STUDIA UBB EDUCATIO ARTIS GYMN., LXX, Special Issue 2, 2025, pp. 159-172
(RECOMMENDED CITATION)
DOI: 10.24193/subbeag.70.sp.iss.2.43

EFFECTS OF LOCAL HYPOXIA ON HEMATOLOGICAL PARAMETERS IN ATHLETES

Alexis PAUL[1*], Codruța-Florina BULDUȘ[1]

ABSTRACT. ***Introduction***: One of the key components of aerobic capacity is the hemoglobin quantity in the blood. Naturally, the body produces the erythropoietin, which promotes the synthetization of red blood cells, in states of tissue hypoxia. ***Aim****:* The Aim of this study is to investigate the effects the blood flow restriction at muscular level in athletes has on hemoglobin blood concentration. ***Objective***: The objectives of this study are to create and to implement a training program based on blood flow restriction at muscular level to augment muscle performance in athletes. ***Material and methods***: This method suggests the obstruction of blood flow to the legs using wrapped elastic bands at the superior area of the legs during running. For this study has been used as subject a young male footballer, being 19 years old, and the duration of this study case took 6 weeks. The training method consisted of sets of around 3 min of running adding up to 22-25 mins in total per training. In the first 4 weeks the subject completed on average 4.5 training sessions/week and in the last 2 weeks he completed 12 training sessions/week. Blood tests have been done at the beginning of the study, after 4 weeks of study and after 6 weeks of study. ***Results***: After the first 4 weeks blood samples were taken and the results showed an increase in hematological values including hemoglobin, +0.3 g/dL, hematocrit, +2.5%. At the end of the 6 weeks, the blood samples showed a slight decrease in some hematological values compared to the ones at 4 weeks. Also, the results suggested modifications regarding the structure of the red cells. ***Discussion****:* The hematological modifications attained through this method can be compared with the results of other known methods such as blood transfusion or high-altitude training. ***Conclusion***: This method caused improvements in the hematological values and of the VO_2 MAX.

Keywords: hemoglobin; local hypoxia; hematocrit; aerobic training

[1] Faculty of Physical Education and Sport, Babeş-Bolyai University, Cluj-Napoca, Romania
* Corresponding author: alexis.paul0773939@gmail.com

INTRODUCTION

Aerobic capacity is a fundamental component for a wide range of sports and it is commonly measured through VO_2 max (maximum oxygen consumption rate under conditions of maximal aerobic metabolism), expressed in milliliters per kilogram per minute (ml/kg/min).

The primary physiological systems that determine VO_2 max are the cardiovascular and respiratory systems. During maximal exertion, cardiac output increases to approximately 90% of an individual's maximum capacity, while pulmonary ventilation reaches around 65% of its maximum potential. These figures suggest that the cardiovascular system is the primary limiting factor for VO_2 max, rather than the respiratory system (Guyton & Hall, 2006).

The cardiovascular system, through the functional development of the heart, directly affects the volume of blood ejected with each contraction. The vascular system regulates blood flow to tissues based on their metabolic needs through vasoconstriction or vasodilation.

Another crucial factor influencing VO_2 max is the blood itself, specifically the number of red blood cells and, by extension, the concentration of hemoglobin. A higher concentration of hemoglobin enhances the diffusion of oxygen from the alveoli into the capillaries and increases the amount of oxygen that can be transported simultaneously to active tissues. Therefore, an increased oxygen transport capacity of the blood correlates with an improved aerobic capacity (Jelkmann, 2003). Under physiological conditions, hemoglobin levels are regulated by erythropoietin (EPO), a hormone secreted in response to systemic or localized hypoxia.

Most training techniques aim to enhance VO_2 max by improving cardiac performance and thereby increasing cardiac output. However, relatively few interventions focus on increasing VO_2 max through elevating hemoglobin concentrations. One might assume this is due to a negligible performance advantage in competition, yet several observations contradict this assumption: (1)The widespread use of high-altitude training, which leads to increased hemoglobin concentrations; (2) The inclusion of substances that raise hemoglobin levels—such as chemically induced hypoxia agents or erythropoietin—on anti-doping lists; (3)The categorization of any physical method that increases red blood cell count, such as blood transfusions, as prohibited in competition settings (World Anti-Doping Code, 2025). The parameters influencing aerobic capacity are illustrated in Figure 1.

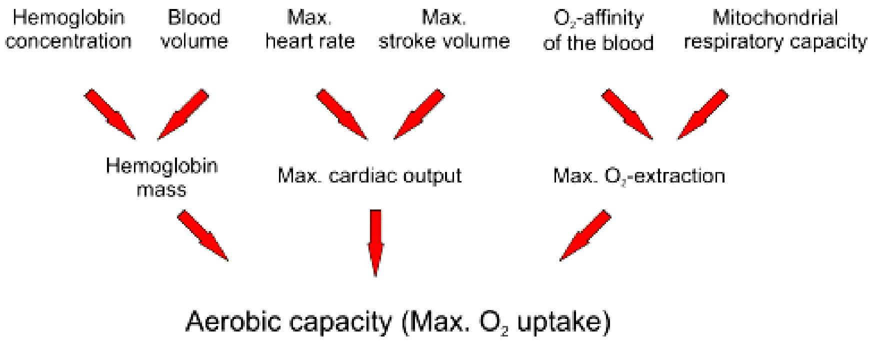

Fig. 1. Determinants of aerobic capacity
(Jelkmann & Lundby, 2011)

Taking these aspects into account, the training methodology underpinning this study is based on increasing red blood cell production by inducing peripheral hypoxia through external physical means aimed at drastically reducing oxygen delivery to high-demand tissues - specifically, skeletal muscle. This training method is known as Blood Flow Restriction (BFR). Initially employed during resistance training to promote increases in muscle mass and strength (Cognetti et al., 2022), BFR has subsequently been applied to aerobic training, showing potential for increasing VO_2 max (Held et al., 2020).

However, there is a limited number of studies addressing this topic, and the concentration of hemoglobin before and after the implementation of such training programs is not typically included among the measured parameters.

Tissue Hypoxia or ischemia arises from several causes, including obstruction of blood vessels, resulting in diminished blood flow to tissues (Guyton & Hall, 2006). To diffuse in the tissues from the blood, oxygen needs constant partial pressure (PO_2) difference between the two. This is achieved through a constant blood flow to the tissue. If the blood vessel is facing an obstruction, the result might be a lowered PO_2 distally of that point, thus occurring a substantial decrease in oxygen diffusion to the tissue (Guyton & Hall, 2006).

A protein complex of critical importance in hypoxic states is Hypoxia-Inducible Factor 1 (HIF-1). This factor becomes active exclusively under hypoxic conditions; under normal conditions, it is inhibited by other proteins, which themselves become inactive in the absence of adequate oxygen. HIF-1 functions as a transcription factor for multiple genes involved in erythropoiesis and angiogenesis, and regulates intracellular homeostasis (Guyton & Hall, 2006).

HIF-1 promotes angiogenesis as an adaptive response to hypoxia. By expanding the vascular network within the affected tissue, oxygenation is improved. This process is mediated by HIF-1 through the transcriptional regulation of another key factor: Vascular Endothelial Growth Factor (VEGF) (Guyton & Hall, 2006). HIF-1 also plays a significant role in inflammation. This factor is essential for the metabolism of myeloid cells. Elevated HIF-1 expression in vivo has been associated with increased inflammation, whereas its suppression impairs the ability of myeloid cells to proliferate and migrate. (Ziello et al., 2007).

Purpose of the Study

The aim of this research is to investigate the effect of muscular blood flow restriction on serum hemoglobin concentration in a professional athlete.

Research Hypothesis

The working hypothesis is that regular blood flow restriction during physical exercise, applied over a medium-term period (1–2 months), will lead to an increase in serum hemoglobin concentration and, consequently, an improvement in aerobic capacity.

Objectives

The objectives of this study are to create and implement a training program based on blood flow restriction at muscular level to augment muscle performance in athletes.

MATERIALS AND METHODS

The Subject

The subject in this study case was a young male having the age of 19 years. The subject is a very active person, from a physical standpoint, and a professional football player, having great fitness. He has an athletic physical construction, a height of 175 cm and weight of 64 kg, and an ectomorph somatotype. The subject gave informed consent to participate in the study.

Materials

The primary material utilized in this case study was the flossing band. This band is composed of an elastic material, and for the purposes of the experiment, two bands were required, one for each of the subject's lower limbs. The bands used in the study have a resistance capacity of 100 kg, are made of latex, measure 207 cm in length, 1.5 mm in thickness, 5 cm in width, weigh 100 g, and possess a maximum elasticity of 150%.

To measure blood oxygen saturation and heart rate, a Contec pulse oximeter was used.

The subject also utilized a modern sports watch, the Garmin Vivoactive 5, which was used to monitor distance, determine running pace, and assess VO_2 max levels.

Methods

The intervention method used in the study was a combination of several approaches: flossing, blood flow restriction (BFR) exercises, and physical training. This is a therapeutic technique that involves wrapping elastic bands around joints or muscles. The purpose of this method is to improve joint mobility, enhance performance, accelerate recovery, and reduce pain caused by certain injuries. The theory behind this technique is that applying the flossing band creates pressure that stimulates the mechanoreceptors located in the muscular fascia. This is followed by reperfusion of the compressed area, leading to increased blood flow.

The recommended method of using the band is to wrap it in such a way that each subsequent layer covers 50% of the previous one. For maximum effect, the joint or muscle should be positioned at the end of its range of motion. It is advised to keep the flossing band wrapped around the tissue for a period of 1 to 3 minutes. Exceeding this duration may result in the formation of hematomas (Konrad et al., 2021).

Blood Flow Restriction (BFR) involves the use of a tourniquet to reduce arterial blood flow and, at the same time, restrict venous return in a specific area. During BFR, strength or aerobic exercises are performed. This method was initially used to increase muscle strength and mass, but its applications have expanded to include recovery stimulation and the prevention of muscle atrophy following injuries or surgeries. Moreover, BFR is favored because it provides a strong stimulus to the muscles without placing additional stress on the joints, unlike traditional resistance exercises. Although limited data is available on this topic, BFR during aerobic exercise has shown to improve cardiovascular function (Held et al., 2020).

The aim of using BFR during aerobic exercise is to induce local hypoxia in the targeted limb. Based on literature research, it is reasonable to assume that local ischemia can occur even during low-intensity exercise (Egun et al., 2002). Applying elastic bands above the femoral arteries, in the inguinal region, results in several physiological and hemodynamic changes that lead to hypoxia in the lower limbs, as illustrated in Figure 2.

Fig 2. Elastic bands wrapped around the inguinal area

During the first two weeks, a training session consisted of six running intervals, each lasting 3 minutes, performed at a pace of 5–6 min/km, with the elastic bands wrapped around the legs. Each running interval was followed by a 3-minute rest period, during the last 20 seconds of which the bands were applied.

In the initial days of training, some rest periods were extended by 30–60 seconds, and some running intervals were shortened by 30 seconds due to the subject reaching their upper threshold of discomfort and pain tolerance. However, after a few days of training, the body adapted to the stimulus, and the subject was able to follow the prescribed protocol.

After two weeks, the running intervals were extended by 30 seconds each, resulting in six intervals of 3 minutes and 30 seconds. Over the four weeks, the average training frequency was 4.5 sessions per week, with a minimum of 2 and a maximum of 6 sessions per week. A precise average of 4.5 sessions could not be maintained due to objective factors, such as scheduling conflicts with the subject's football activities.

Training sessions were conducted on a running track, treadmill, or on the street. The bands were applied to the upper part of the lower limbs, in the inguinal region, and were wrapped five times around the limb, stretched to 125% of their original length, with the layers placed approximately one over the other. This area was chosen because the major blood vessels of the lower limb, the femoral artery and vein, are relatively superficial there, and applying pressure to them can significantly restrict circulation.

During weeks 4 to 6, the frequency, duration, and intensity of the training sessions increased. In each of these two weeks, the subject completed 11 training sessions, with two sessions per day on four days of the week (morning and evening), and one session per day on the remaining three days. The total running time with the bands applied increased to approximately 25 minutes per session. The training intensity was also increased by reducing the rest period between intervals to 1 minute and 30 seconds. Running intervals ranged from 3 to 4.5 minutes, with occasional sessions reduced to 2 minutes, depending on the subject's tolerance to physical discomfort. The running pace slowed to 6–7 minutes per kilometer.

RESULTS

Interpretation of the blood test results

The results of the blood tests are presented in Table 2. After the first four weeks of the study, positive increases were recorded in several hematological parameters: red blood cell (RBC) count increased by +0.1 x10^3/μL, hemoglobin (Hb) by +0.3 g/dL, hematocrit (Ht) by +2.5%, and mean corpuscular volume (MCV) by +3.3 fL. Mean corpuscular hemoglobin (MCH) remained unchanged, while the mean corpuscular hemoglobin concentration (MCHC) decreased by -1.3 g/dL.

Some of these increases, such as in MCV and Ht, may be attributed to improved hydration status or fluid retention. However, if these hematological changes were solely due to such factors, one would expect reductions in RBC count and Hb concentration, as these are density-based metrics. At this stage of the study, the erythrocytes increased in size, and their number also rose, yet the amount of Hb per erythrocyte remained constant.

During this four-week period, the subject completed 18 training sessions, totaling 378 minutes of running with compression bands applied, which corresponds to an average training volume of 94.5 minutes per week.

In the final two weeks of the study, the subject completed 24 training sessions totaling 600 minutes, averaging 300 minutes of training per week. Compared to the hematological values recorded at week 4, the results at week 6 show decreases in RBC count (-0.17 x10^3/μL), Hb (-0.4 g/dL), Ht (-2.2%), and MCV (-1.2 fL). Conversely, the MCH value increased by +0.3 pg/cell. Thus, following this two-week period, there was a reduction in both the number and volume of erythrocytes, accompanied by an increase in hemoglobin content per cell, as indicated in Table 1.

Table 1. Blood Test Results Before and After the Study

Test Name	Before Study	After 4 Weeks	After 6 Weeks	Normal Range
White Blood Cell Count ($x10^3/\mu L$)	6.93	5.54	6.06	4–10
Red Blood Cell Count ($x10^6/\mu L$)	4.91	5.01	4.84	4.3–5.7
Hemoglobin (g/dL)	14.5	14.8	14.4	13.2–17.3
Hematocrit (%)	41.6	44.1	41.9	39–49
Mean Corpuscular Volume (fL)	84.7	88.0	86.6	80–99
Mean Corpuscular Hemoglobin (pg)	29.5	29.5	29.8	27–34
MCH Concentration (g/dL)	34.9	33.6	34.4	32–37
Red Cell Distribution Width (%)	12.6	12.8	12.8	11.6–14.8

After the first four weeks of the study, the changes observed in hematological indices represent a noticeable increase. For reference, following a transfusion of one unit of blood, an individual typically registers an approximate increase of 3% in hematocrit level (Mark E. E., et al., 2006). In comparison, after four weeks of intervention, the subject in our study demonstrated a 2.5% increase in hematocrit.

This raises the question why the positive trend observed in the first four weeks did not persist in the final two weeks, especially considering that the total exposure to hypoxia during this latter period was approximately 60% greater, yet occurred within half the timeframe.

First and foremost, it is necessary to consider additional factors that may influence hematological values. One such factor is the ambient air temperature, which cannot be controlled. Fluctuations in external temperature are correlated with changes in hematocrit and hemoglobin levels—specifically, their decrease with rising temperatures and increase with cooling. The general trend observed is a reduction in hematological indices during the winter-to-summer transition period (Hoekstra et al., 2007).

Figure 3 states the weekly mean of the daily maximum temperature (the first week corresponding with the 10-16 march period, 2025. The values have been recorded in Cluj-Napoca).

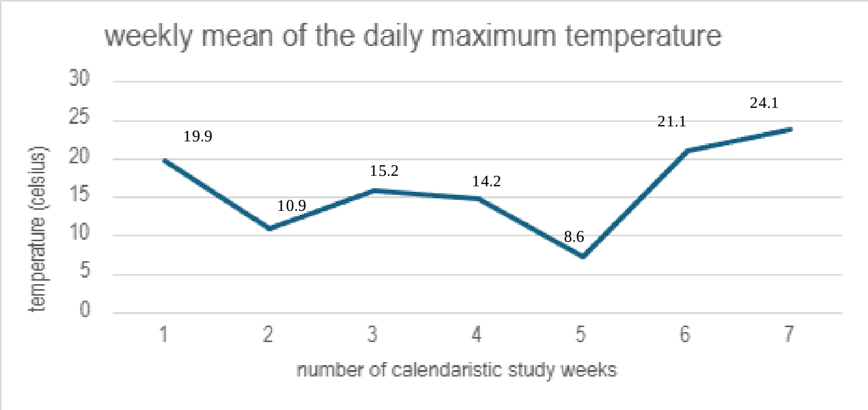

Fig. 3. Weekly Average Daily Maximum Temperatures

The first set of blood analyses corresponds to the first week in the graph, while the set taken after four weeks of study corresponds to the fifth week. During the first five calendar weeks represented, a certain consistency in the maximum daily temperatures can be observed, with a slight downward trend. Although the general seasonal expectation for this time of year (spring) is for hematological values to show a downward trend, the subject demonstrated contrary results - namely, positive changes in hematological parameters.

The third set of blood tests, conducted after six weeks of study, corresponds to the seventh week in the graph. Between weeks five and seven, there was a significant increase in maximum temperatures, which resulted in a decrease in most hematological indicators compared to week five, except for one important indicator - MCH - which increased.

Throughout the seven calendar weeks of the study, a clear upward trend in ambient temperature was recorded. However, hematological values remained relatively stable: some parameters showed negligible changes, while others, such as MCV (Mean Corpuscular Volume) and MCH, showed increases—indicating a change in the composition and size of the red blood cells. Some studies suggest that the decrease in hematocrit and hemoglobin levels due to increased external temperature may, in fact, be caused by a reduction in red blood cell volume (Boneh et al., 1993). However, during our study, despite the rise in outdoor temperatures, the volume of red blood cells did not decrease; in fact, it increased.

For reference, Table 2 shows the subject's hematological blood analysis results from January 9, a period when the outdoor temperature was much lower, around 0°C.

Table 2. Blood test results in low-temperature conditions

White Blood Cells (k/µL)	Red Blood Cells (mil/µL)	Hemoglobin (g/dL)	Hematocrit (%)	Mean Corpuscular Volume (fL)	Mean Corpuscular Hemoglobin (pg/cell)	Mean Corpuscular Hemoglobin Concentration (g/dL)	Red Cell Distribution Width (%)
6.29	5.38	15.8	45.3	84.2	29.4	34.9	12.7

Although the subject had not engaged in any intense physical training prior to these tests, the hematocrit, hemoglobin, and red blood cell count were higher than those measured at the end of the study. However, structural and compositional characteristics of the red blood cells showed negligible differences from the baseline values. Through the implementation of this training protocol, an increase was achieved in both red blood cell volume and hemoglobin content per cell.

Inflammation as a Possible Cause for the Plateau in Hematological Improvements (Weeks 4–6)

One potential explanation for the stagnation in hematological improvements between weeks 4 and 6 may be inflammation. It is well established that chronic inflammation can hinder erythropoiesis (Weiss et al., 2018). Inflammatory cytokines reduce iron absorption in the small intestine, thereby resulting in insufficient iron levels for a healthy erythropoietic process.

Training with elastic bands that induce hypoxia can also generate inflammation, similar to the effects seen in tourniquet-based interventions (Leurcharusmee et al., 2018). Inflammation levels in the body may be indirectly measured by white blood cell count. Furthermore, elevated expression of Hypoxia-Inducible Factor-1 (HIF-1) - a response to hypoxic conditions encountered during the training sessions in this study - is associated with increased inflammation throughout the body.

During weeks 4 to 6, the subject was exposed to a significantly longer duration of muscular hypoxia compared to the first four weeks of the study. This extended hypoxic exposure is likely to have caused a greater inflammatory response, which in turn inhibited erythropoiesis and halted the previously observed upward trend in hematological indices.

According to the blood test results, the following changes were observed:

- A decrease in white blood cells during the first four weeks (−1.39 k/µL)
- A subsequent increase by the end of the study (+0.52 k/µL)

These variations in leukocyte count - used here as an inflammation marker—appear to be negatively correlated with the hematological indices.

Interpretation of Physical Performance Index Results

The primary indicator used to measure aerobic capacity is VO_2 Max. Table 3 presents the VO_2 Max values recorded at different stages throughout the study.

It is important for the hematological changes discussed in the previous section to have practical applicability and to be reflected in the subject's aerobic capacity. After the first four weeks of the study, a 14% increase in VO_2 Max was observed, followed by an additional 1.5% increase over the subsequent two weeks. In total, VO_2 Max increased by 16% throughout the study.

Table 3. VO_2 Max values and measurement intervals

Timepoint	VO_2 Max (ml O_2/min/kg bodyweight)
Before the study	56
After 4 weeks	64
After 6 weeks	65

The significant increase observed during the initial four weeks can be attributed to the favorable hematological adaptations recorded during that period. As discussed earlier, in the final two weeks of the study, there was a regression in certain hematological parameters. This regression, combined with the increase in ambient temperature and systemic inflammation, led to a cessation in the rapid progression of VO_2 Max. Despite this, VO_2 Max not only remained stable but increased slightly by 1.5%.

Other contributing factors to the increase in VO_2 Max may include angiogenesis. Although this study did not directly assess changes in muscular vascularization, existing literature supports the occurrence of this process (Guyton & Hall, 2006).

Results concerning changes in heart rate and respiratory rate

During training with elastic bands, the subject's heart rate reached 150-155 bpm, compared to 145 bpm during identical runs without bands. However, respiratory effort increased significantly with the bands: post-run breathing was heavy and speaking was difficult, whereas after unbanded runs, breathing remained normal, and conversation was possible.

This disparity-modest heart rate increase but pronounced respiratory response-can be explained by differences in the regulation of these systems. Respiratory rate is primarily driven by muscular oxygen demand and CO_2 levels, rather than directly by heart rate. The elastic bands induced localized hypoxia in the lower limbs, increasing metabolic demand and triggering heightened respiration.

Heart rate and cardiac output are regulated by neural signals and humoral mechanisms. While neural input remained active during banded exercise, venous return was restricted due to compression of femoral vessels. This limited the humoral response, reducing stroke volume and overall cardiac output. According to the equation: Cardiac Output = Arterial Pressure / Total Peripheral Resistance. The increased peripheral resistance from the bands further impeded cardiac output. Thus, despite active neural input, full cardiovascular adaptation was compromised due to impaired humoral function.

Subjective changes reported by the participant

Throughout the study, the subject described sensations commonly referred to as "heavy legs" or "loaded legs," indicating a general state of muscular hypertonus. The subject, a performance-level football player, regularly experienced muscular over-contraction in the lower limbs during and after matches prior to the study. Remarkably, after completing the six-week training program, the subject no longer reported any muscle discomfort during or after matches.

DISCUSSION

As stated before, the results regarding the blood analysis obtained after the first 4 weeks of the study can be easily compared with the results of other known methods that improve hematological values. The increment in hemoglobin concentration was of 0.3g/dl, from 14.5g/dl to 14.8g/dl, and the hematocrit increased by 2.5%, from 41.6% to 44.1%.

By comparison, following blood transfusions with a 450 mL transfusion unit, hemoglobin concentration increases by approximately 1 g/dL (Naidech, A.M., et al., 2008), while hematocrit levels rise by approximately 3% (Mark E. E., et al., 2006).

According to Heinicke et al (2005), a three-week altitude training at 2050 meters in elite biathlon athletes led to an increase in hemoglobin concentration in men from 14.0 ± 0.2 to 15.3 ± 1.0 g/kg, while red blood cell volume (RBCV) increased from 38.9 ± 1.5 to 43.5 ± 3.9 ml/kg. In our study, the RBCV increased from 29.8ml /kg to 31.6ml/kg.

CONCLUSION

This six-week case study observed improvements in hematological parameters and VO_2 max, reflecting enhanced aerobic capacity. During the first four weeks, the subject completed 378 minutes of training with elastic bands applied to the inguinal region, averaging 4.5 sessions per week. In the final two weeks, training volume increased to 600 minutes, with an average of 12 sessions per week.

After four weeks, hematocrit rose by 2.5%, hemoglobin by 0.3 g/dL, and mean corpuscular volume by 3.3 fL. By week six, these indices declined slightly, though mean corpuscular hemoglobin increased by 0.3 pg/cell. This reversal may be due to a sudden rise in temperature and greater inflammation from localized hypoxia. Despite the decline, red blood cell morphology improved, with increases in cell volume and hemoglobin content.

REFERENCES

Cognetti, D.J., Sheean, A.J., & Owens, J.G. (2022). Blood Flow Restriction Therapy and Its Use for Rehabilitation and Return to Sport: Physiology, Application, and Guidelines for Implementation. *Arthrosc Sports Med Rehabil., 28*, 71-76. doi: 10.1016/j.asmr.2021.09.025

Egun, A., Farooq, V., Torella, F., Cowley, R., Thorniley, M.S., & McCollum, C.N. (2002) The severity of muscle ischemia during intermittent claudication. *J Vasc Surg., 36*, 89- 93. doi: 10.1067/mva.2002.123678

Elzik, M.E., Dirschl, D.R., & Dahners, L.E. (2006). Correlation of transfusion volume to change in hematocrit. *Am J Hematol., 81*, 145-1466. doi: 10.1002/ajh.20517

Guyton, A. C. & Hall, J. E. (2006). *Textbook Of Medical Physiology*. Philadelphia: Elsevier Saunders

Heinicke, K., Heinicke, I., Schmidt, W., & Wolfarth, B. (2005). A three-week traditional altitude training increases hemoglobin mass and red cell volume in elite biathlon athletes. *Int J Sports Med. 26*, 350-355. doi: 10.1055/s-2004-821052

Held, S., Behringer, M., & Donath, L. (2020). Low intensity rowing with blood flow restriction over 5 weeks increases V̇ O2max in elite rowers: A randomized controlled trial. *J Sci Med Sport, 23*:304-308. doi: 10.1016/j.jsams.2019.10.002

Hoekstra, T., Veldhuizen, I., van Noord, P.A., & de Kort, W.L. (2007). Seasonal influences on hemoglobin levels and deferral rates in whole-blood and plasma donors. *Transfusion, 47*, 895-900. doi: 10.1111/j.1537-2995.2007.01207.x

Jelkmann, W. (2003). Erythropoietin. *J Endocrinol Invest., 26*, 832-837. doi: 10.1007/BF03345232

Jelkmann, W., & Lundby, C. (2011). Blood doping and its detection. *Blood, 118*, 2395-2404. doi: 10.1182/blood-2011-02-303271

Kristal-Boneh, E., Froom, P., Harari, G., Shapiro, Y., & Green, M.S. (1993). Seasonal changes in red blood cell parameters. *Br J Haematol., 85*, 603-607. doi: 10.1111/j.1365-2141.1993.tb03354.x

Konrad, A., Močnik, R., & Nakamura, M. (2021). Effects of Tissue Flossing on the Healthy and Impaired Musculoskeletal System: A Scoping Review. *Front Physiol. 12*:666129. doi: 10.3389/fphys.2021.666129

Leurcharusmee, P., Sawaddiruk, P., Punjasawadwong, Y., Chattipakorn, N., & Chattipakorn, S.C. (2018). The Possible Pathophysiological Outcomes and Mechanisms of Tourniquet-Induced Ischemia-Reperfusion Injury during Total Knee Arthroplasty. *Oxid Med Cell Longev. Nov 5*;2018:8087598. doi: 10.1155/2018/8087598.

Lista Interzisă (2025). Retrived from https://anad.gov.ro/web/images/lista_medical/LISTA_INTERZISA_2025_-_WEB.pdf

Naidech, A.M., Kahn, M.J., Soong, W., Green, D., & Batjer, H.H., & Bleck, T.P. (2008). Packed red blood cell transfusion causes greater hemoglobin rise at a lower starting hemoglobin in patients with subarachnoid hemorrhage. *Neurocrit Care, 9:*198-203. doi: 10.1007/s12028-008-9113-8

Weiss, G., Ganz, T., & Goodnough, L.T. (2019). Anemia of inflammation. *Blood, 133*, 40-50. doi: 10.1182/blood-2018-06-856500

Ziello, J.E., Jovin, I.S., & Huang, Y. (2007). Hypoxia-Inducible Factor (HIF)-1 regulatory pathway and its potential for therapeutic intervention in malignancy and ischemia. *Yale J Biol Med., 80*, 51-60. PMID: 18160990