CHAPTER-II

REVIEW OF RELATED LITERATURE

The present chapter consists of various research studies relevant to the study under investigation. A search for the reference materials would assist the investigator to determine the effectiveness of the various combinations of the variables, methodology used and the results obtained. Study of the Related Literature comprises loading, reading and evaluating reports of research as well as reports of casual observation and opinion that are related to the individuals planned research report. A study of relevant Literature is an essential step to get a full picture of what has been done with regard to the problem under study. The investigator has made an attempt to bring a brief review of research related to the present study to form the background for the present study.

**Carlone et al., (1982)** studied the behaviour of the oxy hemoglobin curve in ten patients with respiratory alkalosis (arterial [H+] less than 37nm, pco2 less than 32 mmHg and HCO-3 less than 2200 mEq/L) and ten patients with metabolic alkalosis [H+] less than 34nm, pCo2 greater than 37 mmHg and HCo-3 greater than 28.0 MEq/L) to determine whether different alkalotic states similarly affect the red blood cell [H+] and 2,3 – dishosphoglycerate interaction and the thus the oxygen affinity of hemoglobin. The findings were statistically indistinguishable in respiratory alkalosis and metabolic alkalosis. a) Low plasma [H+], normal red blood cell [H+], and high transmembrane [H+] gradient; b) Elevated red blood cell 2, 3 – disphospho glycerate inversely proportional to low arterial plasma [H+]; c) decrease in oxygen affinity of hemoglobin when normalized for plasma [H+], but less decreased when normalized for red blood cell [H+] other factors capable of affecting the oxygen affinity of hemoglobin were mean corpuscular hemoglobin concentration; red blood cell adenosine triphosphate; carboxyhemoglobin; and Methemoglobin were not significantly different between groups.

To examine the hemoglobin concentration of the runners **Casoni et al., (1983)** investigated the hemoglobin and Iron concentrations and the haematocrit of 45 marathon runners
examined before and after the 1982 Italian marathon championship and of 79 runners examined before and after the 1982 Firenze Faenza race (107 Km). The obtained results suggested that the training programs followed by the marathon runners (unto 260 m per week in the months preceding the race) were accompanied by a significant decrease of the hemoglobin and iron levels and of the hematocrit. Similar had been observed in the participants to the Firenze - Faenza race. Nevertheless, in these ultra marathoners the decreases of the hemoglobin and iron concentration and of the hematocrit were less marked, possibly because their training programs were less intense than those of the marathon runners. The obtained findings were in favor of the hypothesis that the degree of “sport anemia” might be relate to the amount training of the athletes.

In a study Casoni et al., (1985) determined Red blood cell indices, serum iron, and serum ferritin concentration in 45 marathon runners, 56 ultra marathon runners, and 32 healthy sedentary controls. A significant reduction of hemoglobin concentration, hematocrit, mean corpuscular volume, serum iron, and serum ferritin were found in marathon runner compared to control subjects. The same variables were also reduced, but to a lesser extent, in the less trained ultra marathon runner. The decreased hemoglobin concentration demonstrated in the runners that the examined hemoglobin concentration was related to both a reduced hematocrit and might depend on a reduction of the body iron stores.

To determine the acute effect of training on red blood cells of 20 male elite long distance runners as compared to a control group of blood donors Brodthagen et al., (1985) investigated in 11 of the runners following a race of 15-30 km. The runners had elevated resting value of red cell 2,3 – DPG (P less than 0.05) and mean cell volume CP less than 0.01); blood HP and ATP were not different from concentrations in the control group. An increased proportion of young erythrocytes in runners might explain the red cell status of the athletes. No statistically significant changes in red cell 2, 3 – DPG, ATP, mean cell volume or blood Hb were found in post exercise.

R. J. L. Davidson et al., (1986) observed the twelve parameters of blood cell profiles of 6 subjects before and after each phase of a triathlon event. This involved 29 miles cycling, 12
miles running and finally 18.5 miles canoeing. From the statistical analysis of collecting hematological data they found significant decrease in plasma volume (8.7% ± 3.1%) following the first phase (cycling); this decrease was sustained to the end of the event. A substantial increase in the number of circulating leukocytes after cycling (84 ± 58%) and running (255 ± 83% of pre-event value) was also observed. There was no further leukocyte increment after the canoeing stage which might indicate that the circulating concentration of these cells was maximal after running. Fluid shifts following the postural alteration accompanying the different types of exercise and subject variability might have masked any subtle changes in the red cell parameters.

**Biancotti PP et al., (1992)** conducted a study to evaluate hematological status in a group of male athletes of different sports. One hundred eighty-one male athletes were tested and divided into seven groups according to sport exercise: cross-country skiing, cycling, fencing and tennis (joined together), rowing, running, soccer, swimming. For every athletes erythrocyte and hemoglobin blood concentration, hematocrit, serum iron, transferrin, ferritin and haptoglobin concentration were measured and also the mean cell volume and serum iron/transferrin ratio were calculated. Data were compared to find out correlation indices and then grouped according to the practiced sport. Statistical indices were computed for each group and for all parameter and analysis of variance were carried out to find out the significant differences. The only parameter i.e. serum level of haptoglobin showed statistically significant difference among groups. The evidence of this study suggested that individual variability for the remaining parameters exceeds any variation possibly induced by different sport practices.

**Spodaryk (1993)** obtained more information on the effects of long lasting endurance and strength training on the constituents of several hematological and iron-related parameters the blood in 39 male athletes from the polish team who participated in the Olympics in Seoul in 1988. The athletes were divided into groups, endurance-trained subjects (group E, cyclist, Canoeists and rowers; n=22) and strength – trained subjects (group S, wrestlers and judo; n=17). The control group was composed of untrained male subjects (n=48). Blood samples were taken from an antecubilal vein with the subject at rest for determinations of hemoglobin concentration ([Hb]), packed cell volume (PCV), erythrocyte (RBC) and reliculocyte count, Plasma free
hemoglobin concentration, haptoglobin concentration, Serum iron, transferring concentration and ferritin concentrations ([Ferr]); red blood cells were used for estimation of glutamatoxalate transaminase (GOT) activity and free erythrocyte protoporphyrin concentration ([FEP]). Results showed that the mean [Hb], PVC, RBC measured in the E athletes were significantly lower than in the control group but were comparable to those obtained in the S athletes. There were no significantly differences in the hematological indices mean corpuscular volume (MCV), mean corpuscular hemoglobin and mean corpuscular hemoglobin concentration between the groups of athletes and the control group. A significant increase in reticulocytosis and GOT activity was observed in the endurance – trained athletes. No impairment of erythropoiesis was observed as indicated by several sensitive markers of hemoglobin formation (FEP, MCV and inspection of blood smears) in the athletes.

To evaluated the foot-strike hemolysis alters vascular volumes and selected hematological properties in trained athletes, H.J. Green et al., (1998) measured total blood volume (TBV), red cell volume (RCV) and plasma volume (PV) in cyclists (N= 21) and runners (N= 17) and compared them to those of untrained controls (N= 20). TBV (ml / kg) was calculated as the sum of RCV (ml / kg) and PV (ml / kg) obtained using Cr and I-labeled albumin respectively. Hematological assessment was carried out using a Coulter counter. Peak aerobic power (VO2peak) was measured during progressive exercise to fatigue using both cycle and treadmill ergometry. They concluded that although differences existed between the genders in VO2 peak for both cyclists and runners but no differences were found between the athletic groups within a gender. Since the vascular volumes did not differ between cyclists and runners for either the males or females but foot-strike hemolysis would not appear to have an effect on that parameter.

To compare the response of intermittent high intensity (HIGH) exercise to continuous moderate intensity (MOD) exercise and rest (REST) on plasma erythropoietin concentration Bodary (1999) collected blood samples immediately before the exercise (PRE), immediately following the exercise (POST) and 4 (heart rate (4 HR), 12 (12 HR), 24 (24 HR) and 48 (48 HR) following the exercise. The HIGH treatment consisted of 60 min of exercise alternating 5 min of running at ~90% of 02 max with 5 min of brisk walking. The MOD treatment consisted of a
continuous 60-min run on the treadmill at 60% of O2 max. The variables examined included plasma erythropoietin concentration (EPO), Hemoglobin (Hb) concentration ([Hb]), hematocrit (Hct), red blood cell count (RBC), and mean corpuscular volume (MCV). ANOVA revealed the expected treatment-by-time interaction for Hct and [hb] suggested a hemodilution at 24 and 48 hrs post exercise for the MOD and HIGH treatments. However, no significant treatments by time interactions were observed for [EPO], RBC, or MCV. These indicated that intermittent high intensity exercise did not have a significant effect on [EPO] in trained distance runners.

Baruch Wolach et al., (2000) assessed the effects of aerobic and anaerobic exercise on the phagocytic process in 18–26 year old trained female judoka (n = 8) and untrained controls (n = 7). Each subject participated randomly in two different testing sessions (Aerobic, 20 minutes of treadmill running at 70–80% of maximal heart rate; anaerobic, Wingate anaerobic test). Venous blood samples were drawn before, immediately after and 24 hours after each session. They observed no significant differences in basal values of net chemotaxis (chemotaxis – random migration), bactericidal activity, and superoxide anion release between the judoka and the untrained women. There was a significant decrease in net chemotaxis 24 hours after the aerobic exercise in both the judoka and the untrained controls. Bactericidal activity and superoxide anion release did not change significantly after aerobic exercise in either group. There were no significant changes in net chemotaxis, bactericidal activity, and superoxide anion release after anaerobic exercise in either the judoka or untrained women. Similar effects of both exercise sessions in the judoka and the untrained women suggested that training had no effect on Neutrophil function response to aerobic and anaerobic exercises.

Alice Santos-Silva et al., (2001) compared the lipid profile and the levels of leukocyte activation, red blood cell (RBC) damage and of oxidative stress between high competition swimmers and adolescents practicing moderate regular physical exercise with similar body mass index. As markers of leukocyte activation, they measured plasma lactoferrin, elastase and granulocyte–monocyte colony stimulating factor. Further, they also measured RBC membrane band 3 profiles and membrane-bound hemoglobin, as markers of RBC damage and aging; total and differential leukocyte count and RBC count, hematocrit, hemoglobin concentration and hematimetric indexes. Lipid profile included the evaluation of triglycerides (TG), total
cholesterol (Chol), high-density lipoprotein cholesterol (HDLc), low-density lipoprotein cholesterol (LDLc), apolipoproteins AI and B (Apo AI and B), and lipoprotein. To evaluate oxidative stress, lipoperoxidation products and total antioxidant capacity were measured. They found that high competition adolescents presented increased plasma levels of leukocyte activation products, increased RBC damage suggesting aging and premature removal, and higher oxidative stress. Lipid profile showed some risk and some protective changes. Study suggested that high competition exercise, by imposing a higher and sustained oxidative and proteolytic stress, might contribute in the future to a higher risk of cardiovascular disease. The authors believed that these findings warrant a reevaluation of current views in the intensity, duration and regularity of physical exercise, and that the evaluation of leukocyte activation products, RBC damage, oxidative stress and lipid profile might represent good markers to establish putative protective thresholds.

Alexander Kratz et al., (2002) reported the changes in basic biochemical parameters, cardiac markers, CBC counts, and WBC differentials observed in participants in a marathon before, within 4 hours, and 24 hours after a race. The concentrations of glucose, total protein, albumin, uric acid, calcium, phosphorus, serum urea nitrogen, creatinine, bilirubin, alkaline phosphates, total creatine kinase, creatine kinase-MB, myoglobin were increased after the race, consistent with the effects of exertional rhabdomyolysis and hemolysis. The increase in WBC counts was due mainly to neutrophilia and monocytosis, with a relative decrease in circulating lymphocytes, consistent with an inflammatory reaction to tissue injury. A significant percentage of laboratory results were outside the standard reference ranges, indicating that modified reference ranges derived from marathon runners might be more appropriate for this population. They provide a table of modified reference ranges (or expected ranges) for basic biochemical, cardiac and hematologic laboratory parameters for marathon runners. They believed that participants in marathon races may require medical attention and the performance of laboratory assays.

To find out the effect of endurance sports activity on Hemoglobin and Red blood cell count, Saurin Sanghavi et al., (2003) compared and analyzed the results of sports persons and sedentary persons. The work was carried out in the Indian Petro Chemical Ltd (IPCL) Township
sports complex and IPCL Hospital (Health center). Hemoglobin and red blood cell count were analyzed of both the sportspersons and the control group using electronic auto analyzer cell counter (SYSMEX) and they found that sportspersons possessed lower Red blood cell count and Hemoglobin content than the sedentary group. The study revealed that endurance sports activity over a longer duration reduced the hemoglobin and red blood cell count.

K. Spiropoulos and G. Trakada (2003) made a study to evaluate the possible changes in blood cell count and biochemical parameters observed in participants in a marathon 3 days before and 3 days after and before and immediately after a cardiopulmonary exercise test. Incremental cycle ergometry up to maximal capacity was performed in 7 marathon runners, 3 days before and 3 days after the race. The peak oxygen consumption (peak %VO2) achieved was statistically significantly lower after than before the race. No statistically significant differences were observed in cardiac frequency or blood cell count. Also, the concentration of sodium, potassium, calcium, magnesium, lactate dehydrogenase (LDH), phosphocreatine kinase (CPK) and glucose, measured before and immediately after the pulmonary exercise test did not differ significantly. A significant percentage of the laboratory results were outside the standard reference rates. According to their conclusion, exercise performance, as expressed by peak %VO2, continued to be decreased in marathon runners 3 days after the race. The blood cell count and biochemical parameters did not differ significantly but many marathon runners were outside the standard reference rates.

Fallon (2004) determined the clinical and performance related utility of hematological and iron –related screening in elite athlete. White blood cell count, red blood cell count, hemoglobin, hematocrit, mean cell volume, mean cell hemoglobin concentration, platelet count, percent hypochromic red cell, serum iron, ferritin, transferrin, and percent tranferrin saturation were measured. Eight female athletes (4.6%) had clinically relevant abnormal, 6 with an obvious explanation on clinical history and examination and 1 who was diagnosed with hemochromatosis following genetic testing. Eightynine (51.1%) female athletes had abnormal that were not associated with obvious clinical sign or symptoms. Twenty-seven female athletes had a serum ferritin less than 30 mg/ml and were placed on iron supplementation. In male athletes, 5 cases had screening abnormalities that were associated with illness or other factors identified during
the clinical consultations. No clinically significant abnormalities in males were generally minor reductions in hemoglobin and/or hematocrit or minor alterations in red cell parameters. Five male athletes had a serum ferritin less than 30 mg/ml and were placed on iron supplementation. Screening for hematological and iron-related abnormalities in male athletes was a very low yield. Due to the critical nature of the effects of anemia and low serum ferritin on some aspects of performance, it was reasonable to perform a full blood count and serum ferritin on male athletes entering an elite training program. Further testing should be performed on clinical grounds. In females, the yield was greater. Again, it was reasonable to perform a full blood count and a serum ferritin on female athletes entering on elite training program. In view of their greater risk of iron depletion and to assess the effect of increased training inherent in elite programs, this could be repeated at 6-month intervals, or a desolated measurement of serum ferritin could be performed. Further testing should be performed on clinical grounds.

Wu et al., (2004) analyzed the detailed changes in hematology and biochemistry test parameters before and after a long-distance race in ultra marathon runners. Blood samples of 11 participants were obtained for standard analysis before, immediately after, two days after and nine days after the 2002 international ultra – marathon 24 hrs championship. They observed that total bilirubin (BIT-T), direct bilirubin (BIL-D), alkaline phosphatase (ALP), aspirate aminotransferase (AST), alanine aminotransferase (ALT) and lactate dehydrogenase (LDH) increased significantly (P< 0.05) the race, whereas, significant declines (P <0.05) in red blood cell (RBC) hemoglobin (Hb) and hematocrit (Hct) were detected two days and nine days after the race, whereas, significant declines (P <0.05) in red blood cell (RBC) hemoglobin (Hb) and hematocrit (Hct) were detected two days and nine days after the race,. While BIL, BIL-D and ALP recovered to their original levels. High-density lipoprotein cholesterol (HDL-c) remained unchanged immediately after the race, but it was significantly decreased on the second and ninth days after the race. Ultra marathon running was associated with a wide range of significant changes in hematological parameters, several of which were injury related. To provide appropriate health care and intervention, the man who received athletics on high high intensity training programs must monitor their liver and gallbladder function.
To observe the changes induced by moderate exercise in hematological parameters of young healthy population, Rashida Bhatti and Din Muhammad Shaikh (2007) conducted a study on Eighty eight (88) students of the Department of Physiology, University of Sindh, Jamshoro. Estimation of hemoglobin, total white blood cells count, differential leukocyte count, erythrocyte sedimentation rate, and blood pressure (BP) were measured before and after standard exercise (30 minutes jogging). Besides others, they concluded that exercise stress leads to significant increase in total white blood cell counts.

Kochanska-Dziurowicz et al., (2007) tested the influence of maximal physical effort on selected blood parameters. This exercise was performed by twenty-two junior ice hockey players during the work on a cycle ergometer with the increasing load i.e. the refusal test. Blood were taken before and just after exercise to determine red blood cells (RBC), hematocrit (HCT), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), hemoglobin concentration (HGB), myoglobin concentration (Mb) and erythropoietin concentration (EPO). It was found that the maximal physical effort caused statistically significant increase in mean red blood cells, hematocrit value and average hemoglobin concentration. Statistically significant increase in average myoglobin concentration in sportsmen with the initial myoglobin concentration which was at the normal level (subgroup A, n=11) was found. On the other hand, mean corpuscular hemoglobin concentration underwent statistically significant decrease. It was proved that after the refusal test mean corpuscular volume, mean corpuscular hemoglobin, average myoglobin concentration in athletes with the initial relatively high myoglobin concentrations (subgroup B, n=11) and average erythropoietin concentration did not show any statistically significant changes. Physical effort causes the plasma volume changes, as a result of water migration between extra vascular and intravascular spaces. It was calculated that the plasma volume decreased on average about 9.055+4.293%. In the group of examined athletes, the statistically significance decreases of blood plasma volume caused the increase of plasma components. Ascertained changes of myoglobin concentration in subgroup A after maximal work are big enough that they do not result only from decrease of the plasma volume.
To observe the effects of exercise and/or training on hematological indices, circulating side population (SP) cells, and cytokines, specifically, hemoglobin (Hgb), hematocrit (Hct), white blood cell (WBC) and platelet (Plt) numbers, SP cells and plasma vascular endothelial growth factor (VEGF) and interleukin-6 (IL-6) levels. Gina G. Wardyn et al., (2008) analyzed before and following exercise to maximal fatigue of 37 nonsmoking subjects, aged 19 to 35 years, free of cardiopulmonary disease were enrolled and characterized as “trained” or “untrained.” Standard hematological indices were measured. Blood cells were stained with Hoechst 33342 vital dye and analyzed using flow cytometry for enumeration of SP cells. The levels of IL-6 and VEGF were determined by enzyme-linked immunosorbent assay. Results indicated that trained individuals had higher oxygen utilization capacity and significantly longer exercise times than that of the untrained individuals. Following exercise, significant increase were observed in Hgb, Hct, Plt, SP cell numbers, and IL-6 levels of both trained and untrained individuals in either gender. No significant change in WBC numbers or VEGF levels was observed. Although circulating SP cell numbers were significantly increased, the “quality” of SP cells, defined by the ratio of lower SP to upper SP cells, was unchanged. Increase in SP cells did not correlate with cytokine level.

Vedat Cinar et al., (2009) designed an experiment to investigate the effect of supplementation with calcium for duration of 4 weeks had an effect on blood parameters in sedentary male athletes at rest and exhaustion. Thirty healthy subjects from 18 to 22 years in age were included in the study. The subjects were divided into three groups: Group 1- consisted sedentary athletes receiving 35 mg/kg/day calcium gluconate, Group 2- subjects equally calcium supplementation with training 90 min/day for 5 days/week and Group 3- same exercise regime but did not receive calcium supplements. Blood parameters were determined in the experimental subjects at rest and after exhaustion. They found that the leukocyte count (WBC) of athletes in groups 2 and 3 were significantly higher at exhaustion. There were no significant differences in the WBC of the two supplemented groups. The erythrocyte count (RBC) was increased in the supplemented athletes after training, but hemoglobin, hematocrit, and thrombocyte levels remained unchanged. The mean corpuscular volume increased in the calcium-supplemented group at rest.
Sakir B. et al., (2010) analyzed the hematological parameters of elite women taekwondoers before and after training and found significant increase in WBC, HGB, PLT (P<0.01)\ RBC\ HCT and MCH (P<0.05) levels and insignificant differences (P<0.05) in MCV and MCHC levels. They concluded that since the results of the data were in the normal limits, there was no risk for sportswomen. However, since it was possible to find important evidences related with human health and performance due to the environmental and individual parameters, it is recommended that regular researches should be followed.

Evrim C. et al., (2010) examined the effect of aerobic exercise on the body composition and hematological parameters of 58 obese and overweight sedentary women. 29 obese women with average age 41.55 ± 6.72 year, average height 159.21 ± 7.18 cm, average weight 85.97 ± 9.60 kg, and 29 overweight women with average age 35.10 ± 9.11 year, average height 160.59 ± 5.20 cm, average weight 68.55 ± 6.72 kg, were volunteered in this study. 3 days per week for 8 weeks duration aerobic exercise protocol were administered on the selected subjects. Before and after the exercise protocol, the body fat percentage, the rate of the waist to the hip, elasticity, some hematological parameters (WBC, RBC, MCV, HGB, HCT, PLT), systolic and diastolic blood pressure were measured. Before and after the exercise of the obese and overweight groups, the understandable increase in the level of RBC, HGB, HCT and understandable decrease in the level of MCV were observed. Results indicated that understandable increase in WBC was found as different from the overweight group, no important difference in PLT in both groups was observed. Further, when differences between two groups were examined, after the exercise, the level of RBC in the obese group was higher than those in the overweight group.

Serkan Ibis et al., (2010) conducted a study to find out the acute effect of hematological parameters on aerobic and anaerobic exercise of 18 volunteers with average age 21.6 years. Max VO2 values of volunteers were obtained using bicycle ergonometric test. Aerobic exercise was taken with 50% of max VO2 for 45 minutes and anaerobic exercise was taken with 120% of max VO2 till exhausted. Blood samples were taken before exercise, just after exercise and 24 hours after exercise and they looked at hematocrit values. They found no significant values observed in hematological results for aerobic exercise. But, there were some significant values observed in
Hb, Hct, Wbc just after anaerobic exercise whereas some significant decreases were observed for 24 hours after exercise. Comparison of both exercises time showed that there was significant increase in anaerobic exercise and decreases in aerobic exercise. They concluded that maximal and hard exercise affects hematological values more than moderate exercise. The reason of this observation was because there has been a change in hematocrit levels and movement of leukocyte from margination pool to demargination pool in blood circulation duration of exercise and after exercise.

**Gert Ulrich et al., (2011)** evaluated differences in total hemoglobin mass (tHb mass) and red blood cell profile between 59 elite junior athletes (29 endurance-trained (END) and 30 non-endurance-trained (nEND) male and female adolescent athletes). tHb mass (CO rebreathing) and specific variables of red blood cell profile (hemoglobin concentration, hematocrit, erythrocyte indices) were determined. They found that in both groups, tHb mass related to body weight and the variables of red blood cell profile had not changed significantly after 6, 12 and 18 months of regular training. They concluded that, in elite junior athletes, differences in tHb mass between END and nEND were similar, however, smaller compared with previously in adult athletes reported values. At the age of 15–17 years, 18 months of regular training did not induce significant changes in tHb mass beyond alterations explained by physical growth and also variables of red blood cell profile did not change significantly.

**Mohammed H. et al., (2011)** investigated the effect of aerobic and anaerobic exercise programs on cardiopulmonary and platelets function in 40 obese subjects with normal blood pressure. Blood was drawn before and after the exercise program. Antibody-staining for platelet activation markers P-selectin and fibrinogen receptors was done without any stimulation in platelets rich plasma for flow cytometric analyses. All subjects were included in exercise programs for three successive months, three times per week. At the end of the program, it was shown that exercises led to increases in percentage aggregated platelets and percentage of platelets expressing P-selectin or CD62p binding and improved parameters of cardiopulmonary functions. This increase in percentage of platelets that expressing P-selectin continued even with anaerobic exercises; and was accompanied by an increase in percentage aggregated platelets.
Arazi H et al., (2011) conducted a study to investigate the variations of hematological parameters following two bouts of selected concurrent endurance and resistance exercises in one day. Eight male students of physical education in Guilan University volunteered for their study. Participants performed concurrent endurance-resistance exercises for 90 minutes in the morning and afternoon bouts. Blood samples were obtained before, immediately after and three hours after the exercise to measure for hematological parameters – white blood cell, red blood cell, hemoglobin, hematocrit, mean hemoglobin concentration, mean corpuscular volume, platelet, and plasma volume. The participants were fasting for at least 12 hours prior to the first blood sampling. They used analysis of variance with repeated measures and post hoc test to evaluate the hematological variations. Their findings indicated that white blood cell and platelet counts increased significantly three hours after, and immediately after exercise, respectively. Furthermore, hematocrit, hemoglobin, and red blood cell counts decreased significantly three hours after exercise. However, no significant variations were observed for MCH, MCHC, MCV and PV parameters. They concluded that the fall in blood factors essential for gas exchange and its possible impact on oxygenation of active muscles, as well as the rise in coagulative and immunity factors following two bouts of exercise.

Serkan.I et al., (2011) evaluated chronic effects of plyometric training on hematological parameters of the Turkish National Alpine Ski Team athletes during 12-week preparation period. 12 sportsmen with mean age 17.50 years volunteered in this study. The training program was applied for twelve weeks and five days a week in total 60 training unit. As the program preceded the intensity and content of training increased. Blood samples were taken before and after training program. The Red blood cell (RBC), white blood cell (WBC), Granulocyte (GR), hematocrit (HCT), Hemoglobin (HGB), Mean Corpuscular Volume (MCV), Mean Corpuscular Hemoglobin (MCH), Mean Corpuscular Hemoglobin Concentration (MCHC) measurement were analyzed blood samples with automatic hematological analyzer (Toshiba Acute PPS TBA-40FR). Wilcoxon Signed Rank test was used in order to compare statistical values of before and after exercise. Before and after training program values were compared for RBC, WBC, GR, MCV, MCH, MCHC and no significant changes have been observed for these values. However there were significant (p>0.05) increase of HCT and HGB values. They concluded that twelve
weeks plyometric training program increased the red blood cells and hemoglobin levels and as a result improved oxygen carriage capacity of the Turkish National Alpine Ski Team athletes.

Cagri C. (2012) conducted a study to compare and examine the biochemical and hematological parameters between 103 healthy female elite athletes in different branches and sedentary. Parameters of leukocyte (WBC), erythrocyte (RBC), hemoglobin (HGB), hematocrit (HCT), platelet (PLT), glucose, creatine, aspartate aminotransferase (AST), alanine aminotransferase (ALT) were investigated. The results of research indicated that significant differences were found between sedentary group and experimental group formed from female athletes in different sports branches. It might be said that more comprehensive studies on the effects of training should also be examined to determine relationship between hematological and biochemical values, and sportive performance.

Hurmuz K. et al., (2012) conducted a study in order to determine the influence of five-day handball competitions on hematological levels of male handball players. 12 elite male handball players with an average age of 22.16±1.85 years participated in this study on voluntary basis. Physical measurements including body height, body weight, body-mass index and body fat percentages and hematological levels of the handball players were analyzed before (BC) and after the competitions (AC). Blood samples were taken from the forearm ante-cubital area in line with hygiene rules before and after competitions, and erythrocyte, leucocytes and blood platelet parameters were analyzed in laboratory with using auto-analyzers. They concluded that decrease in BC and AC values for body weight, body-mass index; body fat percentages, MCV, MCH, CH and LY and the increase in RBC and NE values were significant. Conclusively, erythrocyte, leucocytes and blood platelet levels display different behaviors in acute competition-like exercises.

To analyze different effects of strenuous exercise and moderate exercise on platelet function in men Jong-shyan Wang et al., (2012) administrated Strenuous and moderate exercise (about 50% to 55% of peak oxygen consumption, V02pOak) on a bicycle ergometer in 10 sedentary and 10 physically active healthy young men on two separate occasions. Blood samples were collected before and immediately after exercise. A newly designed tapered parallel plate
chamber was used to assess platelet adhesiveness. Platelet aggregation induced by ADP was evaluated by the percentage of reduction in single platelet count. 3-Thromboglobulin (B-TG) and platelet factor 4 (PF4) were measured by ELISA. In addition, similar studies on 5 patients with stable angina were also conducted. They concluded that (1) in the sedentary healthy group, platelet adhesiveness and aggregation were increased by strenuous exercise and depressed by moderate exercise; (2) in the active healthy group, platelet adhesiveness and aggregation were enhanced by severe exercise, whereas only aggregation was decreased by moderate exercise; (3) in the patients with stable angina, platelet adhesiveness and aggregation were enhanced by strenuous exercise and adhesiveness was suppressed by moderate exercise; (4) the degree of hemoconcentration induced by acute exercise tended to be related to the severity of exercise in all subjects; and (5) although severe exercise elevated 3-TG and PF4, there were no significant changes in 3-TG PF4 and the ratio of B-TG to PF4 in healthy subjects after exercise.

To determine the effects of chronic exercise on hematological parameters (erythrocytes, leukocytes and platelets) of elite female wrestlers Murat El oz et al., (2012) selected twenty four (24) female wrestlers (FW) on elite level and 24 sedentary female college students (SF) as subject in this study. After being informed, blood samples of subjects were taken on an empty stomach in laboratory between 9:00-10:00 in the morning. Levels of Leukocytes (WBC), Erythrocytes (RBC) and Platelets (PLT) parameters were determined by using blood count device. Results showed that difference between the levels of leukocyte parameters: Mid, Lymph%, Mid% and Gran%, erythrocyte parameters: HGB, MCH, MCHC and RDW-SD, platelet and platelet related parameters: MPV, PDW and PCT of the two studied groups were statistically significant (p<0.05).

To evaluate and compare the immediate effects of exercise on hematological parameters in healthy trained & un-trained males Shamoon Noushad et al., (2012) collected venous blood samples from 56 trained and 38 untrained male of 19 to 24 years in age subjects before & after 30 min of jogging on treadmill. The blood was then investigated for the changes in Hb, hematocrit, total leukocyte count, erythrocyte, platelets & reticulocyte count. Results indicated that immediately after termination of exercise the hemoglobin, hematocrit erythrocyte and leukocyte levels increased significantly when compared with pre-exercised values in both group
while there was no significant change observed in platelet and reticulocyte count. Moreover, beside changes in pre-exercised values among the trained and untrained subjects, the rise in erythrocyte and total leukocyte count was significantly more in trained subjects when compared with untrained. They concluded that exercise with physiological stress to body became healthy and induced certain changes that enhance the ability to cope with stress. Moreover, regular aerobic exercise improved ability of the body to use oxygen and defense mechanism.

Fereshteh Shahidi et al., (2012) conducted a study to examine the effect of a maximal aerobic exercise session in the morning and the afternoon on certain hematological factors of 21 young male athletes randomly selected from the students of Physical Education in the University of Tehran. Subjects were divided into a morning group (N=10; 20.9±0.99 years, 67.35±6.27 kg body wt. and 180.4±4.28 cm ht.) and an afternoon group (N=11; 21±0.63 years, 67.13±9.13 kg body wt., and 176.9±9.01 cm ht.). The morning and afternoon groups performed the seven-station Bruce protocol from 8 to 10 A.M. and 3 to 5 P.M. respectively. Blood samples were collected from both groups before, immediately after, and 2 hours after the exercise. The result suggested significant differences in the levels of hemoglobin and erythrocytes of the two groups at different stages of blood sampling. No significant difference was observed in the level of hemoglobin and erythrocytes before and two hours after the exercise. Measurement of the level of leukocytes in the two groups and at different stages of blood sampling indicated significant differences, and both groups showed significant differences in the level of platelets at different stages of sampling (P≤0.05). Comparison of the two groups revealed that there was no significant difference between the morning and the afternoon group in the levels of hemoglobin, platelets, erythrocytes, and leukocytes before, immediately after, and two hours after the exercise. Based on the results of the research, they argued that a maximal aerobic exercise session in the morning and the afternoon changes the level of hemoglobin, platelets, erythrocytes, and leukocytes, and that the time of exercise had no effect on the amount of change. They recommended that blood was the third component of the circulatory system where changes occur following exercise-induced increase in metabolism.
Abbass Ghanbari-Nia 

t er al., (2013) conducted a study to find out the effects of a circuit resistance training session with a light intensity on some hematological parameters of 20 male Physical Education students. After equalization, they were randomly divided into two groups including light-intensity exercise (35% of a maximum repetition) and no exercise (the control). Persons in the first group were asked to perform 10-step circuit exercise for three non-stop alternating rounds with a rest period at each round. Hematological parameters measured included white blood cells, platelet variables, and red blood cells. Results of their study showed that none of the variables related to white blood cells and platelet had a significant change in the group of light-intensity exercise (35% of a maximum repetition) except only mean corpuscular volume (MCV), and whereas, among the variables related to red blood cells, decreased significantly. In the control group, a significant increase in Neutrophil percent (NEUT) and hemoglobin and a significant decrease in lymphocyte percent (LYM) were observed. Other variables showed no significant change in this group. In addition, there was no difference between the groups.

Ibrahim Erdemir (2013) conducted a study to identify the differences in blood parameters between morning exercise and evening exercises. 12 participants, in younger adults aged 20 years, were recruited and their blood was taken for four times, from 8:00 to 9:00 (pre and post) for morning exercise and from 20:00 to 21:00 (pre and post) for evening exercise. The results found that leukocytes (WBC, NE and LY), erythrocytes (RBC, HGB, HCT, MCH and MCHC) and thrombocyte (PLT, MPV and PCT) showed significant differences (p<0.05) between the morning and evening exercises. Additionally, no significant differences were found in the other parameters in blood. He concluded that hematological parameters displayed different behaviors in acute exercise at different times of a day. Leukocytes, erythrocytes and thrombocyte levels displayed different behaviors in exercises at morning and evening.