

**ANALYSIS OF MODERN METHODS OF INTERVAL HYPOXIC
TRAINING (IHT) AS MORE EFFICIENT FORMS OF RESTORATION,
RECOVERY, RECREATION**

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Abstract

The realization of this article was imposed by the need to react concretely on the problem of analyzing modern methods of interval hypoxic training (IHT) as more efficient forms of restoration, recovery, recreation.

In this regard, this article seeks to recall the importance of overcoming the obstacles of the analysis of modern methods of interval hypoxic training (IHT) as more efficient forms of restoration, recovery, recreation. Individual physical working capacities and rehabilitation process efficiencies are determined by the hypoxic adaptation efficiency.

Interval hypoxic training (IHT) is a technique developed in the former Soviet Union, that consists of repeated exposures to 5–7 minutes of steady or progressive hypoxia, interrupted by equal periods of recovery. It has been proposed for training in sports, to acclimatize to high altitude, and to treat a variety of clinical conditions, spanning from coronary heart disease to Cesarean delivery. Some of these results may originate by the different effects of continuous vs. intermittent hypoxia (IH), which can be obtained by manipulating the repetition rate, the duration and the intensity of the hypoxic stimulus. The present article will attempt to examine some of the effects of IH, and, whenever possible, compare them to those of typical IHT. IH can modify oxygen transport and energy utilization, alter respiratory and blood pressure control mechanisms, induce permanent modifications in the cardiovascular system. IHT increases the hypoxic ventilatory response, increase red blood cell count and increase aerobic capacity. Some of these effects might be potentially beneficial in specific physiologic or pathologic conditions. At this stage, this technique appears interesting for its possible applications, but still largely to be explored for its mechanisms, potentials and limitations.

Introduction

Interval hypoxic training (IHT), a technique developed in the former Soviet Union, consists of repeated 5-7min of steady (in the range of 9- 12%) or progressive hypoxia (down to 5-7%), interrupted by equal periods of recovery. It was used to increase the resistance to hypoxia to radiations, to train competitive athletes, to adapt to high altitude, and to treat many different disorders. Only recently a few western groups started evaluating the effects of these techniques. The first data available refer to effects of IHT on exercise capacity, red blood cell count, ventilatory control, and the autonomic nervous system. IHT is a specific condition of intermittent hypoxia (IH). Differences relating continuous hypoxia to IH, in general, and more specifically to IHT, are still poorly understood. These differences depend on many different aspects, such as total duration of hypoxia, and the number, duration and intensity of hypoxic exposures. Growing evidence suggests that the effects elicited by manipulating these elements may be quantitatively and even qualitatively different. The present article reviews experience, examines some of the specific effects of intermittent vs. continuous hypoxia, and, whenever possible, compares them to the known effects of IHT.[12,13]

The method of interval hypoxic training (IHT) is used to increase physical endurance of athletes and for treatment of certain systemic diseases, due to the ability of IHT affect metabolism, homeostasis and the immune system. The aims of the article are to improve the results by implementing modern methods of hypoxic interval training IHT as more efficient forms of restoration, recovery, recreation.

The support for this model has a high degree of applicability in terms of community mitigation and resilience, as it allows this approach to be applied in the specific context and, last but not least, a signal that these things should be treated more seriously and responsibly by all actors involved in training on the problems and barriers to achieving modern IHT methods as more efficient forms of restoration, recovery, recreation. [1,2]

Hypoxia training involves reducing the amount of oxygen available in the breathed air. When there is a low level of oxygen available, the body produces more red blood cells to streamline respiratory processes and use available oxygen. The diaphragm and lungs become stronger, but the pulmonary alveoli increase their elasticity and surface area. In this way, they can transport more oxygen through red blood cells, increasing the capacity for intense effort. [7].

The actuality. New methods and devices for pursuing performance enhancement through altitude training were developed in Scandinavia and the USA in the early 1990s. At present, several forms of hypoxic training and/or altitude exposure exist: traditional ‘live high-train high’ (LHTH), contemporary ‘live high-train low’ (LHTL), intermittent hypoxic exposure during rest (IHE) and intermittent hypoxic exposure during continuous session (IHT). Although

substantial differences exist between these methods of hypoxic training and/ or exposure, all have the same goal: to induce an improvement in athletic performance at sea level. They are also used for preparation for competition at altitude and/or for the acclimatization of mountaineers.

The state of hypoxia (oxygen deficiency) occurs whenever the oxygen tension in the cells and tissues of the body becomes below the critical value, at which it is still possible to maintain the maximum rate of enzymatic oxidative reactions in the mitochondrial respiratory chain. The reasons directly responsible for the onset and development of hypoxia may be external (changes in median gas composition, altitude, difficulty breathing) and internal (functional failure or pathological changes in vital organs, abrupt changes in metabolism, accompanied by an increase in tissue oxygen, the action of poisons and harmful metabolic products, etc.).

Regardless of the reasons generated, hypoxia has a pronounced effect on the flow of metabolic and physiological processes in the body that determine a person's health and efficiency.

Short-term exposure to moderate degrees of hypoxia stimulates aerobic metabolism in most organs and tissues, increases the general non-specific resistance of the body, contributes to the development of adaptation to various side effects. [5].

Intermittent/Interval Hypoxic Training or Intermittent/Interval Hypoxic Treatment (IHT) – a commonly employed designation of a treatment method using intermittent hypoxic exposure as the main therapeutic factor.

An IHT session consists of an interval of several minutes (3–10 min each) breathing hypoxic (low oxygen) air, alternated with similar intervals breathing ambient (normoxic) or hyperoxic air (Hypoxia – Hyperoxia mode – IHHT).

The procedure may be repeated several times in variable-length sessions per day, depending on a physician's prescription or a manufacturer's protocol (Navarrete-Opaz et al.,2014). Standard practice is for the patient to remain stationary while breathing hypoxic air via a hand-held mask. The therapy is delivered using a hypoxicator during the day time, allowing the dosage to be monitored.

Unlike climbing a mountain, where the body adapts to gradually lower levels of oxygen, IHT deprives the body of oxygen in short, sharp bursts. During treatment, oxygen saturation levels in the blood, heart rate, and blood pressure are closely monitored. This enables oxygen levels to be reduced safely.

The main idea of the interval hypoxic treatment method is repeated reduction of blood oxygen to the individual hypoxia adaptation level intermingled with recovery intervals.

A reduction in oxygen level stimulates activity of protective proteins (e.g. antioxidant enzymes, heat shock proteins, Fe-regulating proteins, repair enzymes,

growth factors, peroxiredoxins, etc. by starting a cascade of reactions that leads to hypoxia adaptation and new defensive mechanisms formation which produce positive physiological changes and outcomes in clinical practice [Bernardi et al.].[5].

Material-method

The object of study is the more efficient forms of restoration, recovery, recreation.

The subject of the study is the influences of modern methods of interval hypoxic training (IHT) as more efficient forms of restoration, recovery, recreation.

The aim of our study is to demonstrate the effectiveness of modern methods of interval hypoxic training (IHT) as more efficient forms of restoration, recovery, recreation.

The aim of the study was to solve the following problems:

1. To determine the characteristics of interval hypoxic training (IHT) and significant effects on the body as more efficient forms of restoration, recovery, recreation and to reveal the influence of training on the whole body and of man as a whole.

2. Identification of appropriate means and methods in the training process

Research methods: Analysis and generalization of data from the scientific-methodical literature, study of experimental data and statistical-mathematical methods.

Experimental study. Since the 1968 Mexico City Olympics, various studies have been conducted to assess the performance of exercise training in hypoxic conditions to enhance the performance of athletes. Currently, these training methods are commonly applied by several athletes and coaches [9].

An increase in the duration of exposure to hypoxia or a marked increase in the resistance of this effect, depending on the degree of reduction of O₂ pressure in the inhaled air, inevitably leads to various functional disorders and the development of static pathology (for example mountain sickness etc.). Developing tissue hypoxia is the most dangerous companion of the most serious diseases. However, recurrent hypoxia, to varying degrees, is common to many forms of work, military, and sports activities. [4] Given this situation, conditions of moderate hypoxia or repeated use of its short-term effects can be used to increase the body's adaptive reserve, to treat and prevent a number of diseases, and to prepare for the conditions of professional activity.

Many types of professional work, individual forms of military and sports services in particular are associated with the need to perform intense muscle work, which dramatically increases the demand for oxygen and leads to tissue hypoxia, which is reversible and gives rise to a significant increase in aerobic metabolism when stopped or reduced. Also, the occurrence of regional hypoxia is caused by the

need to maintain fixed positions of the working act, which impedes blood flow and breathing and significant emotional stress, accompanied by the release of catecholamines in the blood and increased metabolic demand for oxygen in tissues. It should also be noted that many types of professional and military activities require many hours of work in an enclosed space, in a state of strained waiting (activity of operators, management of complex devices and systems). Severe hypodynamics on the background of negative emotions in these cases contributes to the development of asthenia and decreased efficiency.

In order to ensure a successful activity under the specified conditions and to maintain a high performance, a special hypoxic method is required. The main means of such training are the occasional sessions of repetition of artificially induced hypoxia (increase in pressure chambers, breathing in a closed space or simply holding the breath, inhaling mixtures with low O₂ content, etc.), varying in duration and the extent of PO₂ reduction. Until now, several types of technical devices have been developed and proposed for practical use, allowing the creation of an artificial hypoxic environment. Depending on their characteristics, such devices are divided into stationary chambers (pressure chambers, high-capacity hypoxicators), portable, designed to serve a small number of patients in rapidly changing environmental conditions and individual devices of use (special masks with extra space, etc.). Using this type of technical device, it is possible to implement different methodologies for the use of artificially induced hypoxia and its combination with other physiotherapeutic, dietary and pharmacological effects, in order to improve health, physical and mental performance, treat and prevent various diseases. [10, 17].

Interval hypoxic training (IHT) is the effect of hypoxic exposure determined by the total duration of the session and the magnitude of the decrease in the partial pressure of oxygen in the air we breathe. With a sudden decrease in PO₂, accompanied by the acute development of severe hypoxic conditions, maintaining a certain level of functioning of the body is possible only for a few tens of seconds or minutes. With a less pronounced decrease in PO₂, the development of hypoxia and normal functional activity extend over a period of time, measured in several minutes or even hours.

When establishing optimal hypoxic training regimens, a general principle must be observed: resistance and duration of hypoxic exposure must be limited to the physiological norm, at which it is possible to effectively compensate for continuous functional changes and rapid recovery after discontinuation of the hypoxia session.

It is noted that the evolution of adaptation to hypoxia conditions and the increase of the general non-specific resistance of the body is significantly accelerated if the total dose of hypoxic exposure is divided into several separate repetitive periods of hypoxic exposure, performed after certain moments of

normobaric respiration. [5]. This form of organizing hypoxic training is commonly referred to as intermittent or interval training, hypoxic (Interval Hypoxic Training (IHT)). In this article, we will adhere to the last term as the most accepted of specialists. [5]. In this form of hypoxic preparation, there is the possibility of a large variation in the ratio of resistance and duration of an individual hypoxic stimulus to the duration of normobaric breathing pauses and the total time of exposure to hypoxia.

When establishing the basic parameters of Interval Hypoxic Training (IHT), it should be borne in mind that the development of the body's response to the acute effects of hypoxia takes some time: the time required for a separate hypoxic exposure is 3-10 minutes. The total duration of the daily hypoxia session should be sufficient to develop an adaptive response of the body to such effects.

This total dose of hypoxia will depend on its degree and the general state of non-specific resistance of the body. As a rule, the total duration of hypoxic sessions for one day should not exceed 1.5-2 hours.[14,16]

Regarding the severity of hypoxic exposure, the intervals of permissible decrease in O₂ concentration in the inhaled air during hypoxic sessions used as training can be divided into three degrees: • moderate (subacute) hypoxia, obtained by reducing the O₂ content in the inhaled air in the range from 20 to 15%; • acute hypoxia, which develops when the O₂ content of inhaled air drops to 15-10%; • hyperaxial hypoxia, which occurs when O₂ drops in inhaled air below 10% vol.

By altering the total hypoxic indices (IHT), it is possible to achieve the necessary degree of selective influence on the basic physiological functions of the body and a visible way the different parts of the metabolism. It opens up opportunities to use (IHT) to prevent and treat various types of diseases, improving health and increasing productivity.

The basic concept in Interval Hypoxic Training (IHT) is the choice of an effective method that is made according to the chosen training purpose, the specific composition of users and their functional state, as well as the specific conditions of the professional activity where this method is applied . Below is a description of the main schemes (IHT) that are commonly used to improve functional status and increase patient productivity without significant deviations in health and with a certain level of physical fitness.

Alexander Törpel et al. (European Journal of Applied Physiology, 2019):

“While the external intensity of hypoxia determines the type of the environmental condition (e.g., the fraction of inspired oxygen: FiO₂), the internal intensity of hypoxia is characterized by the amount of oxygen deficit in the organism (e.g., the oxygen saturation of the blood: SpO₂, measured by a pulse oximeter). Here, the intensity of internal hypoxia depends among others on the intensity of external hypoxia, some physiological processes (e.g., lung diffusion capacity), the chemoreceptor sensitivity (García-Río et al. 2007) and the

compensatory response of the organism (e.g., the cardiorespiratory system; Bärtsch and Gibbs 2007). With regard to the latter three factors, inter-individual differences and age-specific changes can be determined (García-Río et al. 2007; Lhuissier et al. 2012; Stam et al. 1994). Consequently, there are inter-individual differences of the internal intensity of hypoxia during the administration of an external hypoxia which may result in a different severity of the hypoxic stimulus for the organism (variations by up to 10% or more of the SpO₂, see Chacaroun et al. 2017; Burtscher et al. 2004; Harshman et al. 2015).

SpO₂ of about 80% corresponds to the average internal intensity of hypoxia during an external hypoxia with a FiO₂ of 17–10% (see Burtscher et al. 2004; Chacaroun et al. 2017).

Endurance exercise is significantly influenced by the oxygen-transporting capacity of the body to localized areas, such as the active muscles. Enhancing the oxygen-transporting capacity increases the efficiency of aerobic energy production and, consequently, enhances the maximum oxygen uptake (VO₂max) and exercise performance by improving the time until fatigue and increasing exercise intensity. Altitude/hypobaric hypoxic training improves athletic performance in aerobic events by enhancing the oxygen-transporting and oxygen-utilizing capacities through hematological changes, such as those in hemoglobin (Hb) mass and erythropoiesis, and by non-hematological changes, such as those in cardiovascular function and oxygen availability in the skeletal muscles [4, 16].

Results

The general training effect of (IHT), as mentioned above, depends on the choice of its main parameters - intensity of hypoxic exposure (O₂ content in inhaled air), duration of individual hypoxic exposure, duration of a pause of normal breathing of the air of the normal composition, number of repeated exposures, hypoxic training session and other additional conditions. In order to rehabilitate and prevent diseases, the following well-studied schemes (IHT) can be proposed:

Tabel no.1 Schemes (IHT) can be proposed

Basic training regimen.	Retractable training regimen.
The duration of a separate period of hypoxic exposure is 3-5 minutes, the pause of normobaric respiration is 5 minutes. The number of repeated exposures in a session is 10-12 times. O ₂ content of inhaled air - 14-15%. During a training day, one or two sessions (IHT) may be accepted in this mode. It is applied for 3-4 weeks, 4-5 times a week, with regular medical	The duration of a separate period of hypoxic exposure is 1 min, the pause of normobaric respiration is 1 min. The number of repeated exposures in a series is 3 to 6 times. The number of episodes in a session (IHT) is 3-4 times. A break of normobaric breathing between sets is 5 min. O ₂ content of inhaled air - 12% vol. This mode is applied in the

supervision.	initial stage of formation, with the resumption of courses after a forced break, as well as any sudden change in conditions and people lifestyle.
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Tabel no.2 Schemes (IHT) can be proposed

An energizing training regimen.	Prophylactic regimen.
The duration of a single period of hypoxic exposure is 30 sec. The number of repeated exposures in a session (IHT) is 12-16 times. The normobaric breathing pauses between series is 1.5-2 minutes. The O ₂ content of the inhaled air is 10% vol. Mandatory conditions of application of the regime: the absence of any serious disease, good tolerance to hypoxic conditions.	The duration of a separate period of hypoxic exposure is 45 sec, the normobaric respiratory pause is 45 sec. The number of repeated exposures is 10-12 times. The number of episodes in a session is 3-4 times. The normobaric breathing pauses between series is 1.5-2 minutes. The O ₂ content of the inhaled air is 12-14% vol. The regimen is used during periods when no other form of physiotherapy is applied.

By combining the schemes (IHT) described above, in accordance with the general conditions and tasks of rehabilitation of people, it is possible to avoid unwanted emotional disturbances and achieve a marked improvement in health and high efficiency

Hypoxic training equipment. The successful application of the interval hypoxic training (IHT) method in practice is primarily associated with its hardware and the method used to create hypoxic conditions. To date, several methods and technical devices have been proposed for the creation of hypoxic conditions that can be used in various ways (IHT).

In an early stage of development, the ideas of the method (IHT) were used mainly by simplified methods to create hypoxic conditions that do not require the use of special equipment. These methods include breathing protection, breathing in an enclosed space, breathing with additional dead space, etc. Some improved changes to these methods are still applied in practice today. The main disadvantage of the simplified methods is associated with the impossibility to create stationary breathing conditions necessary for the dosing of hypoxic exposure. Stationary methods of creating hypoxic conditions using pressure chambers and special hypoxicator devices lack this disadvantage. The hypoxia pressure chamber method has a long tradition and is well established in practice. Its disadvantages are the high cost, bulkiness, difficulties in operation and the impossibility of rapid changes in the parameters of the hypoxic stimulus, which is necessary in the implementation of individual methods (IHT). These deficiencies are eliminated in

hypoxic devices. The simplest of these are respiratory systems with partial O₂ absorption and CO₂ absorption emitted during the respiration process. In the more advanced hypoxic apparatus, the principle of separating the membrane from gas mixtures is used to create hypoxic mixtures with a specific composition. [5] The Everest 1 device produced by Klimbi (Moscow) is one of the most sophisticated and easy to use devices - hypoxicators. The principle of separating gas mixtures using high capacity membrane modules is used, and the compressor with a sufficiently high power used in the device allows to maintain the required speed of the injected flow of the hypoxic air mixture, at which the user does not encounter difficulties in implementing any program (IHT) proposed. Athletes could take advantage of IHT, which seems more beneficial than IHE in performance enhancement. The intensity of hypoxic exercise might play a role on adaptations at the molecular level in skeletal muscle tissue. There is clear evidence that intense exercise at high altitude stimulates to a greater extent muscle adaptations for both aerobic and anaerobic exercises and limits the decrease in power. This review also provides a rationale on how to combine the different hypoxic methods and suggests advances in both their implementation and their periodization during the yearly training programme of athletes competing in endurance.[3].

Conclusions

Interval hypoxic training (IHT) is a new training method that is widely used in clinical and sports medicine as a means of treatment without pills, as a means of treating and preventing disease, strengthening health and improving physical performance.

Practical applications of (IHT) become possible through the use of hypoxicator devices based on the principle of gas mixture separation .

With such devices can be equipped physiotherapy offices in clinics, sanatoriums and rest centres, sports and medical rehabilitation centers.

The use of the method (IHT) for the rehabilitation and improvement of work capacity, together with traditional means, allows to obtain high results in a much shorter training period.

The Hypoxia Therapy method is very natural, as it utilizes unique genetically installed human body phenomena: an organism rapidly compensates disruptions at all levels caused by decreases in oxygen intake, adapting to its new environment. So-called ‘super-recovery’ follows total recovery of a disrupted function so that body resistance to a specific factor improves.

Prenatal body evolution takes place in a low PO₂ environment similar to an altitude of 5,000-6,000m above sea level (asl). Furthermore, PO₂ values in the womb and fetal tissues change cyclically.

Ability of the fetus to super-recover in response to decreased PO₂ is an aspect of specific fetus «training» and forms its ability to resist external factors following parturition.

Intermittent Hypoxia Therapy is a convenient way to tune the oxygen transport system and increase the power of the oxidative process. It relates to the fact that the oxygen the transport system, including breathing, cardiovascular systems, blood, multilayered regulators and cell breath systems dominate in terms of responsibility for adaptive changes.

These effects are realized also during continuous intensive physical exercises of aerobic nature of longer than 30 minutes. Hypoxic training is easy to perform, which along with the absence of limitations is another benefit for patients, especially those overweight or with metabolic syndrome.

Highland communities typically enjoy a 15–20 years longer lifespan. Median lifetime of Hunz valley inhabitants, in the Karakorum mountains, at 2,500m asl, is 120 years.[5]. The large majority of specialists on sport domain, after the undertaken studies, proposed varied solutions to improve this process and promoted modern methods and means. In this way, came into being some installations, equipments and computerized technologies that more contributed to the improvement of the training process development [10,14].

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