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Posted Date: 3 September 2024

doi: 10.20944/preprints202409.0049.v1

Keywords: Oxygen deprivation training; Biochemical Variables

 doi:10.20944/preprints202409.0049.v1

Article

Effect of High Intensity Composing Training Using Hypoxic Mask on Some Biochemical Variables of Fencing Players#

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Abstract: The research aimed to identify the effect of high-intensity compound exercises for physical performance skills using the means of hypoxia training in some biochemical variables in the blood of fencing players. The researcher used the experimental approach and determined the community, namely the players of Maysan governorate teams in fencing and for the three weapons (fencing sword, shish, Arab sword) the category of applicants over the age of (20) years, and by (4) players for each weapon, which reached the number of society (12) players, and some procedures were adopted to achieve the objectives of the study. The study came out the results of the study recorded a significant impact on the high level of measurement of blood biochemical variables (EPOs, FERSs, Hb, Hct) and improved by high-intensity compound exercises using the training hypoxic mask among members of the research community.

Keywords: oxygen deprivation training; biochemical variables

1. Introduction

The remarkable progress of the physiology of sports training and its interpretations in physiological responses and adaptations has become the cornerstone of the development of performance, as studies have recently relied on what science has developed in sports technology, to provide innovative scientific means with better effectiveness that affected various sports activities, and employ them accurately during training doses to create the desired impact in athletes and improve their level of achievement.

In view of the importance of diversity in the means and methods of modern training science and the combination of them, and accompanied by effective training of influential quality consistent with the nature of the muscular work carried out in achieving the desired goals for which it was developed, to improve the physical efficiency of the working and corresponding muscle groups to perform the duty of the required motor action, in light of the economy of time and effort of the training process to prepare and prepare athletes for sports competitions, so it has become necessary for us to delve into the fields of modernity by modern scientific means that facilitate the application of specialized methods, including a training method Lack of oxygen using the training mask method in controlling the amount of inhaled oxygen, and this method puts cells and muscle tissue working with exceptional effort under completely different conditions represented in the lack of availability of oxygen received by them, which makes them in front of challenges and pressures as a result of the implementation of the load of exercises formed leaving a degree of oxygen deficit shedding on them, to cause changes in the overall functions of the individual organic, including blood biochemistry, which plays a vital role and Baz to control and address this deficit during the exercise of physical efforts under this method Training.

From the foregoing, the importance of our research in shedding light on the body's biological responses has emerged, due to the formation of high-intensity compound training loads for physical performance skills using the oxygen mask method, which we find one of the most auxiliary and

 doi:10.20944/preprints202409.0049.v1

appropriate training methods for training fencing players, and its impact may be reflected in the improvement of the level of biochemical variables in the blood, as it is a worthwhile phenomenon and the extent to which it is used to employ its results in raising the level of achievement.

Previous studies, most of which focused on the use of the hypoxic training method and its functional returns, which limited the results of research on the circulatory and respiratory systems, so there is the need for more information that has not been addressed as blood biochemistry, and what happens to it from the responses that accompany the adaptation process in the training of physical competence skills for fencing players exclusively, which put us in front of a question regarding the phenomenon to provide the most accurate data that is not available and that can be used to serve in its outcome to raise the level of achievement, so we decided Delve into this research phenomenon by answering the following question:

- What is the level of changes that may occur in the biochemistry of the blood due to the application of high-intensity compound training loads for physical performance skills using the training hypoxic mask method.

Identifying the effect of high-intensity compound exercises for physical performance skills using the means of training hypoxia mask in some biochemical variables in the blood of fencing players.

High-intensity compound exercises for physical performance using the training hypoxia mask method affect the adaptation of some biochemical variables in the blood among members of the research community.

2-. Research Methodology and Field Procedures

2.1. Research Methodology

The researcher adopted the experimental method for its suitability and the nature of the research phenomenon to be studied.

2.2. Research Community

The researcher identified the research community, who are the players of Maysan governorate teams in fencing and for the three weapons (fencing sword, shish weapon, Arab sword weapon), the category of applicants over the age of (20 years) and registered with the lists of the sub-federation of fencing for the season (2023-2024), and by (4) players for each weapon, out of which their number reached (12) players and their percentage was (100%), where clinical and laboratory tests were conducted by a specialized medical staff at Al-Zahrawi General Hospital to ensure their safety and freedom from diseases that may Affecting the results of the research, homogeneity has been done in (height, body mass, chronological age, training age), as well as the equivalence of the study variables, which include (EPO & FERs & Hb & HCT), and it was found that there is clear homogeneity and equivalence in those variables.

2.3. Field Research Procedures

2.3.1. Procedures for Measuring Biochemical Variables in Blood

In order to measure the biological variables of the study (EPO, FERs, Hb, HCT), (5 ml) of venous blood was drawn for members of the research community at rest, by specialized medical staff in the Middle East laboratory using medical syringes volume (5 ml), (4 ml) of blood was placed in a special tube prepared for the purpose of preservation after shaking it to mix with (Trisodium citrate) to prevent coagulation, and then the blood was separated by a centrifuge to obtain plasma, so that the biochemical indicators of the blood can be analyzed through special kits prepared to analyze the level of (EPO & FERs), as the process of analyzing the variables researched by the technology of the device (ELISA) and programming it after the kit for each variable is placed according to the instructions of its manufacturer, while Tube type (EDTA) has been placed in it (1 ml) of blood prepared to analyze the level of (Hb & HCT) by CBC Sysmex after the blood is placed in the place designated for analysis.

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2.3.2. Main Experience

After obtaining all the original approvals from the Fencing Sub-Federation and the members of the research community learned about the importance of the study and the extent of its benefit, they expressed their consent to cooperate with the researcher and implement his research procedures, and after completing all preliminary procedures, starting with the results of the clinical examination and laboratory analysis, which resulted in the safety of the community and their full health, the blood draw was performed at rest time in the tribal measurements of the biochemical indicators in the blood On Monday, 28/11/2022 at ten o'clock in the morning, we proceeded to implement His experience, as the members of the research community were exposed to doses of loads of high-intensity physical skill compound exercises using the proposed training hypoxia mask method prepared by the researcher within the general program in the special preparation stage, as the duration of the application of the exercises reached (8) weeks, with three training units per week for the days (Saturday, Monday, Wednesday) with a total of (24) training units from 17/4/2022 to 17/4/2022, and the high-intensity compound exercises aimed to adapt the biochemical variables in the blood, as the proposed physical skill exercises were suitable In its content, the rules of the exercises of the hypoxic method (training mask) and the nature of the training stage This is in accordance with the principle of specificity of that stage, and the method of interval training of high intensity and gradation was used by increasing the load and the use of tools and assistive devices that correspond to the players and taking into account the differences between them and the age stage of the members of the experimental research community, and after the implementation of the prescribed time period of applying high-intensity training, the aforementioned blood draw was performed in the dimensional measurements of biochemical variables in the blood and under the same conditions on Sunday, corresponding to 30/1/2022 at ten o'clock in the morning.

2-4 Statistical Treatments: The researchers used the statistical bag (SPSS) version (23).

3-. Results

Table 1. shows the arithmetic means, standard deviations, calculated (T) value, significance level, and significance of differences in measuring variables (EPO & FERS & & Hb & HCT) (pre-post) for the experimental group.

Statistical Treatments	Unit of measurement	Going to	±	Calculated value (T)	Sig	Significant differences
EPO						
southern	mg/dl	5.94	1.08	21.35	0.000	Moral
Go away		12.63	1.12			
FERs						
southern	ng/ml	52.19	1.86	63.83	0.000	Moral
Go away		89.16	1.18			
Hb						
southern	ng/ml	13.71	0.87	8.14	0.000	Moral
Go away		16.83	1.04			
HCT						
southern	ng/ml	42.06	0.95	13.61	0.000	Moral
Go away		46.53	0.99			

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4. Discussion

4.1. Discussion Hormone Erythropoietin (EPO)

It is clearly evident the high level of secretion of the hormone erythropoietin from the kidneys and liver and its concentration in the blood, as a result of the implementation of doses of carrying high-intensity physical exercises using the training hypoxia mask in doses, and this is what was shown by statistical treatments, which gave an impression of the role of the hormone and the phenomenon to be studied, and the researcher explains it to the increasing imperative need to provide oxygen to produce the energy necessary for the performance performed, which led to an increase in the secretions of the kidneys and liver in concentrations of the hormone erythropoietin in the blood plasma, to target the marrow The bone and stimulating it to raise the rates of production of red cells (hematocrit) as a result of gene expression of the stores of those organs, and this explanation was consistent with all previous studies "during the lack of oxygen in the cells, gene expression is in stimulating the secretion of the hormone EPO) from the kidneys and liver, which are the organs responsible for secreting the hormone in the blood plasma." (Lundby, C 2009) and "Exposure to hypoxia leads to increased secretion of EPO) by the kidneys and liver to target the bone marrow to increase red blood cell production." (2015 Erslev A.) & (Jelkmann, W, 2011) & (Kasperska, A, 2020)

The researcher also explains that the indications of the increased secretion of the hormone erythropoietin in the blood plasma, to the nature of the formation of loads of compound exercises of high physical intensity skill carried out using the training mask with a lack of oxygen training, which would increase the burden on repetitive muscle contractions, as it exposes them to a deficit in the amount of oxygen contained to muscle cells, which generates oxygen debt, and this cycle leads to different vital reactions Stimulate performance and adapt work under exceptional circumstances, represented in the efficiency of metabolism and economy with an expense Energy within muscle cells, and this increases their effectiveness in producing anaerobic and aerobic energy and the stores of the number of mitochondria increase, thus increasing the stores of muscle glycogen as well as the number of red blood cells, and this explanation is logical and consistent with all previous studies that confirmed "The implementation of hypoxic training during performance exposes muscle cells to oxygen deficiencies, which leads to vital reactions that in turn help in their adaptation and ability to work under conditions of oxygen debt, and improve the level of technical and digital performance of athletes." (Dale R., 2015) & (Walter F., 2016) & (M. VOGT, 2001) and also "the body's need for the secretion of the hormone EPO) increases with increased exposure to hypoxic training, which allows for the improvement of blood variables, including saturation, through the increase in the number of red cells." (Czuba, M., 2014) & (Mackenzie, R., 2008) & (Carsten Lundby, 2011)

The researcher also explains that the method of applying complex exercises with physical performance skills with oxygen text occurs responses physiological adaptations in the body Poor training without hypoxia and this interpretation is consistent and consistent with all previous studies that confirmed that "hypoxia training occurs responses and adaptations to the characteristics of the physiological state in the body, has become fold training without the method of lack of oxygen." (Czuba, M., 2011) & (Katayama, K., 2004) & (Vogt, M., 2001) & (Zoll, J., 2006) & (Geiser, J., 2001) & (Gore, C. 2001)

4.2. Discussion Protein Ferritin (FERs) and Hemoglobin (Hb):

The researcher believes that the volume of muscle work carried out and the accompanying method of lack of oxygen, due to the volume of repeated exercises that posed continuous challenges to the exceptional burdens on the members of the various members of the players throughout the period of application of the exercises, which were characterized by high stress in the physical performance of the complex skill, and this act requires the acquisition of large amounts of oxygen to compensate for the deficiency in muscle tissue, which contributed to the intensification of the work of iron stores associated with oxygen carrier hemoglobin, and this resulted from the impact of the increased rate of hormone secretion Ferritin is proportional to the amount of hypoxia due to the

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muscle contractions performed, and this explanation was consistent and consistent with what all previous studies indicated "iron demand levels rise to meet the requirements for the production of red blood cells in the bone marrow, and therefore iron stores increase due to the high level of FERs)". (Anderson, G.J., 2007) & (Govus AD, 2015) & (DellaValle, D.M., 2014) & (Levine BD, 2005) and "The increase caused by hypoxia in erythrocyte formation increases the demand for iron and therefore increases its level in the blood stores of protein (FERs)." (Garvican LA, 2014) & (Garvican-Lewis LA, 2016) & (Bonovas S, 2016)

The researcher also believes that the adoption of a training philosophy represented in the method of applying compound exercises approved by lack of oxygen, which took into account the principle of gradation in training doses and loads, in addition to the adoption of the training mask to control the volume of oxygen inhalation, as it was consistent with the training philosophy as it contributed remarkably to the excitation of muscle fibers and their increasing need for the volume of oxygen associated with hemoglobin, so it is necessary to double the number of red cells that increase their need to call additional quantities of iron stores by manufacturing cells in the bone marrow, This is what provoked the stimulation of ferritin protein and raised its level in the blood and worked to fill the warehouses with iron, and this explanation is logical and came consistent and consistent with all previous studies that confirmed that "the high concentrations of ferritin in the blood is an indicator commensurate with the high volume of iron stores in the body." (Wachsmuth NB, 2013) & (Xiong S, 2003) & (Okazaki K, 2019) and also "Physical activity with high levels of ferritin protein is characterized by high levels in the blood and full stores with iron." (Zacharski LR, 2000) & (Pedlar CR, 2018) & (Sercan Öncen, 2018) and "determines the role of protein (FERs) in maintaining cell and tissue balance, in iron processing of bone marrow and erythrocyte synthesis during training in hypoxia". (JEFF M., 2016) & (Peeling P, 2014)

The researcher also believes that skeletal muscles are affected by physical effort skill in the shadow of lack of oxygen, and its effect is reflected in increasing the saturation of hemoglobin (Hb) oxygen in large proportions in the volume of blood, and this explanation came in line and consistent with what the results of previous studies indicated that "hypoxia is a factor that contributes to increasing the rate of excretion of iron from protein stores (FERs) and that the increase is commensurate with the level of low saturation of hemoglobin (Hb) with oxygen." (Gore, C. J., 2006) & (Ben A., 2013) and also "high-intensity hypoxic exercise temporarily lowers O2 saturation after which the saturation level rises with high hemoglobin in the blood." (Lee M. 2006) & (Wetter TJ, 2001) & (Dominelli PB, 2019) & (Dominelli PB, 2020)

4.3. Discussion Hematocrit (HCT)

It has been shown that there has been a significant steady increase in the percentage of measuring the number of red cells stacked and their size in the hematocrit blood after performing multi-objective physical and skill training loads, and the researcher explains it to the urgent need for the role of red cells stacked (HCT) for cells and muscle tissue, as the frequency of their functions increases during high-intensity physical exertion under hypoxia conditions, in order to enhance the stores of myoglobin muscle cells and tissue with oxygen necessary for energy requirements, which in turn exposes them to productivity in This explanation is consistent and consistent with the results of previous studies that "hypoxia training is more efficient and has positive effects on the hormone (EPO) and the size of cells stacked with blood (HCT) and is considered one of the most important adaptations in the blood, in terms of the ability of hemoglobin to bind and deliver oxygen to cells and muscle tissue." (Brocherie F, 2015) & (Hun-young Park, 2016) & (J.M. Hendriksen, 2003) and "Enhanced erythrocyte activity (HCT) and increased rate of excretion of iron stores in the blood, when exposed to high-intensity physical exertion with hypoxia conditions in muscle cells and tissue". (Michalczyk, M., 2017) & (Rodriguez, F., 2000) and also "HCT concentration) rises after hypoxic training". (Schmidt W, 2008) & (Chacón Torrealba, 2020)

The researcher also confirms that the indications of increasing the levels of stacked red cells and their percentages in relation to the total blood volume (hematocrit (HCT) are due to the scientific method used in the formation of compound exercises using a training mask, to reduce the percentage

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of oxygen necessary for tissues and cells voluntarily from the normal level, and as a result of the great effort in muscle fibers that consume large amounts of oxygen, which requires compensating them in larger quantities as a result of the shortage in their stores in order for the cell to carry out its functional duties, and not to be exposed to it. To stresses, responses appear to stimulate the function of the organs of the kidneys and the liver, so they release the hormone (EPO) in the blood, which targets the red bone marrow and stimulates it to raise the ceiling of the level of production of red cells and thus increases the number and size of cells stacked (hematocrit (HCT) in the blood, and this explanation was consistent and consistent with what was reported by previous research and studies: "Hypoxia resulting from low oxygen tension in the blood increases the production of the hormone (EPO), which activates receptors in the bone marrow to differentiate red blood cells, stimulating the production of new cells to be released into the blood to enhance oxygen-carrying supply." (Breymann C, 2000) & (Lemaître F, 2009) & (Robach P, 2004) and also "hypoxic conditions cause an increase in the number and size of hematocrit HCT stacked cells) in the blood, with an increase associated and projected with the maximum consumption of oxygen in muscle cells after performing high-intensity physical loads". (Lemaître F, 2009) & (Semenza GL., 2000) and also "exercises under the influence of hypoxia method are effective in improving the transport capacity of oxygen in the blood, as it increases the production of red blood cells (HCT) by the hormone (EPO), and this adaptation continues after several weeks after exposure to persistent hypoxia". (Gore, C. J., 2013) & (De smet, 2017)

The researcher believes that the rate of measuring the number of stacked cells and their size (HCT) is not affected and remains at the level of their normal levels and does not increase, unless individuals exert high-intensity physical effort or are exposed to an exceptional case of lack of oxygen that may affect the internal environment of the cells, which is reflected in their dysfunction and thus raise the level of the number and size of cells stacked in the blood (HCT), after exercising physical loads with auxiliary training means in light of the lack of oxygen level in the body, it is likely that the process of increasing at a point in time of the level of stress of the load of high-intensity training, and here we believe that the interpretations and opinions that we discussed previously were consistent and consistent with all previous studies, which confirmed that "the effectiveness of hypoxia training affects the improvement of blood variables, and is the result of the type of exercises used, the size and intensity of exposure to hypoxia, its duration, and the means and methods used. for sporting event." (Kamila Płoszczyca, 2018) & (Robach P, 2006)

The researcher also believes that the implementation of compound exercises using the mask of training with lack of oxygen, is to follow a technological means to control the percentage of inhaled oxygen and gradually through multi-level valves, to simulate the actual reality in the pressure that occurs on the functions of organs and systems of the body, under the conditions of the fight as a result of high and continuous physical effort, and this cycle adds a burden to the burdens of training loads by reducing the amount of oxygen, which reflected positively on the biochemical indicators and achieved satisfactory results in the blood components of the experimental group members, This explanation was in line with all previous scientific studies and research, which confirmed that "training with hypoxic masks is one of the modern methods that have the ability to have positive effects on the functional status of players." (Laura Magliulo, 2021) & (Büşra Alkan, 2022) & (Connor J., 2021) & (WAEL RAMADAN, 2021) ALSO ""Exposure to hypoxic training for a minimum of six weeks provides changes in the blood and enhances physical performance ". (McLean BD, 2014) & (Hun-Young Park, 2018)

Through the above explanations of the indications of biochemical indicators in the blood, which the researcher sees as natural and harmonious with the improvement of the biological state achieved by the proposed high-intensity compound exercises by adopting the safe oxygen training mask method, and its impact on the organic organs of members of the experimental research community, as these exercises represented the philosophy of external load with all the training methods and tools used accompanied by the training mask, which was intended to apply the desired effect to certain levels, as it misled the internal environment For members of society and through which the so-called state of internal pregnancy is achieved, which most of the literature agreed to describe as the internal

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functional changes occurring in the human body under the influence of an external load, and it is recognized that all training processes cannot achieve their goals, unless a state of changes occur in the functional indicators of the body, and in another way the state of development in biochemical variables in the blood is only a reflection of the adaptation and improvement of the biological state of the fencers.

5. Conclusions and Recommendations

5.1. Conclusions

1. The results of clinical and functional examinations showed that they are healthy and the research community is in good health.

2. The results of measuring the biochemical variables in the blood showed that they fall within the normal limits of the members of the research community.

3. The effect of external training load with the internal load of the body on the height of the overall elements of the study.

4. The results of the study recorded a significant impact on the high level of measurement of biochemical variables of blood (EPO, FERSs, Hb, Hct) and improved by high-intensity compound exercises using the training hypoxic mask among members of the research community.

5.1. Recommendations

1. Adopting the proposed high-intensity compound exercises using the training hypoxia device as an aid in improving the biochemical indicators in the blood.

2. Adopting the results of the study in the biochemical variables in the blood as an indication of the adaptation of the functional organs and systems of the body of the players.

3. The need to use modern training devices and tools that serve physical and motor performance, including the training hypoxia device because of its positive impact on the process of improving the biochemical variables in the blood of the players.

4. Conducting periodic medical examinations during the training stages as a criterion to confirm the health status of athletes.

5. Conducting similar studies on other physiological variables in multiple sports events and on different age groups and for both sexes.

References

1. Anderson, G.J., Darshan, D., Wilkins, S.J., and Frazer, D.M.: Regulation of systemic iron homeostasis: how the body responds to changes in iron demand. Biometals, 20(4), 2007, 665–674.
2. Ben A. Holliss, Jonathan Fulford, Anni Vanhatalo, Charles R. Pedlar, and Andrew M. Jones: Influence of intermittent hypoxic training on muscle energetics and exercise tolerance, American Physiological Society, J Appl Physiol 114, 2013, 611–619.
3. Bo Berglund; High-Altitude Training Aspects of Haematological Adaptation, Sports Medicine, 14(5), 1992, 289-303.
4. Bonovas S, Fiorino G, Allocca M, et al. Intravenous Versus Oral Iron for the Treatment of Anemia in Inflammatory Bowel Disease: A Systematic Review and Meta-Analysis of Randomized Controlled Trials. Medicine (Baltimore), 95(2), 2016, 2308.
5. Breymann C, Rohling R, Huch A, Huch R. Intraoperative endogenous erythropoietin levels and changes in intravascular blood Vume in healthy humans. Ann Hematol, 79(6), 2000, 183–186.
6. Brocherie F, Millet GP, Hauser A, Steiner T, Rysman J, WehrlinJP, Oliver G. Live High-Train Low and High" Hypoxic Training ImprovesTeam-Sport Performance. Med Sci Sports Exerc, 47(10), 2015, 2140-2149.
7. Büşra Alkan, Sevgi Özalevli, Özlem A. Sert: Wearing a surgical mask: Effects on gas exchange and hemodynamic responses during maximal exercise, Clinical Physiology and Functional Imaging, 42, 2022, 286–291.
8. Carsten Lundby, Synthesis, function and possible new avenues for erythropoietin, The Journal of Physiology, V 6, 2011, 1249.
9. Chacón Torrealba, T., Aranda Araya, J., Benoit, N., and Deldicque, L.: Effects of High-Intensity Interval Training in Hypoxia on Taekwondo Performance. Int. J. Sports Physiol. Perform. 15, 2020, 1125–1131.

 doi:10.20944/preprints202409.0049.v1

10. Connor J. Doherty, Leah M. Mann, Sarah A. Angus, Jason S. Chan, Yannick Molgat-Seon, Impact of wearing a surgical and cloth mask during cycle exercise, 46, 2021, 753–762.
11. Czuba, M., Maszczyk, A., Gerasimuk, D., Roczniok, R., Fidos-Czuba, O., Zajac, A.: The effects of hypobaric hypoxia on erythropoiesis, maximal oxygen uptake and energy cost of exercise under normoxia in elite biathletes. J. Sport Sci, 13(4), 2014, 912–920.
12. Czuba, M., Waskiewicz, Z., Zajac, A., Poprzecki, S., Cholewa, J., and Roczniok, R.: The Effects of Intermittent Hypoxic Training on Aerobic Capacity and Endurance Performance in Cyclists. J. Sports Sci. Med. 10(1), 2011, 175–183.
13. Dale R. Wagner and Nicolas W. Clark: Similar results for face mask versus mouthpiece during incremental exercise to exhaustion, Journal of Sports Sciences, 34(9), 2015, 23:37.
14. De Smet, S., Van Herpt, P., D'Hulst, G., R., Van Leemputte, M., & Hespel, P.: Physiological adaptations to hypoxic vs. Normoxic training during intermittent living high. Frontiers in Physiology, 8, 2017, 347.
15. DellaValle, D.M., and Haas, J.D. 2014. Iron supplementation improves energetic efficiency in iron-depleted female rowers. Med Sci Sports Exerc. 46(6), 2014, 1204–1215
16. Dominelli PB, Baker SE, Wiggins CC, Stewart GM, Sajgalik P, Shepherd JR, Roberts SK, Roy TK. Dissociating the effects of oxygen pressure and content on the control of breathing and acute hypoxic response. J Appl Physiol, 127, 2019, 1622–1631.
17. Dominelli PB, Wiggins CC, Baker SE, Shepherd JR, Roberts SK, Roy TK, Curry TB, Hoyer JD, Oliveira JL, Joyner MJ. Influence of high affinity haemoglobin on the response to normoxic and hypoxic exercise. JPhysiol 598, 2020, 1475–1490.
18. Erslev A.: Erythropoietin coming of age. N Engl J Med. 316(2), 2015, 101-103.
19. Garvican LA, Saunders PU, Cardoso T, et al. Intravenous iron supplementation in distance runners with low or suboptimal ferritin. Med Sci Sports Exerc, 46(2), 2014, 376-385.
20. Garvican-Lewis LA, Govus AD, Peeling P, Abbiss CR, Gore CJ. Iron Supplementation and Altitude: Decision Making Using a Regression Tree. J Sports Sci Med. 15(1), 2016, 204-205.
21. Geiser, J., Vogt, M., Billeter, R., Zuleger, C., Belforti, F., and Hoppeler, H.: Training high–living low: changes of aerobic performance and muscle structure with training at simulated altitude. Int. J. Sports Med. 22, 2001, 579–585.
22. Gore, C. J., Hahn, A. G., Aughey, R. J., Martin, D. T., Ashenden, M. J., et al.: Live high: train low increases muscle buffer capacity and submaximal cycling efficiency. Acta Physiol. Scand. 173, 2001, 275–286.
23. Gore, C. J., Rodríguez, F. A., Truijens, M. J., Townsend, N. E., Stray-Gundersen, J., and Levine, B. D. Increased Serum Erythropoietin but Not Red Cell Production after 4 Wk of Intermittent Hypobaric Hypoxia (4,000-5,500 M). Journal of Applied Physiology, 101(5), 2006, 1386–1393.
24. Gore, C. J., Sharpe, K., Garvican-Lewis, L. A., Saunders, P. U., Humberstone, C. E., Robertson, E. Y., et al." Altitude Training and Haemoglobin Mass from the Optimised CarbonMonoxide RebreathingMethod Determined by aMeta-Analysis. Br. J. Sports Med. 47(1), 2013, i31–i39.
25. Govus AD, Garvican-Lewis LA, Abbiss CR, Peeling P, Gore CJ. Pre-Altitude Serum Ferritin Levels and Daily Oral Iron Supplement Dose Mediate Iron Parameter and Hemoglobin Mass Responses to Altitude Exposure. PLoS One, 10(8), 2015, 1-11.
26. Hun-Young Park, Chulho Shin, Kiwon Lim: Intermittent hypoxic training for 6 weeks in 3000 m hypobaric hypoxia conditions enhances exercise economy and aerobic exercise performance in moderately trained swimmers, Biology of sport" AQUARTERLY JOURNAL OF SPORT AND EXERCISE SCINECES, 35(1), 2018, 49–56.
27. Hun-young Park, Hyejung Hwang, Jonghoon Park, Seongno Lee, Kiwon Lim: The effects of altitude/hypoxic training on oxygen delivery capacity of the blood and aerobic exercise capacity in elite athletes—a metaanalysis, J Exerc Nutrition Biochem, 20(1), 2016, 015-022.
28. J.M. Hendriksen: The effect of intermittent training in hypobaric hypoxia on sea-level exercise: a cross-over study in humans, Eur J Appl Physiol, 88, 2003, 396–403.
29. JEFF M. BAKER, GIANNI PARISE: Skeletal Muscle Erythropoietin Expression Is Responsive to Hypoxia and Exercise, American College of Sports Medicine, 2016, 1294-1301.
30. Jelkmann, W.: Regulation of erythropoietin production. J. Physiol. 589, 2011, 1251–1258.
31. Kamila Płoszczyca, Józef Langfort and Miłosz Czuba; The Effects of Altitude Training on Erythropoietic Response and Hematological Variables in Adult Athletes: A Narrative Review Frontiers in Physiology, April, 9, 2018, 1-15.
32. Kasperska, A., and Zembron-Lacny, A.: The Effect of Intermittent Hypoxic Exposure on Erythropoietic Response and Hematological Variables in Elite Athletes. Physiol. Res. 69(2), 2020, 283–290.
33. Katayama, K., Sato, K., Matsuo, K., Iwasaki, K., and Miyamura, M.: Effect of intermittent hypoxia on oxygen uptake during submaximal exercise in endurance athletes. Eur. J. Appl. Physiol. 92, 2004, 75–83.
34. Laura Magliulo, Danilo Bondi, Tiziana Pietrangelo, Stefania Fulle, Raffaela Piccinelli, Mattia Taraborrelli & Vittore Verratti: Serum ferritin and vitamin D evaluation in response to high altitude comparing Italians trekkers vs Nepalese porters, European Journal of Sport Science, 21(7), 2021, 994-1002.

 doi:10.20944/preprints202409.0049.v1

35. Lee M. Romer,1 Hans C. Haverkamp,2 Andrew T. Lovering,2 David F. Pegelow,2 and Jerome A. Dempsey2, Effect of exercise-induced arterial hypoxemia on quadriceps muscle fatigue in healthy humans, Am J Physiol regul integr comp physiol 290, 2006, 365–375.
36. Lemaître F, Seifert, L, Polin, D, et al.: Apnea training effects on swimming coordination. Journal of Strength and Conditioning Research, V 23, 2009, 1909–1914.
37. Levine BD, Stray-Gundersen J. Point: positive effects of intermittent hypoxia (live high:train low) on exercise performance are mediated primarily by augmented red cell Vume. J Appl Physiol, 99, 2005, 2053–2055.
38. Lundby, C., Calbet, J., and Robach, P.: The response of human skeletal muscle tissue to hypoxia. Cell. Mol. Life Sci. 66, 2009, p 3615–3623.
39. M. VOGT, A. PUNTSCHART, J. GEISER, C. ZULEGER, R. BILLETER, AND H. HOPPELER, Molecular adaptations in human skeletal muscle to endurance training under simulated hypoxic conditions, J Appl Physiol, 91, 2001, 173–182.
40. Mackenzie, R. W., Watt, P. W., and Maxwell, N. S.: Acute normobaric hypoxia stimulates erythropoietin release. High Alt. Med. Biol. 9, 2008, 28–37.
41. McLean BD, Gore CJ, Kemp J. Application of 'live low-train high' for enhancing normoxic exercise performance in team sport athletes. Sports Med, 44(9) ,2014, 1275-1287.
42. Michalczyk, M., Czuba, M., Zydek, G., Zajac, A., and Langfort, J.: Dietary recommendations for cyclists during altitude training. Nutrients, 8, 2016, 377.
43. Okazaki K, Stray-GundersenJ, Chapman RF, Levine BD. Iron insufficiency diminishes the erythropoietic response to moderate altitude exposure. J Appl Physiol, 127(6), 2019, 1569-1578.
44. Pedlar CR, Brugnara C, Bruinvels G, Burden R. Iron balance and iron supplementation for the female athlete: a practical approach. Eur J Sport Sci. 18(2), 2018, 295-305.
45. Peeling P, Sim M, Badenhorst CE, et al. Iron status and the acute post-exercise hepcidin response in athletes. PLoS One, 9(3), 2014, e93002.
46. Robach P, Fulla Y, Westerterp KR, Richalet JP. Comparative response of EPO and soluble tranFERrin receptor at high altitude. Med Sci Sports Exerc, 36, 2004, 1493-1498.
47. Robach P, Schmitt L, Brugniaux JV, et al. Living high-training low: effect on erythropoiesis and aerobic performance in highly-trained swimmers. Eur J Appl Physiol, 96, 2006, 423-433.
48. Rodriguez, F. A., Ventura, J. L., Casas, M., Casas, H., Pages, T., Rama, R. et al.: Erythropoietin acute reaction and hematological adaptations to short, intermittent hypobaric hypoxia. European Journal of Applied Physiology, 82, 2000, 170–177.
49. Schmidt W, PrommerN. Effects of various training modalities on blood Vume. Scand J Med Sci Sports V 18(1), 2008, 57-69.
50. Semenza GL. HIF-1: mediator of physiological and pathophysiological responses to hypoxia. J Appl Physiol, 88, 2000, 1474-1480.
51. Sercan Öncen, Salih Pinar: Effects of Training mask on Heart rate and Anxiety during the graded exersice test and recovery, European Journal of Physical Education and Sport Science, 4(2), 2018, 1-8.
52. Vogt, M., Puntschart, A., Geiser, J., Zuleger, C., and Hoppeler, H.: Molecular adaptations in human skeletal muscle to endurance training under simulated hypoxic conditions. J. Appl. Physiol. 91, 2001, 173–182.
53. Wachsmuth NB, Vzke C, Prommer N, et al. The effects of classic altitude training on hemoglobin mass in swimmers. Eur J Appl Physiol, V 113(5), 2013, 1199-1211.
54. WAEL RAMADAN, CHRYSOVALANTOU E. XIROUCHAKI, REFAAT MUSTAFA, AMR SAAD, SANDRA APARECIDA BENITE-RIBEIRO: Effect of wearing an elevation training mask on physiological adaptation, Journal of Physical Education and Sport, 21(3), 2021, 1337–1345.
55. Walter F. J. Schmidt, Commentaries on Viewpoint: Time for a new metric for hypoxic dose, J Appl Physiol, 12, 2016, 356–358.
56. Wetter TJ, St Croix CM, Pegelow DF, Sonetti DA, and Dempsey JA: Effects of exhaustive endurance exercise on pulmonary gas exchange and airway function in women. J Appl Physiol 91, 2001, 847–858.
57. Xiong S, She H, Takeuchi H, et al. Signaling role of intracellular iron in NF-kappaB activation. J Biol Chem, 278(20), 2003, 17646–17654.
58. Zacharski LR, Ornstein DL, Woloshin S, Schwartz LM. Association of age, sex, and race with body iron stores in adults: analysis of NHANES III data. Am Heart J, 140(1), 2000, 98–104.
59. Zoll, J., Ponsot, E., Dufour, S., Doutreleau, S., Ventura-Clapier, R., Vogt, M., et al.: Exercise training in normobaric hypoxia in endurance runners. III. Muscular adjustments of selected gene transcripts. J. Appl. Physiol. 100, 2006, 1258–1266.