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Original Article

HIF Changes and The Personal Record Improvement as a Result of Hypoxic Training for 800m Athletes

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Abstract

The Study aims to test the effect of oxygen deficiency on HIF and personal record of 800m athletes. One experimental group of (6) athletes, with pre and post measurements designe was used for testing the effect of the training program on the studed variables. The athlets used masks in order to have the same condition of mountain training under Oxgyn difficiecy. The training program lasted for 8 weeks, 4 sessions per week. The results showed the positive effect of the training program using masks on the red cell number, Blood Hemoglobin amount in Blood, as weel as the increase in HIF result and the decrease of Lactic acid concentration in blood. The training program also improved VO_2Max of the participants. The personal records of the participants were improved. The authors recommend using the masks involved in a precisely designed training program, which relay on the energy production system specially for 800m running event for improving the physiologycal variables that effect directly on HIF Gen expression that increase VO2 max and speed endurance.

Keywords: *HIF Gene expression, 800m Run, Hpoxic training*

Introduction

Athletic training is a key factor in enhancing functional indicators, physical abilities, and technical skills, ultimately leading to improved athletic performance. Athletic exercises primarily involve muscle contractions, which can be executed over short or extended periods depending on the training objectives and the specific areas targeted for development.

Scientists developed oxygen tents, also known as hypoxic tents. These tents simulate high-altitude conditions by either increasing atmospheric pressure or reducing oxygen levels through a higher nitrogen concentration in the air. This innovation

replicates the effects of oxygen deficiency on vital organs without the need for actual altitude exposure. (Saltin, 2007)

Athletes can now train to sustain prolonged physical effort under reduced oxygen conditions without risking adverse health effects. This approach hinges on the careful design of the training program to ensure safety and effectiveness. (Ahmad, 2003)

The 800-meter race relies on the regulation of energy production, which is crucial for achieving peak performance. This event engages all three energy systems: the ATP-PC system, the anaerobic system, and the aerobic system. The contribution of each system varies depending on factors such as the research methodology, the athletes' skill level, and their performance level. According to Deuster et al. (2007), the energy system contributions for medium-distance races are approximately 10%, 20%, and 70% for the ATP-PC, anaerobic, and aerobic systems, respectively. In contrast, Van Someren et al. (2006) reported slightly different rates of 6%, 33%, and 61%.

The 800-meter race consists of two laps around a standard 400-meter track. Maintaining maximum speed throughout the entire distance is impractical, necessitating a balanced use of energy. At the start of the race, the ATP-PC system dominates for the first 100 meters. As the race progresses, the speed decreases slightly, and the anaerobic system becomes the primary energy source for the next 700 meters. The aerobic system contributes more significantly in the final 100 meters as the athlete increases their pace. However, pushing for maximum speed throughout the race can lead to oxygen deficiency and lactic acid buildup in the muscles and bloodstream, accelerating fatigue. Therefore, training for this event must focus on developing the muscles' ability to sustain high speeds while managing lactic acid accumulation. Enhancing both anaerobic and aerobic energy systems is essential for improving performance in the 800-meter race.

Coaches in the United States and Germany have successfully incorporated hypoxic training into their programs, yielding significant improvements in athlete performance and competitive success. Hypoxic training has gained widespread popularity and is now a cornerstone of modern training regimens. It utilizes advanced equipment, innovative techniques, and diverse exercises to enhance physiological adaptations across various sports. (Abdelfatah,2019)

Hypoxic training offers numerous benefits, including increased hemoglobin levels, improved efficiency of the respiratory and circulatory systems, delayed onset of fatigue, and enhanced overall athlete health. (Ahmad, 2003)

For 800-meter runners, maintaining slow and regular breathing is critical, as it directly impacts aerobic endurance during the race. Therefore, it demands a unique

combination of physical fitness elements and energy system efficiency to achieve the physiological adaptations necessary for optimal performance. (Bastawisi, 2000)

There is a growing importance of molecular biology in sports science. This field provides insights into how training influences gene expression and muscle protein production, enabling coaches to design tailored programs that enhance physical performance. Molecular biology has become a vital tool for understanding the genetic mechanisms underlying athletic development. (Bahaa,2000)

Molecular biology plays a key role in quantifying and qualifying genes, as well as understanding their functions in protein synthesis. Regular athletic training induces qualitative and quantitative changes in muscle proteins, leading to increased muscle volume. By leveraging molecular biology, coaches can better understand how training influences gene activity and muscle protein production, enabling them to design effective programs for performance enhancement. (Hussain,2017)

molecular biology equips scientists with tools to study how training regulates gene activity and impacts muscle protein production. This knowledge aids in planning training programs that optimize performance through techniques such as chromosome mapping and gene localization. (Abdelrahman,2019)

Hypoxia-Inducible Factor (HIF) is a critical protein that mediates the body's adaptive responses to oxygen deficiency. Present in nearly all cells, HIF migrates to the cell nucleus under low-oxygen conditions, acting as a transcription factor to promote oxygen delivery to tissues. HIF ensures adequate oxygen supply to cells and stimulates erythropoietin (EPO) production in low-oxygen environments. When oxygen levels rise, HIF and EPO production decrease. (Israa,2019)

The application of genetic analysis in sports science is becoming increasingly important. However, there is a notable lack of research in the Arab world exploring the role of genetics in training and athletic performance. This gap highlights the need for further studies in this field.

The research problem highlights that athletics competitions demand high levels of physical and functional preparation, which are inherently interconnected and essential for athlete development. Athletes undergo significant and continuous changes in their functional and motor systems, particularly in their muscular organs, which are often subjected to fatigue and pain. To address these demands, various training tools and techniques are employed, especially for high-intensity activities like medium-distance races. Among these techniques, hypoxic training stands out, as it targets both anaerobic and aerobic systems. This is particularly crucial for medium-distance runners, who require

highly efficient circulatory and respiratory systems. It is equally important to focus on enhancing their ability to tolerate oxygen debt and sustain physical effort for extended periods, alongside improving their overall physical capabilities.

Through observations of various championships, the authors noted that athletes from Kenya, Ethiopia, and other high-altitude regions consistently dominate and outperform their competitors. This advantage is likely attributed to the unique environmental conditions in these regions, such as climate, atmospheric pressure, and reduced oxygen levels. These factors appear to enhance their physiological adaptability and performance. Motivated by these observations, the authors sought to identify training methods that could replicate such high-altitude conditions. They concluded that hypoxic training is the most effective approach, as it simulates the physiological demands experienced by athletes living and training at high elevations.

Upon reviewing previous studies, the authors found that many relied on superficial measurements, which may yield less reliable results. This limitation motivated them to conduct a more in-depth investigation, focusing on internal biological responses, particularly the genetic expression of Hypoxia-Inducible Factor (HIF).

In this study, the authors applied hypoxic training to assess its effects on functional capabilities and HIF gene expression. The goal was to generate more precise and scientifically supported insights into how this training method influences physiological and genetic responses.

Study Hypotheses

1- There are statistically significant differences between pre and post measurements of the experimental group in functional variables and HIF (under consideration) for medium distance races athletes in favor of the post measurements.
2- There are statistically significant differences between pre and post measurements of experimental group in medium distance races athletes Personal record tests in favor of the experimental group.

Method

The authors used the experimental with one experimental group using pre and post measurements design.

Participants

The study included six athletes registered with the Egyptian Athletics Federation for the 2024/2025 season, all of whom were affiliated with the 6th October Sports Club. Tables (1 and 2) provide a detailed description of the experimental group participants. The skewness values for all variables fell within the range of ±3, confirming that the participants shared similar

characteristics relevant to the study. This consistency ensured a homogeneous sample, which is crucial for the reliability of the research findings.

Table 1. Characteristics of the participants group

Groups	Mean	SD	Skwness
Age (year)	17.67	0.75	1.04
Hight (cm)	174.27	3.61	-0.61
Weight (kg)	66	3.87	0.36
Training experience (year)	7	6.5	1.03
Personal Record (min)	2.14	0.062	0.571

Table 2. Homogeneity of the participants in Physiologycal variables (n = 6)

Physiological Variables	Mean	SD	Skewness
VO2 MAX(ml/kg/min)	37.978	3.386	-2.211
HIF (Delta Ct)	4.556	0.675	1.301
Red cell (cells/ul)	4300.000	118.110	0.427
Hemoglobin (g/dl)	14,067	0.663	0.130
Lactic (mmol/L)	1.944	0.073	-1.014

Pilot Study

The training program was designed to incorporate hypoxic training. To achieve this, participants wore Phantom Athletics Training Masks during the physical training sessions for the 800-meter run. These masks are innovative tools designed to enhance respiratory muscle strength and overall fitness during athletic activities. The mask features four adjustable difficulty levels, allowing for customization based on the athlete's needs.

The main objective of the pilot study was to test the masks, evaluate the planned training intensity, and ensure it aligned with the participants' abilities without causing health issues or adverse side effects. Additionally, the study aimed to determine the most suitable mask difficulty level for the athletes, ensuring optimal adaptation and performance.

Procedures

Pre- measurements

The pre-measurements were conducted from 18/8/2024 to 20/8/2024 in 6th October club. The tests were the personal record of 800m. In addition, drawing blood samples for the physiological variables (see table 2).

Training Program

The main study lasted 6 weeks from from 22/8/2024 to 3/10/2024 for 6 weeks and 4 training sessions per week. While the purpose of the program is to test the hypoxic training, the loads during the program were designed to put the athletes under oxgyn difficiecy condition by

wearing the masks during physicalpart of the section. As mentioned before, 800m run depends on the three energy sources of the body, but mainly on anaerobic lactic acid and aerobic sources. As a result, the intensity of the training loads was relative to the time of 800m run wich trigger the same energy sources. The authors adopted the following contribution percentage 10%, 20% and 70% of energy resources.

Table 3. Time distribution of the training program

Nr	Variables	Time distribution
1	Program duration	Specific preperation
2	Number of weeks	6 weeks
3	Number of training sessions per week	4 sessions
4	Total sessions	24 sessions
5	Warm up, Physical and technical preperation, cooling down	90 minutes
6	Total duration time per week	360 minutes
7	Total duration time of the training program	2160 minutes

The duration of each section of the training session was 20 min, 60min, and 10 min for warming up, physical and technical exercises, and cooling down, respectively. Warming up included jogging, mobile flexibility and Agility, balance, and coordination exercises. Their aim is to raise the body temperature, stimulate central nervous system to receive effort during the and protect the athletes from injuries. While the main part included the Hypoxic training using the masks, finally cooling down and relaxing exercises like static agility and deep breathing exercises.

Table (4) illustrates a general view of the training program including energy systems along the whole season training parts, then focuses on the specific part weher the designed hipoxic training took place. Figure (1) presents loads intensity along the 24 training sessions, where each session has internal load form for each section and exercise groups.

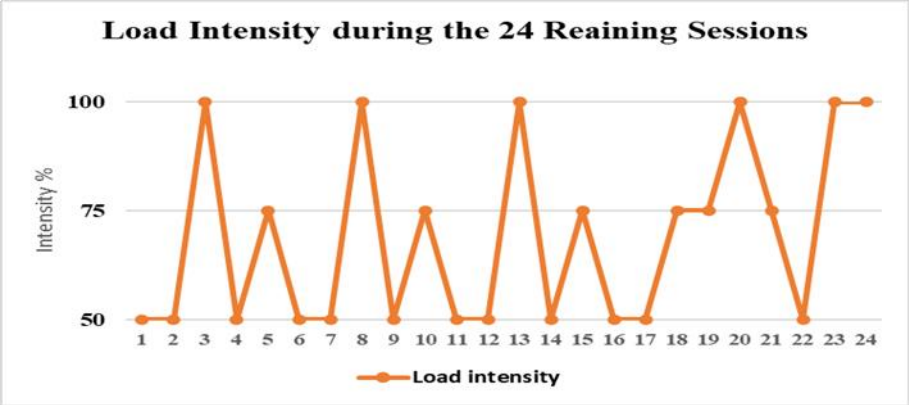

Figure (1) Training loads intensity along the 24 training sessions of the specific preperation of 800m run athletes

Table (4) The plan of the training program

Period	24 days (24 training sessions)				
Energ System	aerobic	Lactic Acid			ATP-PC
Part of the season	general	Spesific preperation			Competitions
Energy systems contribution rate	70%	20%			10%
Number of days	-	24			-
How to form the intesity		 50%	 75%	 100%	
Number of das of each load		16	5	3	
Technical	-	30 min			-
Physical training	-	Hypoxic training			-
Skill training	-	Two technical phases each session			-

Table 5. Training loads of the technical exercises with phantom masks

Weeks	session number	Intensity	Rest between repetitions	Rest between sets (min.)	Running distance (m)
First	1	50%	Return to the pulse of repetition for each player	5-7	400-400-800-400- 600
	2	50%		5-7	400-400-800-400- 600
	3	100%		5-7	400-800-800-600-800
	4	50%		5-7	400-400-800-400- 600
Second	5	75%		5-7	400-600-600-800-600
	6	50%		5-7	400-400-800-400- 600
	7	50%		5-7	400-400-800-400- 600
	8	100%		5-7	400-800-800-600-800
Third	9	50%		5-7	400-400-800-400- 600
	10	75%		5-7	400-600-600-800-600
	11	50%		5-7	400-400-800-400- 600
	12	50%		5-7	400-400-800-400- 600
Fourth	13	100%		5-7	400-800-800-600-800
	14	50%		5-7	400-400-800-400- 600
	15	75%		5-7	400-600-600-800-600
	16	50%		5-7	400-400-800-400- 600
Fifth	17	50%		5-7	400-400-800-400- 600
	18	75%		5-7	400-600-600-800-600
	19	75%		5-7	400-600-600-800-600
	20	100%		5-7	400-800-800-600-800
Sixth	21	75%		5-7	400-600-600-800-600
	22	50%		5-7	400-400-800-400- 600
	23	100%		5-7	400-800-800-600-800
	24	100%		5-7	400-800-800-600-800

The athlete repeated the exercise after the heart rate decreased to individual limit for each athlete, this limit is calculated by using athlete age and his heart rate at passive rest. For those participants was 130 pulse/min (± 3). In addition, each running distance was performed with maximum speed which limited by the athlete individual time according to the pre-tests of (400, 600, 800 meter). In other words, we assume that the maximum distance of the athlete is 800m covered in his best personal, then when we form 50% of the intensity, it would be running 400m in his best personal time of 400m. By this method we can ensure that the nevous system is doing the same operation and reaction every time depending on the same energy resources, unlike if we ask the athlete to rum 800m in longer time than his best in order to reduce the intensity to 50%, he wouldn't depend on the same energy sources and would weaken the nervous system stimulation.

Post measurements

The Post measurements of all tests (800m record as well drawing the blood samples) were from 5/10/2024 to 7/10/2024 in 6th October club.

Tools and devices

1- Cones
2- Oxygen deficiency masks (Phantom Athletics Training Mask)
3- Ice box
4- Resistance bands
5- Divided boxes
6- Mini hurdles
7- Stop watch
8- Swedish seat
9- Exercise bands
10- Measurement tape
11- Agility ladder

Statistical Analysis

According to the objectives and hypotheses of the study, the author calculated the Mean, Standard deviation, Skewness, Mann-Whitney, and improvement percentage of the output data.

Results

Table (5) declears the statistical significe differences at (0.05) between the pre and post measurements of the participants in functional and HIF variables. Where the calculated Z values are greater than the tabular value.

Table 5. Signifficance of differences between pre- and post measurments of 800m run and blood test results

variables		Pre- measurements		Post measurements		Z* Value	Error
		Rank	Total Rank	Rank	Total Rank		
Physiological	VO2 Max (ml/kg/min)	3.50	21.00	9.50	57.00	2.887	0.002
	HIF (Delta Ct)	4.25	25.50	8.75	52.50	2.169	0.026
	Red cells (cells/ul)	3.50	21.00	9.50	57.00	2.882	0.002
	Hemoglobin (g/dl)	3.50	21.00	9.50	57.00	2.882	0.002
	Lactic acid concentration (mmol/L)	9.50	57.00	3.50	21.00	2.913	0.002
Personal record	800m run	9.50	57.00	3.50	21.00	2.887	0.002

* Z Table value at (0.05) = 1.96

Discussion

The authors attributed these outcomes to the well-structured design of the oxygen deficiency training program, which involved scientifically rationed training loads tailored to the age and training stage of the research sample. The incorporation of oxygen deficiency exercises as a core component played a significant role in enhancing and improving functional physiological variables. Furthermore, the authors linked the improvement in post-measurement results to the direct impact of the proposed program. This program featured scientifically designed oxygen deficiency exercises with varied training loads, which contributed to the observed advancements in performance metrics.

These findings align with the results of several previous studies, including those by Sahar Omran Naser (2019), Hythem M. Aboelmaged Eldakak (2014), Lobna Enaam Abdelkareem (2011), Wfaa Sabah Khfagy (2005), Clark et al. (2008), and Stewart Ghodal (2011). These studies collectively demonstrate that oxygen deficiency exercises positively enhance functional physiological variables, particularly in athletics and other sports.

Oxygen deficiency exercises involve intentionally reducing the oxygen supply to tissues and cells below normal levels, which is achieved through methods such as limiting breathing times, controlling inhalation and exhalation at specific intervals, or training in low-oxygen environments. This deliberate oxygen reduction triggers vital physiological reactions that compensate for the oxygen deficit. Over time, consistent exposure to these exercises leads to functional adaptations, improving the body's ability to cope with oxygen deficiency and enhancing the physiological efficiency of vital organs (Aziza, 2008).

Mohamed Alawy and Abo-Elalaa Abdelfatah (2000) highlighted the successful application of hypoxic training in sports such as swimming, athletics, and basketball. They noted its positive effects, including improved maximum oxygen consumption, optimized blood distribution within muscles, increased glycogen storage in muscles, and enhanced activity of enzymes involved in both aerobic and anaerobic ATP production (Mohamed & Abo-Elalaa, 2000).

These findings align with the observations of Bastawesy Ahmed (2000), who emphasized that hypoxic training enhances cardiovascular efficiency by reducing resting heart rates compared to traditional breathing training methods (Bastawesy, 2000).

The effectiveness of hypoxic training in promoting adaptations in the respiratory and cardiac systems. They also noted its role in increasing aerobic endurance and contributing to higher levels of athletic achievement (Wagdy & Mohamed, 2002).

Hypoxic training limits blood distribution inside the muscle that increases blood effectiveness, metabolism and anaerobic ATP production through lactic acid, and it helps in improving performance by its role.

There is positive relation between improving body functional efficiency and digital achievement level. The authors accepted these results. Improving in digital achievement level of the experimental group is due to using hypoxic training whose effects reflected on efficiency of both respiratory and cardiac systems. (Elhazaa,2019)

Personal record is just the total cooperation and efficiency of different body organs and Personal record produces improving in functional capabilities of interior body organs.

Using training with oxygen deficiency has an effective impact which leads to respiratory and cardiac systems adaptation in addition to increasing aerobic endurance and developing and improving achievement level. (Ahmed,2003)

Hypoxic training which was performed on a group of elite athletes had positive effects on improving physiological functional indicators then improving sports achievement level. (Resan,2016)

Heshmat et. al (2017) pointed that HIF-1 of skeletal muscles arouses genes participated in blood vessels formation and sugar breaking down. It also participated in inhibition of oxygen consumption and aerobic metabolism. This is in opposite of exercises adaptation which activates HIF-1 in skeletal muscles, but this activation reduced after a period of endurance exercises and decreasing oxygen levels in muscles and skeleton during training. This is due to increasing oxygen consumption. Cell response for oxygen deficiency is aroused by activating

sensitive copying factor for oxygen deficiency (HIF-1). HIF-1 genes increase oxygen transmission through techniques as red blood cells formation by Erythropoietin and induced angiogenesis by endothelial growth factor and improving tissues function during oxygen deficiency through increasing glucose transporters and glycolytic enzymes. This makes HIF-1 as mediator in muscles adaptation in endurance exercises but HIF-1 may also prevent cell oxygen consumption and oxidative metabolism of mitochondria and it opposites the peripheral growth of trained muscle.

Skeletal muscles adapt easily with changed functional needs. This adaptation with long term aerobic exercises leads to better aerobic performance during higher intensity through improving metabolic capacity and oxygen supplement. (Hussain,Abdelkafy, Abdelmohsen, 2017)

From the previous, there is a proof of the first research hypothesis validation which is "There are statistically significant differences level (0.05) between pre and post measurements of experimental group in functional variables tests and HIF (under consideration) in favor of post measurement."

These results are accepted by studies of both Esraa Saleh (2019), Hytham M. Aboelmaged Eldakak (2014), Zenab Kahtan Elhashemy (2014), Fayza M. Elsayed Ahmed (2012), Clark and others (2008) Stewart Ghodal and others (2011) that hypoxic training has positive effect on Personal record.

The personal resonrds differences between athletes are real physical capabilities; the fastest athlete is the strongest, the fittest and the best to deserve higher Personal record. The personal record is according to physical capabilities of athletes. (Soliman, Ahmed, Zaky,2002)

This opinion is supported by both of Saad Eldeen Elsharnoby and Abdelmonem Haredy (2004) who emphasized that the best digital achievements are performed through raising physical level. (Saad Eldeen, Abdelmonem,2004)

Developing training performance and Personal record related to raising physical capabilities. (Soliman.1991)

The ability of the athlete to keep high level of performance (90-100%) is due to maximum oxygen consumption which is considered as a success factor. (Johan,2016)

The oxygen amount which muscles consume defines aerobic capacity of maximum oxygen consumption per minute. It is the best individual indicator of the athlete fitness. (Friche,2017)

The authors ensure that hypoxic training makes effect and adaptation in the muscles to endure more load of oxygen deficiency, and it has positive effect on digital achievement level.

These results fulfill the second research hypothesis which is about "There are statistically significant differences between pre and post measurements of experimental group in Personal record of medium distance races athletes in favor of post measurement."

Conclusion

According to the research aim, hypotheses, sample and depending on statistical processes, the authors reached to the following results:

1. There are statistically significant differences in level (0.05) between pre and post measurements of experimental group in maximum oxygen consumption variable (VO2MAX) in favor of post measurement.
2. There are statistically significant differences in level (0.05) between pre and post measurements of experimental group in HIF variable in favor of post measurement.
3. There are statistically significant differences in level (0.05) between pre and post measurements of experimental group in red blood cells in favor of post measurement.
4. There are statistically significant differences in level (0.05) between pre and post measurements of experimental group in lactic acid concentration change variable in favor of post measurement
5. There are statistically significant differences in level (0.05) between pre and post measurements of experimental group in hemoglobin variable in favor of post measurement
6. There are statistically significant differences in level (0.05) between pre and post measurements of experimental group in Personal record of medium distance races athletes (800 m.) in favor of post measurement.

Recommendations

Regarding the role of hypoxic training in general sports field especially in athletics because it has effective impact on physiological and functional aspects then skills levels.
Creating several figures for tools which can be functioned in hypoxic training that affects on physiological and functional variables and Personal record of other sports.

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