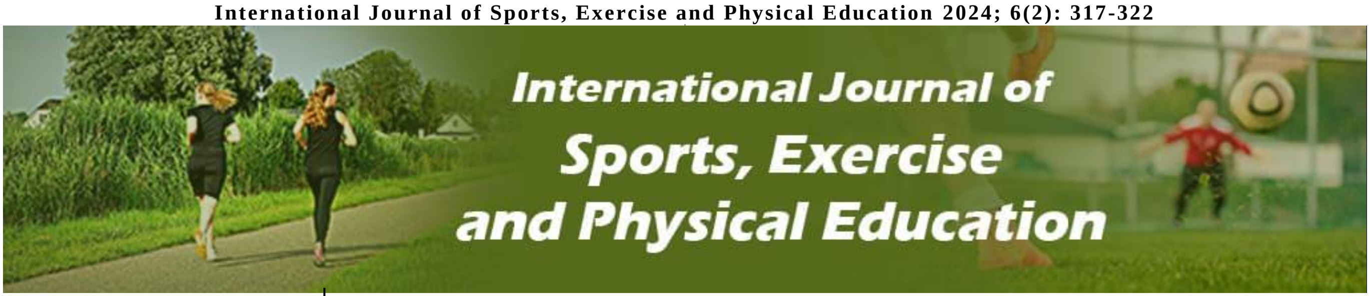


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# Some physiological variables resulting from hypoxic training in young basketball players

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## Abstract
Basketball is one of the games that requires high physical and functional abilities. Therefore, coaches and specialists must work to develop these abilities through various means, including hypoxia exercises, which work directly to create the functional variables of players. The importance of research lies in identifying the most essential functional variables resulting from hypoxia exercises. The researcher noticed a weakness and decline in the players' performance during the competition, especially in the last quarter of the match. Therefore, the researcher solved this problem by developing functional variables for basketball players through Hypoxic Training.
The researcher prepared Hypoxic Training, where the number of training units reached 24 training units at a rate of 3 units per week for eight weeks. The control sample was also based on the trainer's training unit, and the time of the training unit for the experimental sample was 20-30 minutes from the main section. Masks were placed on the nose and mouth to prevent The breathing process while performing the exercise.
After applying the program, the results were extracted using appropriate statistical methods, and several conclusions were reached, including hypoxic training that directly affected the development of some functional variables for the members of the experimental sample. The researcher recommended several recommendations, including the interest of coaches in using hypoxic training within the training units for football players in the basket.

**Keywords:** Hypoxic training, functional variables, basketball performance

## Introduction
Basketball players require a combination of aerobic and anaerobic fitness to meet the physical demands of the sport. Functional systems, particularly the respiratory and cardiovascular systems, play a pivotal role in sustaining performance during high-intensity activities. The efficiency of oxygen utilization and the ability to cope with oxygen debt are critical to maintaining endurance and delaying fatigue.
Hypoxic training, which involves deliberate oxygen restriction during exercise, has gained attention as a method for enhancing physiological adaptations. This training stimulates the body to improve oxygen utilization, increase mitochondrial density, and enhance ATP production, both aerobically and anaerobically. These adaptations can significantly improve players' stamina, recovery, and ability to perform under oxygen-deficient conditions.
However, many basketball players experience performance declines during the fourth quarter of matches, attributed to fatigue and reduced physiological efficiency. This study aims to address this issue by evaluating the effects of hypoxic training on specific physiological variables to enhance players' performance and endurance.

## Research Areas
**Human Domain:** This study focuses on basketball players from the College of Physical Education and Sports Sciences at Mustansiriyah University.

**Spatial Domain:** The research was conducted in the indoor hall of the College of Physical Education and Sports Sciences at Mustansiriyah University.

**Temporal Domain:** The study was carried out over the period from May 11, 2022, to January 25, 2023.

## Materials and Methods

### Study Design

This study employed an **experimental design** with pre- and post-tests conducted on two groups: an experimental group receiving hypoxic training and a control group following a standard training program.

### Participants

Ten basketball players from the College of Physical Education and Sports Sciences, Mustansiriyah University, were divided into:

- **Experimental Group:** 5 players undergoing hypoxic training.
- **Control Group:** 5 players following a conventional training regimen.

### Hypoxic Training Protocol

- **Duration:** 8 weeks, with 3 sessions per week, totaling 24 sessions.
- **Exercise Design:** Hypoxic training lasted 20–30 minutes during the main section of each session. Players used breathing-restrictive masks to simulate oxygen deficiency.
- **Rest and Intensity:** Exercises followed a 1:1 work-to-rest ratio, with intensities varying from moderate to high.

### Measured Variables

The following physiological variables were assessed:

1. **$VO_2max$:** Using the Bruce Test to measure maximum oxygen uptake.
2. **Breathing Rate:** Number of breaths per minute.
3. **Breath-Holding Capacity:** Duration of sustained breath-holding.

**Blood Oxygen Saturation:** Measured with an oximeter

### Search tests

**First: Bruce Test Vo2max [1].**

- The goal of the test is to measure the maximum oxygen consumption.
- Devices and tools: Fit Mate Pro uses a Treadmil device.
- Description of performance: As requested, the player's data is entered into the Fit Mate Pro device.
- Performance method: The tester performs a warm-up on top of the Tread Mill by controlling the speed for a period of (3-5) minutes before performing the actual test. The tester climbs onto the Tread Mill, then wears the Fit Mate Pro's heart rate belt and the Vo2max indicator mask.
- The treadmill is turned on, and then the Fit Mate Pro, previously set to the Vo2max test, is turned on.
- Here begins Bruce's method of performing graduated effort. The tester promises to increase the speed and incline of the Trade Mail device every three minutes and increase the intensity every three minutes according to the schedule—Bruce's stress test. The tester continues to perform until the effort is exhausted, after which he presses the end button of the Trade Mail device.
- Calculating the score: The result is based on the value of the Vo2max given by the device, measured in milliliters/kg/minute.

**Second, test the number of breathing times**

- Performance method: The player sits on a chair, then the tester places a stethoscope on the lower part of the diaphragm.
- Recording method: Record the number of breathing times per minute.

**Third, Breath holding test**

- Method of performance: The player sits on a chair, takes a deep inhale, then places a mask on the nose and closes the mouth, thus indicating the start of the stopwatch, and the player continues to hold the Breath until the end of his ability to continue.
- Method of scoring: The player can make three attempts, and the best attempt is counted (the rest period between one attempt and the next is 15 seconds).

**Fourth, Measuring blood oxygen levels**

The blood oxygen level was measured using an oximeter.

- **How to use:** The index finger of the left hand is inserted and placed towards the left side of the chest inside the two nostrils of the device, then press the power button on the front of the device and wait for several seconds until completion. Two readings appear on the screen, the first indicating the heart rate and the second indicating the saturation percentage. Oxygenated blood.

### Pretests

The pretests were conducted on Thursday, November 10, 2022. The following assessments were performed:

1. **Bruce Test ($VO_2max$):** Conducted at 10:00 AM in the laboratory of the College of Physical Education and Sports Sciences, Mustansiriyah University.
2. **Blood Oxygen Percentage Measurements:** Measurements were taken at 3:00 PM using an oximeter to assess blood oxygen levels.
3. **Respiratory Assessments:** The number of breaths per minute was recorded, followed by a breath-holding test, all conducted on the same day.

### Main Experiment

The main experiment was conducted on Sunday, November 13, 2022. The experimental procedures were as follows:

- **Experimental Group:** Participants underwent **Hypoxic Training** exercises, applied three times per week for a duration of **eight weeks**, totaling **24 training sessions**.
- **Control Group:** Hypoxic Training exercises were not applied to the control group. Instead, the group followed the standard training program designed by their coach.

### Conditions for Hypoxic Training [2, 3]:

- **Volume:** The hypoxic training component constitutes **25-50%** of the total duration of the training unit.
- **Usage Limitations:** Extended use is not recommended due to the risk of fainting or nausea.

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[1] Poole DC, Jones AM. Measurement of the maximum oxygen uptake $\dot{V}o_{2max}$ : $\dot{V}o_{2peak}$ is no longer acceptable. *Journal of Applied Physiology*. 2017;122(4):997-1002. doi:10.1152/japplphysiol.01063.2016

[2] Amr Allah Ahmed Al-Basati: Rules and foundations of sports training and its applications, Alexandria, Dar Al-Maaref, 1998, p. 100.

[3] Abu Al-Ela Ahmed Abdel Fattah: Sports Training, Physiological Foundations, Cairo, Dar Al-Fikr Al-Arabi, 1996, p. 55.

- **Health Precautions:** Training should be stopped immediately if participants experience headaches, which may persist for up to 30 minutes.
- **Adjustments:** Repetitions should be reduced when performing speed-focused exercises.
- **Competition Restrictions:** Hypoxic training is not to be employed during competitions.

### Hypoxic Training Program

- **Frequency:** Three training sessions per week over a period of eight weeks, totaling 24 training sessions.
- **Control Group Protocol:** The control group adhered to the standard training program designed by their coach.
- **Experimental Group Protocol:** The training sessions for the experimental group involved 20-30 minutes of hypoxic exercises, conducted during the main portion of the training unit.
- **Equipment:** Participants used specialized masks covering the nose and mouth to restrict breathing during exercise.
- **Timing:** Exercises were implemented during the specific preparation phase of the training program.
- **Rest Periods:** A work-to-rest ratio of 1:1 was maintained, where rest duration equaled the time taken to perform the exercise.
- **Intensity Variation:** The training followed a principle of undulating intensity, with levels ranging from moderate to high intensity.

**Sample of the training unit (from the main section)**
**Training unit:** Fourth Rest between exercises 1/1

**Unit time of the main section:** 25.29 minutes Rest between sets: 60 seconds

**Table 1:** Hypoxic Training

| Sequence | Training<br>Intensity of training units - moderate to maximum | Time to perform the training | Repeat the training | Rest between training | Groups | Rest between sets | Total time |
|---|---|---|---|---|---|---|---|
| 1. | Dribbling with the ball without wearing a mask along the field back and forth. | 30 sec | 5 | 30 sec | 1 | 60 sec | 5.5 min |
| 2. | Run along the field while wearing a mask until the effort runs out without stumbling. | 35sec | 5 | 35 sec | 1 | 60 sec | 6,25min |
| 3. | Back and forth, dribbling the ball while wearing a mask throughout the field. | 40 sec | 3 | 40sec | 1 | 60 sec | 4,33min |
| 4. | Run along the field, tapping the ball repeatedly while wearing a mask until the effort runs out. | 47 sec | 4 | 47sec | 1 | 60 sec | 4.91min |
| 5. | Dribble the ball between the posts while wearing a mask along the field until the effort runs out. | 50 sec | 2 | 50 sec | 1 | 60 sec | 3.5min |
| 6. | I climbed the stairs while wearing a mask until the effort ran out. | 26 sec | 2 | 26 sec | 1 | 60 sec | 1.3 min |

### Post-tests

The posttests were conducted on Monday, January 16, 2023, at 10:00 AM. The same procedures, conditions, and sequence used during the pretests were applied to ensure consistency and reliability in the data collection process.

### Statistical Methods

The statistical analysis was conducted using the SPSS software to process the results and derive evidence. The following statistical tools were employed:

- **Arithmetic Mean:** To determine the central tendency of the data.
- **Standard Deviation:** To measure data dispersion around the mean.
- **Median:** To identify the central value of the dataset.
- **Skewness:** To assess the symmetry or asymmetry of the data distribution.
- **t-Test:** To compare means and evaluate significant differences between the experimental and control groups.

### Presentation, analysis, and discussion of results

### Presentation and analysis of the results of pre-and post-tests and measurements for the control sample

**Table 2:** It shows the pre- and posttest results and measurements of the control group.

| Variables | Unit of measurement | pre | | Post | | Calculated T value | T value Tabulation | significance |
|---|---|---|---|---|---|---|---|---|
| | | $\bar{x}$ | s | $\bar{x}$ | S | | | |
| Vo2max | ml/kg/d | 111.714 | 1.2495 | 112.7 | 1.0295 | 1.4469 | 2.132 | No sign. |
| Number of breathing times | Once/d | 33,35 | 1,88 | 30,39 | 1,79 | 1.0190 | | No sign. |
| Hold your Breath | second | 40 | 4.743 | 39.8 | 5.21 | 0.19824 | | No sign. |
| O2 level in the blood | mmHg | 94.2 | 2.683 | 94 | 3.87 | 1.943 | | No sign. |
| Under a significance level of 0.05 and a degree of freedom of n-1 | | | | | | | | |

From Table (2), it is clear that there are no statistically significant differences in the research sample for the control group in the pre- and post-measurements and tests in the variables investigated, as the arithmetic mean in the pre-measurement for each of (Vo2max, number of breathing times, holding the Breath, O2 percentage in the blood) was (111.714/33.35/40/94.2)

**Display and analyze the results of the pre- and posttests and measurements of the experimental sample**

**Table 3:** Results of pre-post tests and measurements for the experimental sample

| Variables | Unit of measurement | pre | | post | | Calculated T value | T value Tabulation | significance |
|---|---|---|---|---|---|---|---|---|
| | | $\bar{x}$ | s | $\bar{x}$ | s | | | |
| Vo2max | ml/kg/d | 112.01 | 0.990 | 121.6 | 1.949 | 7.87 | 2.132 | No sign. |
| Number of breathing times | Once/d | 36.7 | 3.15 | 29.46 | 1,70 | 4.78 | | sign. |
| Hold your Breath | Second | 39.4 | 4.449 | 61.6 | 6,65 | 4,95 | | sign. |
| O2 level in the blood | mmHg | 92.2 | 2.16 | 97.6 | 3.87 | 0.546 | | sign. |
| Under a significance level of 0.05 and a degree of freedom of n-1 | | | | | | | | |

Through Table (3), it is clear that there are statistically significant differences between the research sample and the experimental group in the pre-and post-measurements and tests in the variables investigated, as the arithmetic mean in the pre-measurement for each of (Vo2max, number of breathing times, holding the Breath, O2 percentage in the blood) was (112.01/36.7/39.4/92.2) and the standard deviation for the exact measurement (Vo2max, number of breathing times, holding the Breath, O2 percentage in the blood) was (0.990/3.15/4.449/2.16). As for the arithmetic mean in the post-measurement of the same indicators (Vo2max, number of breathing times, holding the Breath, O2 percentage in the blood), it was (121.6/29.46/61.6/97.6), and the standard deviation was as follows (1.949/1.70/6.65/3.87). The calculated (T) value was (7.87/4.78/4.95/0.546).

**Presentation and analysis of the results of post-post tests and measurements for the control and experimental samples**

**Table 4:** Results of post-post tests and measurements for the control and experimental samples.

| Variables | Unit of measurement | pre | | post | | Calculated T value | T value Tabulation | significance |
|---|---|---|---|---|---|---|---|---|
| | | $\bar{x}$ | s | $\bar{x}$ | s | | | |
| Vo2max | ml/kg/d | 112.7 | 0,701 | 121.6 | 1.949 | 7.64 | 2.353 | No sign. |
| Number of breathing times | Once/d | 30,39 | 1.79 | 29.46 | 1.70 | 2,73 | | sign. |
| Hold your Breath | Second | 39.8 | 5.21 | 61.6 | 6.65 | 4,98 | | sign. |
| O2 level in the blood | mmHg | 94 | 3.87 | 97.6 | 3.87 | 5.412 | | sign. |
| Under a significance level of 0.05 and a degree of freedom of n-2 | | | | | | | | |

Through Table (4), it is clear that there are statistically significant differences in the research sample for the control and experimental group in the tests and post-measurements in the variables investigated, as the arithmetic mean in the posttest for the control group was (Vo2max, number of breathing times, holding the Breath, O2 percentage in the blood) (112.7/30.39/39.8/94) and the standard deviation for the exact measurements (Vo2max, number of breathing times, holding the Breath, O2 percentage in the blood) was (0.701/1.79/5.21/3.87), As for the arithmetic mean in the post-measurement of the experimental group for each of (Vo2max, number of breathing times, holding the Breath, O2 percentage in the blood), it reached (121.6/29.46/61.6/97.6), while the standard deviation was (1.949/1.70/6, 65/3.87). The calculated (T) value was (7.64/1,732/4.98/5.412).

**Discussion of Results**

Through Table (2), it is clear that there are statistically significant differences among the research sample for the control group in the measurements and pre-and posttests in the variables investigated for each of (Vo2max, number of breathing times, holding the Breath, O2 percentage in the blood). The significance for all variables was not significant and is attributed to The researcher explaining the reason for the training of the control sample, which relied on the trainer's approach and did not include hypoxic training, which did not affect the variables investigated.

As for Table (3), it is clear that there are statistically significant differences among the research sample for the experimental group in the measurements and pre-and posttests in the variables investigated for each of (Vo2max, number of breathing times, holding the Breath, O2 percentage in the blood). The significance was significant for all the variables investigated, and the researcher attributes the reason for training the experimental sample to be based on Hypoxic Training prepared by the researcher.

Regarding Table (4), it is clear that there are statistically significant differences in the research sample for the control and experimental groups in the tests and post-measurements in the variables investigated. The significance was significant for the variables (Vo2max, number of breathing times, holding the Breath, O2 percentage in the blood) and in favor of the experimental sample if the researcher attributes this to the program proposed and prepared by him.

The training curriculum that included hypoxic exercises (lack of oxygen) led to the development of the anoxic lactic capacity of the experimental sample because this capacity represents the ability to continue the muscular effort in the absence of oxygen, as the anoxic capacity means the ability of the muscle to work within the framework of energy production. Anoxia that ranges between 30 seconds and 2 minutes with maximum intensity.

Anoxic capacity is "the ability to maintain or repeat maximum muscle contractions based on the anoxic energy of the lactic acid system and includes all activities performed with the maximum possible muscle contractions while withstanding fatigue for up to a minute or two."[(4)]

The significant burdens that the members of the experimental sample were exposed to as a result of the training led to an impact on the respiratory system by affecting the respiratory muscles. Its purpose is to compensate for the lack of oxygen resulting from the use of

[4] Bahaa El-Din Ibrahim Salama: Biochemical Characteristics of Sports Physiology, 1st edition, Cairo, Dar Al-Fikr Al-Arabi, p. 277, 2008 AD.

masks, and this leads to flexibility in the strength of the respiratory muscles, which leads to the lungs absorbing more significant amounts of air as The larger the size of the chest cavity, the greater the vital capacity and breathing volume of the players.

This is confirmed by J. A. Crane, "The force of the breathing muscles increases in contraction during increased athletic activity, which leads to the expansion of the rib cage and the entry of more air volume, so the tidal air volume increases, the depth of breathing increases, and gaseous exchange between the blood and the alveoli improves." [5]

As for the number of breathing times and the increase in the percentage of oxygen in the blood, the researcher attributes this to the fact that the body resorts to increasing the speed of breathing during effort or other situations such as poisoning or air pollution. The respiratory system increases breathing speed by increasing breathing times to compensate for the oxygen consumed due to muscular work during performance. It also compensates for the missing amount of oxygen due to hypoxic exercises as a reflex reaction of the respiratory system, thus moving the breathing muscles and achieving adaptation. This is what Ayesh confirmed: "The body resorts to compensating for the lack of oxygen by increasing the speed of breathing or increasing red blood cells" [6] as "increasing the speed of breathing is a reflexive reaction of the respiratory system to compensate for the oxygen consumed during effort and the missing amount of oxygen reaching the muscles as a result of placing the mask on the nose and mouth, which works." Obstructing oxygen entering the body Here, the body also increases red blood cells to compensate for the lack of oxygen because oxygen binding is linked to the hemoglobin inside the red blood cells [7].

Breathing control exercises lead to some physiological adaptations due to the decrease in the level of oxygen and the increase in the level of carbon dioxide in the blood on the central chemical receptors in the brain by 80-85% and on the surrounding chemical receptors in the carotid artery and aorta, causing an increase in the rate of pulse and breathing and nullifying voluntary action. Breathing does not stop.

## Conclusions and Recommendations

### Conclusion

The study confirmed that hypoxic training effectively enhances key physiological variables in basketball players, including $VO_2max$, respiratory efficiency, and oxygen saturation. These improvements are particularly valuable for sustaining performance and delaying fatigue during high-stress game phases, such as the fourth quarter.

By stimulating adaptations in the cardiorespiratory system and increasing oxygen efficiency, hypoxic training addresses the performance declines commonly observed in basketball players. Coaches are encouraged to integrate hypoxic exercises into training programs to enhance functional abilities. The study also recommends exploring the application of hypoxic training in other sports and events to maximize its benefits.

[5] J. J. Crane: Foundations of Clinical Physiology, translated by Dhafer Al-Yassin, Baghdad, University Press, 1986, p. 33.

[6] Ayesh Zaitoun: Human Biology, Principles of Anatomy and Physiology, Jordan, Dar Ammar for Publishing and Distribution, p. 252, 2002 AD.

[7] Alaa Fouad Saleh: The effect of hypoxic exercises on developing speed endurance and achieving a 400-meter run, unpublished master's thesis, College of Physical Education, University of Baghdad, p. 84, 2009.

### Recommendations

1. Trainers' interest in using Hypoxic Training within the training units for basketball players.
2. Basketball coaches and specialists must pay attention to breathing exercises.
3. Conduct studies similar to Hypoxic Training for other games and events.

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