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Sport Students' Hematology Profiles as Detected By The Automatic Sysmex XP-300 at Keberkatan Olahraga Senior High School In Aceh

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ABSTRACT

Physical activity has long been linked to modifications in hematologic profiles as the body's compensating response to the stress of physical training. Several earlier research studies have discovered that physical activity impacts red blood cells, leukocytes, and platelets, while the findings remain contentious. Monitoring an athlete's hematologic profile is critical for effective training management. The purpose of this study is to analyze the hematologic profile of young adults who attend sports-specialized schools. This cross-sectional study included 30 students (15 males and 15 females). Blood samples were collected using standard venipuncture methods and examined on an automatic Sysmex XP-300 analyzer. The analytical results revealed that all participants had mean or median values for each complete blood count (CBC) parameter and leukocyte differential count that were normal for the general population. Females showed greater mean/median values for all CBC indices except hemoglobin, hematocrit, erythrocytes, MCHC, and RDW. For ESR (erythrocyte sedimentation rate), all participants exhibited normal levels, with females having greater levels. The leukocyte differential count showed that the results for male and female patients were comparable. Sport students' hematologic profiles are normal for the overall community. However, it is critical to remember that physical activity alters the blood and its components, prompting the need for hematologic indices specific to athletes or sports students.

Keywords: phyisical activity, hematology

INTRODUCTION

Physical activity has a profound impact on various blood cells, influencing their production, function, and overall role in promoting health. Scientific data suggests that frequent exercise, both acute and chronic, improves these processes across different body systems. Consistent physical exercise improves physical capacity by increasing the efficiency of the circulatory, muscular, respiratory, and neural systems.(Koç, Özen, Abanoz, & Pulur, 2018)

Blood is commonly used as an indicator to assess the impact of exercise on the functioning of physiological systems such as the cardiovascular, immunological, and endocrine systems. Blood is made up of three types of cells: red blood cells (RBCs), also known as erythrocytes; platelets; and white blood cells (WBCs), or leukocytes.(Kenney WL, Wilmore J, & Costill D, 2021; Nunhuck S, 2008) These cells are essential for maintaining homeostasis.(Koç et al., 2018) The primary purpose of hematological components is to transport, protect, and regulate the many body systems. Participation in sports and exercise has a significant impact on red blood cell generation and survival. Similarly, elevated stress from athletics boosts the body's leukocyte count. Platelets and other parameters related to it tend to

grow with continued participation in sports and exercise training.(Eliöz, 2012; Pouramir M, Haghshenas O, & Sorkhi H, 2004; Vatansev & Çakmakçi, 2010).

Hematologic tests are commonly used to measure the health and fitness of trained athletes. Studies have demonstrated that athletes have different resting levels for several parameters than the general population.(Nikolaidis et al., 2003) Hematologic and biochemical indicators varied based on the type, intensity, and duration of the activities. As a result, observing the patterns of hematological alterations caused by traditional physical training in athletes may provide a suitable position for improving the practical or destructive effects of exercise programs.(Ozal, Cengiz, Yaman, & Guclu, 2016) According to reports, athletes have superior physiological responses to progressive training than non-athletes; hence they are handled differently.(Baffour-Awuah et al., 2017)

The purpose of this study is to examine the hematologic profiles of Sport High School students. It is well-known that students enrolled in sport schools regularly engage in training and physical activity. Physical exercise refers to an individual's physical condition that allows them to attain their sporting objectives to the fullest extent possible. This exercise consists of organized, structured, and repetitive muscular motions that use energy to increase fitness.(Putra, B. F., 2019; Setia, D. Y. & Winarno, M. E., 2021) Regular physical activity and training cause physiological and metabolic changes.(Aparicio-Ugarriza et al., 2018; Díaz Martínez, Alcaide Martín, & González-Gross, 2022; Peake, Neubauer, Walsh, & Simpson, 2017) Trainers, sports physicians, and athletes must keep track of these adaptations. It has been suggested that hematologic profiles are suitable indicators for assessing the training effect, as well as for preserving health, detecting chronic stress, inflammation, and exhaustion, or preventing injuries.(Campbell & Turner, 2018; Díaz Martínez et al., 2022; Peake et al., 2017).

The development of athletes' physical fitness and performance is closely linked to the physiological adaptations that occur as a result of consistent training. One key aspect of these adaptations is the alteration of hematologic parameters, which are influenced by the intensity and duration of exercise. Hematologic indices such as red blood cell count, hemoglobin levels, and white blood cell count are commonly monitored to assess the overall health and performance potential of athletes. These parameters play a critical role in oxygen transport, immune function, and recovery, all of which are crucial for athletes who undergo rigorous physical training.

In sports science, understanding how regular physical activity impacts blood parameters is essential for developing effective training regimens that enhance performance while minimizing health risks. The relationship between exercise and hematologic health is particularly important in high school athletes who are still in a stage of physical development. Early detection of abnormal hematologic profiles can help prevent the onset of overtraining syndrome, anemia, or other blood-related issues that could hinder an athlete's progress and overall health. This research is particularly significant as it investigates the hematologic profiles of sports students, which are often under-studied compared to professional athletes.

Despite numerous studies examining the effects of physical exercise on the hematologic parameters of adult or elite athletes, research on high school athletes, especially in a specialized sports school setting, is limited. Most existing literature focuses on adult athletes or those involved in professional sports. However, high school students, particularly those attending sports schools, undergo unique training regimens and physiological changes. Their hematologic profiles may differ from those of professional athletes, necessitating a targeted approach to understanding the effects of exercise on their health. This study, therefore, provides an important contribution to the body of knowledge regarding youth sports performance and health monitoring.

According to Peake et al. (2017), the hematological profiles of athletes, including red blood cell count, leukocyte levels, and platelet counts, are typically different from those of the general population due to the physiological demands of regular physical activity. Their study suggests that understanding these differences is essential for managing training and ensuring athletes' health. Similarly, Nikolaidis et al. (2003) found that athletes have distinct hematological profiles, with higher red blood cell and hemoglobin levels, which improve oxygen delivery during exercise, providing a competitive advantage. These findings underline the importance of monitoring hematologic indices to optimize athletic performance.

The urgency of this research arises from the increasing need for specialized health assessments in athletes, particularly those involved in high-intensity sports. Understanding how physical training affects the hematologic profile of sports students can help improve training programs, prevent overtraining, and detect early signs of health issues. By identifying deviations in normal blood parameters, this research will aid in the development of tailored health monitoring systems that can optimize performance and reduce the risk of injury or illness in sports students.

While research on the effects of exercise on hematologic parameters has been well-documented, there is limited focus on the hematologic profiles of high school athletes, particularly in sports-focused educational institutions. Previous studies have mostly focused on adult or elite athletes, leaving a gap in understanding how younger, developing athletes, particularly those in specialized sports schools, are affected by regular physical activity. This study aims to fill this gap by providing a comprehensive analysis of the hematologic profiles of students at a sports high school in Aceh, Indonesia.

This study is novel in its examination of the hematologic profiles of high school sports students in Aceh, focusing on the impact of consistent physical training on blood parameters such as red blood cells, platelets, and leukocytes. Unlike previous studies, which often focus on elite or adult athletes, this research provides valuable insights into the physiological effects of exercise on younger athletes, highlighting the differences between male and female sports students and their respective responses to physical activity.

The primary objective of this research is to analyze the hematologic profiles of sports students in Aceh, specifically evaluating parameters like hemoglobin, hematocrit, erythrocytes, and leukocytes, to understand the effects of physical activity on their health. The study aims to provide insights into how regular exercise influences blood parameters and to offer recommendations for optimizing training programs. The benefits of this research include improving health monitoring in sports students, preventing training-related health issues, and contributing to the development of more effective sports health management strategies in schools, ultimately enhancing athletic performance and student well-being.

METHOD

The study used a cross-sectional approach and included 30 students (consisted of 15 male and 15 female) from Sport High School. The sample was gathered using the stratified random sampling technique. The students' blood was extracted and then tested using an automatic Sysmex XP-300.

Material and Equipment

The study used standard blood sample material and equipment, including a spuit 3 ml, an EDTA tube, a serum separator tube, a torniquet, an alcohol swab, a cotton pad, a handscoon, and a safety box.

Blood Sampling Technique

The blood was collected from the most common location, the superficial vein in the antecubital fossa (elbow crease). The vein in the antecubital fossa was found by putting a tourniquet on the arm and then asking the subject to clench their fist, which makes the vein

more visible. Next, the vein was palpated (touched) with the index finger to identify its direction, diameter, and depth. The blood collection system operates in an open system.(Keohane, E. M., Smith, L. J., & Walenga, J. M., 2016; Nugraha, 2022) The Clinical and Laboratory Standards Institute (CLSI) recommends that the blood collection method be carried out in the following steps:(Keohane, E. M. et al., 2016; Nugraha, 2022)

1. The identification of the respondent has been documented.
2. The process and purpose of blood sampling have been provided to the respondent.
3. Disinfect the hands with soap and running water.
4. Use gloves of the right size
5. Ensure that all equipment and materials are ready, and prepare the syringe to the needed blood volume.
6. The tourniquet is placed 3-4 inches above the elbow crease, and the vein is palpated to establish the appropriate spot for venipuncture. The research subject is asked to clench their fist to make the vein more visible and easier to find.
7. The venipuncture site is disinfected in a circular motion using an alcohol swab, beginning at the inner section and working outward.
8. The needle is held at a 15-30 degree angle to the skin surface, with the lumen facing upward. The needle is placed through the right index and thumb. The left hand stabilizes the respondent's arm and vein.
9. Once the needle penetrates the vein, the left hand keeps it in place while the right hand pulls the plunger to take blood.
10. The tourniquet is instantly loosened once blood begins to flow into the syringe.
11. Continue to draw blood until the syringe is filled. At the same time, instruct the respondent to slowly open their fists.
12. Once the syringe is full, lay a dry gauze or cotton pad over the puncture site without applying pressure. The needle is carefully removed, and the puncture site is immediately pressed with gauze for approximately one minute. Once the bleeding has stopped, remove the gauze and cover the wound with a plaster.
13. The blood in the syringe is transferred into a EDTA tube. The tube is labeled with the respondent's full name, time, and date of blood collection.

Blood Analysis Using Automatic Sysmex XP-300

The blood sample was examined on an Automatic Sysmex XP-300 hematology analyzer, which is commonly used for laboratory or research testing. The XP-300 requires two reagents for full blood count analysis, as well as cleaning fluid and quality control material. These include cellpack, stromatolyser-WH, cell clean, and eightcheck-3WP. A Full Blood Count was performed using two analysis principles: direct current detection and non-cyanide haemoglobin analysis methods.

To ensure proper analysis, 1ml of blood is required in an adult sample tube or 0.5ml in a micro tube (aspirated sample volume is 50 μl). The procedure for blood analysis:(Sysmex, 2021)

1. Use the default analysis mode, WB (Whole Blood).
2. Entering the sample ID will change the analyzer state to 'Ready'.
3. Register the Operator ID, and the analyzer status will change to 'Ready'.
4. Mix the blood sample carefully.
5. Gently take off the cap from the sample tube.

Connect the tube to the sample probe and activate the start switch. During the sample analysis, the analyzer status will initially read 'Aspirating'; after this changes to 'Running', the sample can be safely withdrawn.

RESULTS AND DISCUSSION

The research subjects consist of 30 sport students, including 15 male and 15 female. The characteristic and hematology profile of the subjects can be seen in the table below.

Table 1 Hematology profile of Sport Students at Keberkatan Olahraga Senior Highschool

Parameters	Male n=15	Female n=15	Total n=30
Age, years old (y.o)	16**	16**	16**
15 y.o	2(13,33%)	4(26,67%)	6(20%)
16 y.o	7(46,67%)	6(40%)	13(43,33%)
17 y.0	2(13,33%)	3(20%)	5(16,67%)
18 y.o	3(20%)	2(13,33%)	5(16,67%)
19 y.o	1(6,67%)	0	1(3,3%)
Complete Blood Count (CBC)			
Haemoglobin, mg/dl	14,83*	12,95*	13,89*
Haematocrit, %	44,13*	38,85*	41,49*
Erythrocyte, cell/µL	5,25**	4,58*	4,88*
Leukocyte, 10^3/µL	8,05*	8,71*	8,38*
Platelet, 10^3/µL	279,27*	323,40*	301,33*
MCV, fL	82,4**	85,9**	84,19*
MCH, pg	28,15*	28,35*	28,25*
MCHC, g/dL	33,56*	33,34*	33,45*
RDW, %	13,3**	12,97*	13,0**
PCT, %	0,27*	0,31*	0,29*
MPV, fL	9,7**	10**	10**
PDW, fL	11,75*	11,9*	11,82*
ESR, mm/hr	7,0*	15,53*	9,5**
Leukocyte differential count			
Basophil	0	0	0
Eosinophil	2,0**	1,0**	2,0**
Band Neutrophil	3,0**	2,0**	3,0**
Segmented Neutrophil	55,0*	57,8*	56,4*
Lymphocyte	33,0**	34,13*	34,0**
Monocyte	5,0**	4,0**	5,0**

Note: * = mean; ** = median

According to table 1, both males and females have a median age of 16 years, with the oldest at 19 years (3.3%) and the youngest at 15 years. Based on the overall number of research subjects, the majority of them were 16 years old. This is consistent with the age range of senior high school students, which is 14 to 18 years. The Ministry of Health of the Republic of Indonesia divides adolescence into two groups: early adolescence (ages 12-16) and late adolescence (ages 17-25).(Depkes RI, 2009)

The complete blood count data demonstrates that females have greater mean and/or median values for each blood parameter than males, with the exception of hemoglobin levels, hematocrit, erythrocytes, MCHC, and RDW. For male individuals, the mean hemoglobin level is 14.83 mg/dl, with a hematocrit of 44.13%, and the median erythrocyte count is 5.25 million/µL. Meanwhile, female individuals have lower mean hemoglobin, hematocrit, and erythrocyte levels (12.95 mg/dL, 38.85%, and 4.58 million cells/µL, respectively). The study's findings are in line with those of Nikolaidis et al., who discovered that the mean values of RBC in females are 4.53 million/µL, while males had 5.04 million/µL. The male hemoglobin and hematocrit are also consistent with this study, with averages of 14.8 mg/dL and 43.2%,

respectively. On the other hand, females in Nikolaidis et al.'s study had greater mean hemoglobin and hematocrit readings.(Nikolaidis et al., 2003)

Other measurements of red blood cells (RBCs) in CBC include mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), and mean corpuscular hemoglobin concentration (MCHC). The MCV measures the average volume (size) of RBCs, with a typical value ranging from 80 to 100 fL. The MCH assesses the average quantity of hemoglobin in a single RBC, with a normal range of 26-34 pg. Finally, the MCHC is a ratio of hemoglobin to red cell volume (normal range: 32-36 g/dL). RBC size variation can be represented in Red Cell Distribution Width (RDW), with a higher RDW indicating more variance in RBC size (normal level: 11.5%-14.5%). These measurements are crucial in the case of anemia.(El Brihi & Pathak, 2024) According to the findings of this study, all research subjects' MCV, MCH, MCHC, and RDW levels are within normal limits. Ozal et al. studied erythrocyte parameters in junior wrestler athletes, where the average values for MCV, MCH, and MCHC were 87.3 fL, 28.29 pg, and 32.72 g/dL, respectively.(Ozal et al., 2016) Similar results were found in Saudi Arabian research by Lobigs et al., which had an average MCV of 84.2 fL, MCH of 28.6 pg, and MCHC of 33.9 g/dL.(Lobigs, 2013)

In this study, the average leukocyte count was 8.05 x 10^3/µL in males and 8.71 x 10^3/µL in females. Overall, the leukocyte counts averaged 8.38 x 10^3/µL. Overall, the average leukocyte count was 8.38 x 10^3/µL. The results of this study are different from those of Baffour-Awuah et al., who found that athletes had an average leukocyte value of 5.18 x 10^3/µL.(Baffour-Awuah et al., 2017) A study comparing athletes and non-athletes found that non-athletes had a significantly higher average leukocyte count (7.21 x 10^3/µL vs. 6.35 x 10^3/µL) ($p = 0.01$).(Koç et al., 2018) A study evaluated leukocyte levels before and after a soccer match between two groups (trained and untrained). The trained group had a lower baseline leukocyte count (134.50±2.46 x 10^3/mm³) than the untrained group (140.10±1.65 x 10^3/mm³, $P = 0.009$). Immediately following the match, the trained group showed a higher leukocyte count (149.95±3.89 x 10^3/mm³ vs. 142.05±4.87 x 10^3/mm³, $P = 0.031$).(Musa, Mabrouk, & Tanko, 2016) This shows that the group that is used to regular physical activity behaves differently than the group that does not.

The leukocyte differential count indicates that male and female results are similar. The basophil cell is constant in all individuals, and no cell was detected. The number of eosinophil cells observed was identical, with a median of 2.0 in males and 1.0 in females. The median value of band neutrophil cells is higher in males (3.0 vs. 2.0), whereas segmented neutrophil cells are higher in females (55.0 vs. 57.8). The median lymphocyte cell count in males is 33.0, while females have a mean count of 34.13. Males have a median monocyte count of 5.0, whereas females have a median of 4.0. A study revealed no differences in monocytes, lymphocytes, or neutrophils between those who engaged in high-intensity exercise and low-intensity exercise. The low-intensity exercise session had no effect on leukocyte subsets at any time point, whereas the high-intensity exercise caused transitory acute lymphocytosis and monocytosis, which recovered to normal 2 hours after the physical activity had finished. Meanwhile, neutrophils were normal right after exercise but then increased after 2 hours of vigorous activity.(Neves et al., 2015)

Lobigs et al. stated that the overall reference ranges for the majority of hematological measurements are lower than those currently employed in the general population.(Lobigs, 2013) When Koc H, et al., compared the hematologic profiles of male athletes and sedentary male students, he discovered that while the average leukocyte count was higher in non-athletes (6.35 x 10^3/µL vs. 7.21 x 10^3/µL), the average values for RBC, hemoglobin, and hematocrit were higher in athletes (5.41 x 10^3/µL vs. 5.10 x 10^3/µL; 15.83 g/dL vs. 14.68 g/dL; 46.04% vs. 43.13%). This suggests that the variations seen are hematological reactions to both acute and long-term exercise, even if these values are still within the normal range.(Koç et al., 2018)

Physical activity impacts red blood cells (RBCs) and hemoglobin through a variety of methods. During exercise, numerous mechanisms collaborate to boost tissue oxygen supply. Initially, the body responds to increased muscle oxygen demand by increasing muscular blood flow through increased cardiac output, shifting blood to active muscles, and improving microcirculation. Red blood cells enhance blood flow by generating nitric oxide (NO) from nitrate and ATP, which increases vasodilation. As blood travels through capillaries near muscle cells, factors such as increased temperature, H+, and CO2 reduce hemoglobin's affinity for oxygen, hence increasing oxygen delivery to muscles. Training enhances oxygen supply by raising maximal cardiac output, boosting vascularization, and improving red blood cell characteristics.(Mairbäurl, 2013)

Regular exercise causes a modest fall in oxygen levels (hypoxia) in tissues, particularly in the muscles. This causes the release of erythropoietin (EPO), a hormone mostly generated by the kidneys. Erythropoietin causes bone marrow to create more red blood cells. This is an adaptive mechanism that increases the oxygen-carrying capacity of the blood. An increased quantity of RBCs improves the blood's ability to deliver oxygen to tissues. Consistent physical training over time increases total RBC count as well as the development of new, younger RBCs that are more efficient in oxygen transport.(Ivanov, 2022; Mairbäurl, 2013)

Aside from that, regular activity increases the amount of plasma in the blood, which helps to accommodate more RBCs and improves circulation. During the early stages of vigorous exercise, plasma volume expansion might cause a brief hemodilution, in which the concentration of hemoglobin per unit of blood decreases. As the body adapts to regular training, the increase in plasma volume is offset by an increase in RBC production, resulting in a greater hemoglobin concentration. This modification allows for a higher oxygen-carrying capacity. With continued training, the body may be able to extend the lifespan of RBCs, ensuring a stable and effective oxygen delivery system, while the turnover rate (production and destruction) of old RBCs can also be adjusted. These changes support the increased physical demand and guarantee a consistent supply of functional RBCs.(Ivanov, 2022; Mairbäurl, 2013)

Table 1 indicates that female individuals had a higher average platelet count than male subjects (323.40 x 10^3/µL vs. 279.27 x 10^3/µL), whereas the average platelet count for all subjects was 301.33 x 10^3/µL. The results are higher than a research study by Kirbas et al., which included 20 athletes and found an average platelet count of 230.6 x 10^3/µL. The study found a substantial difference in platelet counts between athletes and non-athletes ($P < 0.001$).(Kirbas, Tetik, Aaykora, & Duran, 2015) Baffour-Awuah et al. discovered that athletes had a lower average platelet count than non-athletes (243.64 x 10^3/µL vs. 260.58 x 10^3/µL).(Baffour-Awuah et al., 2017)

There are several other hematological parameters that refer to platelet, namely Plateletcrit (PCT), Mean Platelet Volume (MPV), and Platelet Distribution Width (PDW). Based on the findings of this study, all PCT, MPV, and PDW values are normal, regardless of gender. Plateletcrit measurements represent the overall volume of platelets in the blood, comparable to hematocrit. The mean platelet volume quantifies the average size of platelets. The variance in platelet size was measured using the PDW value. A low amount of PDW implies uniformity in platelet size, which generally reflects good platelet function, whereas a high level of PDW suggests greater variability in platelet size, which could indicate platelet production abnormalities.(Budak, Polat, & Huysal, 2016; Pogorzelska, Krętowska, Krawczuk-Rybak, & Sawicka-Żukowska, 2020) A study in Indonesia evaluated reference values for platelet count and several platelet indices in the general population. The study found that the median values for platelet count, PCT, MPV, and PDW were 292 x 10^3/µL, 0.24%, 8.3 fL, and 46.5%, respectively.(Sukorini, Arjana, Ratnaningsih, & Satria, 2024) According to a systematic review, platelet counts tend to fall after moderate exercise but rise after vigorous exercise. Immediately during prolonged aerobic activity, MPV rises in relation to other platelet

indicators, and this rise is correlated with exercise intensity. A brief drop in PDW was noted right after acute exercise, but the majority of studies did not show a substantial rise in PDW following regular activity.(Garai et al., 2017)

A review of the literature reveals that acute vigorous physical exercise can cause platelet activation, whereas regular physical activity or physical fitness reduces platelet activation in response to acute physical exercise. Physical activity has been shown to influence platelet function. Acute physical exertion elevates catecholamine levels, which raises shear stress and damage from oxidative stress. Both of these factors have been shown to activate platelets. The intensity of physical exercise increases arterial blood flow and shear rate. Shear stress also enhances nitric oxide synthesis in the endothelium, affecting platelet and smooth muscle cell bypass in the arterial layers. This causes vasodilation, which increases blood flow at lower shear rates.(Heber & Volf, 2015)

As shown in table 1, all of the research individuals have a normal erythrocyte sedimentation rate (ESR) (male: 7.0 mm/hr, female: 15.53 mm/hr), with female subjects having a higher level of ESR. Females typically have a higher ESR than males, which steadily increases with age. The Westergren method typically yields the following ESR values: ≤10 mm/hr for children, ≤15 mm/hr for males under 50 years old, ≤20 mm/hr for females under 50 years old and males over 50 years old, and ≤30 mm/hr for females over 50 years old.(Al-Marri & Kirkpatrick, 2000; Tishkowski & Gupta, 2024) The erythrocyte sedimentation rate is a well-known hematological test that detects and monitors inflammation in the body. While the ESR is not specific to any particular condition, it is frequently used in conjunction with other tests to determine the extent of inflammatory activity. The test evaluates how rapidly RBCs settle to the bottom of a Westergren tube. This process, known as sedimentation, is usually more rapid in those who have inflammation-related diseases such as infections, malignancies, or autoimmune disorders.(Plebani & Piva, 2002; Tishkowski & Gupta, 2024)

CONCLUSION

The hematologic profile of sport students is within the normal range for the general population. However, it is vital to remember that physical activity affects the blood and its components, necessitating the use of hematologic indices tailored to athletes or sports students. Blood profiling is critical for the sports medicine community to improve athlete health and performance while also aiding in the detection of hemopathologies and other blood-related illnesses.

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