text{Hemoglobin Conc. (gm/dL) x 100}}{\text{PCV in 100 ml of blood}}$$

The whole experiment was performed at a temperature varying from 28–31°C and with the relative humidity ranging between 77% and 82%.

Statistical Analysis:

Two tail t-test was performed to test the significant variation between the mean values. Pearson's product moment correlation was computed to test the relationship between two variables. Level of significance was set at $P<0.05$.

Results & Discussion

The trained volleyball players had significantly lower values of TC, PCV and Hb concentration than their control counterparts, indicating that sport practicing strongly affected these variables in both the sexes (Table 1). However, no significant difference was found in MCV and MCHC when compared either between male and female volleyball players or between the sedentary group and volleyball players of same sex.

Table 1. Physical characteristics and red blood cell variables in volleyball players and sedentary subjects of both sexes.

Variables	Males		Females	
	Volleyball Players (n=20)	Sedentary Subjects (n=20)	Volleyball Players (n=16)	Sedentary subjects (n=20)
Age (years)	21.64 ±3.64	21.01 ±3.45	21.15 ±3.71	21.86 ±3.32 ##
Body mass (kg)	60.87 ±6.94	59.50 ±6.01	54.26 ±3.46 ##	55.64 ±4.56 #
Body height (cm)	173.10 ±4.19	171.89 ±3.90	169.21 ±5.17 ##	167.71 ±3.42 ##
Training Duration (years)	4.31 ±0.13	-	4.02 ±0.24 #	-
RBC Count (million/mm^3)	4.52 ±0.12	4.72 ±0.22 **	4.15 ±0.20 ##	4.31 ±0.16 * ##
PCV (%)	42.15 ±2.12	44.81 ±3.31 **	41.82 ±3.41	44.24 ±2.24 *
Hb Conc. (gm%)	12.67 ±1.62	13.51 ±1.90 **	11.92 ±1.32	13.04 ±1.75 * #
MCV (cu μ)	86.03 ±4.83	87.52 ±5.06	85.64 ±4.76	86.72 ±3.84
MCHC (%)	30.06 ±4.35	30.15 ±4.70	28.50 ±5.61	29.47 ±5.24

Values are mean ± standard deviation
* P<0.01, ** P<0.001 (When compared with the sedentary group of similar sex)
\# P<0.01, ## P<0.001 (When compared between males and females in the same category)

The variables were lower in the trained male volleyball players than the untrained males by 4.94% for TC (P<0.001), by 5.9% for PCV (P<0.001) and by 6.21% for Hb concentration (P<0.001). In case of the female volleyball players, the variables were also lower than their sedentary control subjects by 3.71% for TC (P<0.01), by 5.47% for PCV (P<0.01) and by 8.60% for Hb concentration (P<0.01). Therefore the female volleyball players exhibited lower extent of decrement in the TC and PCV than their male counterparts probably because of their significantly (P<0.01) lower training duration than the male players.

The correlation analysis showed that the reduction in TC, PCV and Hb concentration among the volleyball players of both sexes is significantly correlated with the duration of the training, except in case of PCV in the female group (Table 2).

Table 2: Correlation between the duration of training (years) and the difference in red blood cell variables among the volleyball players.

Variables	Male	Female
RBC Count (million/mm^3)	0.58***	0.56*
PCV (%)	0.53**	0.43 NS
Hb Conc. (gm %)	0.61***	0.57**

Values are Pearson's product moment correlation coefficient (r)
*P<0.05, **P<0.02, ***P<0.01, NS = Not significant

Discussion

The results of the present study corroborated with the previous findings *(Hasilbeder et al., 1987; Magazanik et al., 1988; Schmidt et al., 1988; Schobersberger, 1990; Biancotti et al. 1992)* that the major red blood cell variables undergo a change following any kind of chronic as well as intensive training regimen. Other studies

(Hasilbeder et al. 1987; Biancotti et al. 1992) indicated that these changes in males and females are also dependant on the specific game or training in which the subject participates. The present findings contradicted the observations of *Shiga et al., (1990)* in pubescent subjects that there are sex-dependant differences in TC, PCV and Hb concentration in both highly trained and untrained control individuals.

The correlation coefficients (r) among the volleyball players of both sexes were computed between the training duration and the reduction in the studied hematological variables in comparison with the mean values of the controlled untrained groups. Highest correlation was observed with the reduction in Hb concentration (r= 0.61, P<0.01) among the male volleyball players followed by the RBC count (r= 0.58, P<0.01) in the same group. Significant correlation with RBC count (r= 0.56, P<0.05) and Hb concentration (r= 0.57, P<0.02) was noted in the female group that in turn exhibited insignificant correlation with the PCV.

All early and late changes in the haematological variables after acute or chronic intensive physical exercise regardless of its characteristics (aerobic, anaerobic or mixed) are caused by factors associated mainly with the process of hemoconcentration and hemodilution, changes in plasma catecholamine concentration and the consequences of these mechanisms *(Schwandt et al. 1991; Laub et al. 1993)*. In prolonged chronic exercises, the changes in red blood cell variables are associated with training protocol and the involved mechanisms are chronic intravascular hemolysis associated with strength sports and changes in plasma erythropoietin level *(Schwandt et al., 1991)*.

Nevertheless, from the present study it is not feasible to explain the exact mechanism(s) involved among the male and female volleyball players for the changes in their red blood cell variables, but some speculations may be postulated. The blood volume increases with intense endurance training *(Schmidt et al. 1988; McArdle et al. 1996)*. This is primarily resulted from an increase in blood plasma volume that occurs due to exercise induced increased secretion of antidiuretic hormone and aldosterone which in turn retains water from the kidneys *(Wilmore and Costill, 1999)*. Endurance exercise also increases plasma protein concentration which helps to increase the plasma volume *(Yang et al., 1991)*. However, increase in RBC volume also contributes towards increase in blood volume but the increase in the number of RBC is neither consistent nor proportional with the increase in plasma volume *(Green et al., 1991)*. Therefore, the increase in plasma volume following endurance training is proportionately higher than that of the RBC count and this might have caused a hemodilution among the volleyball players. Consequently, in spite of absolute increases in RBC and plasma volumes, the RBC count and hematocrit value were decreased among the volleyball players following training *(Green et al. 1991; Wilmore and Costill, 1999)*. Insignificant difference in MCV and MCHC between the trained and untrained groups also favours the justification of hemodilution among the volleyball players. *Schobersger et al. (1990)* also proposed that the specific differences in red blood cell variables is also related to the particular type of sport, e.g., soccer, swimming, rowing, wrestling, athletics, etc., and the reduction of blood parameters in a specific sport shows similar trend in both sexes. This finding indicated that sports specific trend in the reduction of hematological parameters is irrespective of sex *(Biancotti et al., 1992)* as also found in the present study.

Conclusion

The present findings indicated that training has effects on red blood cell variables. The values of RBC count, hemoglobin concentration and packed cell volume were significantly lower among volleyball players of both sexes than their sedentary counterparts. Such reductions of red blood cell variables among volleyball players of both the sexes are significantly correlated with duration of the training period. Males exhibited significantly higher values of all these variables than their female counterparts. However, mean corpuscular volume and mean corpuscular hemoglobin concentration did not show any significant variation.

References

Biancotti, P.P., Caropreso, A., DiVicenzo, G.C., Ganzit, G.P. and Gribaudo, C.G. 1992. Hematological status in a group of male athletes of different sports. *Journal of Sports Medicine and Physical Fitness,* **32:** 70-75.

Brodthagen, U.A., Hansen, K.N., Knudsen, J.B., Jordal, R., Kristensen, O. and Paulev P. 1985. Red blood cell, 2, 3-DPG, ATP and mean cell volume in highly trained athletes. Effect of long term submaximal exercise. *European Journal of Applied Physiology,* **53:** 334-338.

Cordova, A., Navas, F.J. and Escanero, J.F. 1993. The effect of exercise and zinc supplementation on the hematological parameters in rats. *Biological Trace Element Research*, **39:** 13-20.

Cordova, M.A. and Escanero J.F.. 1992. Iron, transferring and hepatoglobin levels after a single bout of exercise in men. *Physiology of Behaviour,* **51:** 719-722.

Dacie, J.V. and Lewis, S.M. 1984. *Practical Hematology*, 6th ed, Churchill Livingstone, New York.

Drabkin, S. 1984. *Photometry and spectophotometry: in Medical Physics,* (Glasser ed.), Vol.1: Year Book Medical Publishers, Inc. Chicago.

Gimenez, M., Mohan-Kumar, T., Humbert, J.C., Talance, N.D. and Buisine J. 1986. Leukocyte, lymphocyte and platelet response to dynamic exercise. Duration or intensity effect? *European Journal of Applied Physiology,* **55:** 465-470.

Green, H.J., Sutton, J.R., Coates, G. and Jones, S. 1991. Response of red cell and plasma volume to prolonged training in humans. *Journal of Applied Physiology,* **70:** 1810-1815.

Hasilbeder, W., Schobersberger, W. and Mairbarul, H. 1987. Red cell oxygen transport before and after short term maximal swimming in dependence on training status. *International Journal of Sports Medicine,* **8:** 105-107.

IFCC. 1984. The theory of reference values. Part 3. Preparation of individuals and execution of blood specimen collection for the production of reference and observed values. *Clinical Chimia Acta,* **139:** 203F-230F.

Laub, M., Jacobsen, K.H., Hovind, P., Kanstrup, I.L., Christensen, N.J. and Nielsen, S.L. 1993. Spleen emptying and venous hematocrit in humans during exercise. *Journal of Applied Physiology,* **74:** 1024-1026.

Magazanik, A., Weinstein, Y., Dim, R.A., Darin, M., Schwartzman, S. and Allalouf, D. 1988. Iron deficiency caused by 7 weeks of intensive physical exercise. *European Journal of Applied Physiology,* **57:** 198-202.

McArdle, W.D., Katch, F.I. and Katch, V.L. 1996. *Exercise Physiology- Energy, Nutrition and Human Performance* (4th Ed.). Dona Balado ed.; Williams & Wilkins, Pennsylvania. p 292.

Radomski, M.W., Sabiston, B.H. and Isoard, P. 1980. Development of sports anemia in physically fit men after daily sustained submaximal exercise. *Aviation and Space Environmental Medicine,* **51:** 41-45.

Schmidt, W., Maassen, N., Trost, F. and Boning, D. 1988. Training induced effects on blood volume, erythrocyte turnover and hemoglobin oxygen binding properties. *European Journal of Applied Physiology,* **57:** 490-498.

Schobersberger, W., Tschann, M., Hasibeder, W., Steidl, M., Herald, M., Nachbauer, W. and Koller, A. 1990. Consequences of 6 weeks of strength training on red cell O2 transport and iron status. *European Journal of Applied Physiology,* **60:** 163-168.

Schwandt, H.J., Heyduck, B., Gunga, H.C. and Rocker, L. 1991. Influence of prolonged physical exercise on the erythropoietin concentration in blood. *European Journal of Applied Physiology,* **63:** 463-466.

Sembulingam, K. and Sembulingam, P. 2006. *Essentials of Medical Physiology.* (4th Ed.) Jaypee Brothers Medical Publishers (P) Ltd. New Delhi, India, pp 82-84.

Shiga, S., Koyanagi, I. and Kanuagi, R. 1990. Clinical reference values for laboratory hematology tests calculated using the integrative truncation method with correction. *Japanese Journal of Clinical Pathology,* **38:** 93-103.

Szygula, Z., Spodaryk, K. and Dabrowski, Z. 1986. Post-exercise anemia as a result of exercise overloading of the organism. *Physiology Bohemoslovaca,* **35:** 104-111.

Wilmore, J.H. and Costill, D.L. *Physiology of Sport and Exercise.* (2nd Ed) 1999; Human Kinetics, Champaign (USA). pp 287-290.

Yang, R.C., Mack, G.W., Wolfe, R.R. and Nadel, E.R. 1998. Albumin synthesis after intense intermittent exercise in human subjects. *Journal of Applied Physiology,* **84:** 584-592.