

Development of some aerobic and anaerobic indicators in under-21 footballers using hypoxic training mask during the physical preparation period

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ABSTRACT

This study aims to identify the effect of a training program using the hypoxic training mask on certain aerobic capacities (VMA, VO₂max), on the effectiveness of the repetition rate (RSA), and on the explosive power of football players. The sample was deliberately selected and included 20 football players under the age of 21 from the Tiaret youth team, which plays in the second professional division. A total of 10 players were assigned to a control group and the other 10 players to an experimental group. The research used a series of physical tests that included VMA/VO₂max intermittent yo-yo tests and RSA repetition rate efficiency tests, in addition to the explosive force tests using the MYOTEST device. The same training program was applied to the experimental and control groups, with the first one using the mask for 8 weeks. The study concluded that there are statistically significant differences in the pre- and post-measurement of the experimental and control groups in the measurement of aerobic and anaerobic capacities in favor of the experimental group, who wears the hypoxic mask. This underlines the importance of using modern technological means in the process of physical preparation and raising the level and efficiency of the players to reach the highest levels of achievement.

KEYWORDS

Hypoxic mask; Physical training; Football.

1. INTRODUCTION

One of the most important current topics that arise in the field of scientific research related to physical preparation is the proper preparation and the achievement of players at the highest levels of

success. This is possible thanks to the creation of a set of modern training methods that make the process able to be studied and regulated according to scientific foundations (Buchheit et al., 2012). In turn, sports training is a process aimed at improving the player's physical and skill levels and mentally preparing them to perform all the requirements during football matches (Dellal et al., 2008).

Crisafulli et al. (2007) also indicate that the requirements of the matches in modern football force the player to make more efforts by virtue of tactical discipline and the principle of integration between skill and physical abilities in the physical preparation phase. Physical competence plays an essential role in the skill and mental fitness of the player, which qualifies him to perform his tasks more efficiently and fulfil his defensive and offensive functions during the match (Dellal et al., 2008).

Enright and Unnithan (2011) indicate that oxygen plays an important role in energy production processes, aerobic energy in particular. This deficiency in the respiratory process leads to the development of adaptations that overwork the circulatory and respiratory systems. Therefore, the body's ability to perform the effort and the adaptation of the circulatory and respiratory systems contributes to developing the physical efficiency of the athlete, in addition to its importance in energy production.

Legere and Cazorla mention that the ability of the muscle to absorb oxygen is a significant factor in the restoration of anaerobic energy sources, ATP-CP (Reiss & Prévost, 2013). Coach Rabeh Saâdane, the former coach of the Algerian national team, explained that the team faced difficulties participating at the 1986 World Cup tournament in Mexico, due to the height above sea level, which caused difficulties for the players that had to adapt to the environment resulting in hypoxia.

When the players travelled to the countries in the jungles of Africa, it was also noted that the Algerian clubs showed decreased physical fitness, and even suffered injuries due to fatigue and exhaustion, making them unable to finish the matches with the same pace. This also shows their inability to adapt to difficult climates, such as humidity and difficulty to breathe, and highlights the importance diversifying training methods, including the hypoxic methods that would allow players to adapt to the difficult climate environments.

Granados et al. (2014) say that the methods of hypoxic training simulate altitude conditions. They also mention training in altitude simulation rooms as a solution, which are rooms in which the oxygen pressure simulates heights of more than 1500 metres, that are altitudes that are almost non-existent in Algeria.

Moreover, it is also possible to train using the breathing control method by reducing the breathing rate or by using modern breathing masks. This leads to a decrease in the amount of oxygen

needed by the muscle tissue and body cells, and leads to an increase in the body's ability to adapt to low oxygen and an improvement in the body's physiological responses (Flowers et al., 2015).

Due to the fact that lack of oxygen intake affects the athlete's performance levels, these training methods have had a high demand. On top of that, De Paula and Niebauer (2012) add that hypoxic exercises using modern masks contribute to raising physiological efficiency, represented in aerobic and anaerobic capacities. This is what prompted the researchers to try to shed light on this topic, which deals with one of the challenges of physical preparation in football.

This study introduced a modern technology in the form of the hypoxic training mask; similar to previous studies such as the study made by Porcari et al. (2016), which analyzed the effect of wearing a simulated altitude training mask on aerobic capacity, lung function and haematological variables. That study aimed to use height training and respiratory muscle training (RMT) to improve performance in elite and well-trained athletes by simulating altitude training with hypoxic masks to increase aerobic capacity (VO₂max), endurance and lung function.

The program proposed by Porcari et al. (2016) was applied to 24 trainees over 6 weeks of high-intensity training, showing positive results on pre- and post-training tests. The tests included VO₂max, lung function, maximum inspiratory pressure, haemoglobin and hematocrit, the most important of which was a significant improvement in VO₂max in controls (13.5% and 9.9%) and mask users (16.5 % and 13.6%). Only the mask group showed significant improvements in ventilation threshold (VT), which amounted to 13.9%, there were also improvement trends in VT and PO on the experimental group, but they were similar to the improvements in RCT and PO in the RCR of the control group.

The reasoning behind this improvement is that the mask looks more like a respiratory muscle training device. Using a hypoxic mask during a training program to control the gyro HIIT for 6 weeks can improve the performance variables, such as VO₂max, PPO, VT, PO to VT, RCT, and PO to RCT. Strength, or the stimulation of changes in haemoglobin levels or hematocrit, does not imitate a hypoxic training mask device for heights, but works more like a respiratory training device (Porcari et al., 2016). According to the study conducted by Flowers et al. (2015), exercising for 60 minutes without a mask is equal to about 20 minutes with a mask, and this is the best way to do cardio. Another study made by Epthorp (2014) shows that the usage of a mask leads to the development of muscle efficiency, as the lack of oxygen supply leads to more effort and longer work in order to compensate for oxygen deficiency.

By collecting scientific material and theoretical knowledge on the subject, the researchers found that there are many studies dealing with the subject of hypoxia, but there were few related to

football. To fill these scientific gaps, the researchers decided to explore the use of the hypoxic training masks as a means to increase physical efficiency and improve aerobic capacity.

The main question was: What is the effect of the use of a hypoxic mask on aerobic and anaerobic abilities of football players under the age of 21? The sub-questions were: 1) What is the effect of using hypoxic masks on the maximum aerobic speed (VMA) for football players under the age of 21? 2) What is the effect of using hypoxic masks on the effectiveness of the repetitive velocity efficiency (RSA) for football players under the age of 21? 3) What is the effect of using hypoxic masks on the explosive power of footballers under the age of 21?

The main hypothesis was: The use of a hypoxic mask has a positive effect on the development of certain aerobic and anaerobic abilities for football players under the age of 21. The partial hypotheses were: 1) There are statistically significant differences between the pre- and post-measurements of the experimental and control groups in favor of the experimental group, in the development of VMA and VO₂max for football players. 2) There are statistically significant differences between the pre- and post-measurements of the experimental and control groups in favor of the experimental group, in the development of the effectiveness of the RSA repetition rate of football players. 3) There are statistically significant differences between the pre- and post-measurements of the experimental and control group in favor of the experimental group in the development of the explosive power of football players.

This research aims to design a training program using hypoxic masks in order to develop certain aerobic and anaerobic abilities of football players under the age of 21. It also seeks to encourage researchers and coaches to work on the use of innovative technologies in the training process, updating training routines with the use of modern science.

The importance of this research lies in its novelty, using modern devices (such as the hypoxic mask) and supported with recent studies. Moreover, implementing this training program that simulates the absence of oxygen without making the players travel to higher altitudes saves on costs and provides material liquidity. It also increases the player's muscle activity faster by using a scientific and practical way, allowing opportune and timely adaptations for muscle work requirements and physical loads at different oxygen levels. This is especially true given that traditional football matches last from 90 minutes to 120 minutes, which is very demanding for the player. This makes necessary to provide efficient training alternatives that also make resorting to prohibited substances such as steroids less tempting to achieve the desired results.

2. METHODS

2.1. Design and participants

The researchers used the experimental approach, as it is one of the most appropriate scientific methods to determine the causes of a phenomenon and find the corresponding solutions. It also offers the most reliable approach in its results, as well as its compatibility with the nature of the field tests applied to conduct the research.

A total of 20 players were chosen from the JSMT youth team of the second professional league (U-21 years old). Then, they were divided into two groups, 10 players for the experimental group that used the training mask and 10 players for the control group (Table 1). Before starting the study, the researchers performed a medical examination of the players of the control and experimental groups, and obtained the approval of a qualified doctor.

Table 1. Degree of homogeneity between the two groups

Variable	Unit	Experimental group		Control group		t	p
		Mean	SD	Mean	SD		
Age	Year	20.25	0.85	20.54	0.91	0.91	>0.05
Training age	Year	5.61	0.77	4.88	0.81	0.27	>0.05
Weight	kg	69.09	2.55	68.11	2.13	1.96	>0.05
Height	cm	1.71	0.08	1.72	0.11	1.98	>0.05
Muscle mass index	IMC=P/T ²	26.66	0.92	23.08	0.88	0.17	>0.05

2.2. Instruments and procedures

The research used a series of physical tests that included VMA/VO₂max intermittent yo-yo tests and RSA repetition rate efficiency tests, in addition to the explosive force tests using the MYOTEST device.

The proposed training program was prepared by the technical staff of the team along with the research team. It consisted of two sessions during the week with each group, with the experimental group using the hypoxic masks during the different exercises.

The study implemented subjective and objective indicators to calculate the training load. Additionally, the study used the RPE index and GPS devices to calculate the heartbeat rates. The monitoring was carried over the different phases of the training sessions. An active effort was made to motivate the players to work hard and respect the training, in order to increase the rate of success and efficiency of the program.

2.3. Statistical analyses

The statistical analyses were carried out with the Statistical Package for the Social Sciences (SPSS), version 24. With SPSS, the researchers calculated means, standard deviations and t tests. Statistical significance was set at $p < 0.05$.

3. RESULTS AND DISCUSSION

3.1. Yo-Yo VO₂max/VMA test

Observing the results of the Table 2, it becomes clear that the experimental group obtained 15.70 ± 1.98 in the pre-test, while the post-test was 17.30 ± 0.45 . The calculated value (T) was 17.65, which is higher than the tabular (T) estimated at 2.26, and it is at the level of significance 0.01 and a degree of freedom of 9. This means that the difference between the pre-test and the post-test is a statistically significant difference in favor of the post-test.

As for the control group during the pre-test, it was 15.82 ± 0.61 and the post-test was 16.01 ± 0.78 , and the calculated (T) value was 5.85, which is higher than the tabular (T). This gets an estimated value of 2.37 at the level of significance 0.01 and a degree of freedom 9. This means that the difference is a statistically significant difference between the pre-test and the post-test, favoring the post-test.

The VMA test regarding the calculated T showed similar results. It was estimated at 5.85 for the control sample and 17.65 for the experimental sample. Provided that this is the same test with the VO₂max index, which is higher than the tabular (T) estimated at 2.37, it was given a level of significance 0.01 and a degree of freedom of 9. This means that the difference between the pre-test and the post-test is a statistically significant difference in favor of the post-test.

Table 2. Comparison of the results of the pre- and post-test for the two research groups in the Yo-Yo VO2max/VMA test.

Variable	Test	Experimental group		Control group		p
		Mean	SD	Mean	SD	
VO2max	Pre-test	54.95	1.98	55.37	2.03	<0.01
	Post-test	60.55	1.66	56.03	2.87	
VMA	Pre-test	15.70	0.68	15.82	0.61	<0.01
	Post-test	17.30	0.45	16.01	0.78	

Regarding the discussion of results of the YOYO test to measure the aerobic capacities of VMA/VO2max for the football players, these results are similar to those of previous studies, such as the study by Liesen and Hollman (1972). Their study was conducted on six athletes specialized in 5000 metres running events, with the aim of identifying the effect of the two-week training process at an altitude between 1950 metres and 2800 metres at sea level. The study aimed to measure the efficiency of the circulatory system after returning to sea level. Its results indicated that there was an increase in oxygen of 12.5% compared to that before the start of the training in the field. It also measured a pulse of 180.

The results obtained were also consistent with the results of Schmitt et al., whose study was conducted with the aim of analysing the effect of training while exposed to hypoxia conditions. This aim originated due to hypoxia's effects on the energy exchange and the appropriate systems for such changes. The study was conducted for a period of at least 15 days of exposure to such conditions and after the completion of a training program in conditions of hypoxia at high altitude.

The return to lower levels after the recovery process shows the response of several physiological variables, including an increase in the maximum oxygen volume (VO2max), the increase in the maximum aerobic capacity (PMA), and the uniformity of the body. It was also reflected in an increase in the maximum aerobic speed (VMA) and the increase in the haemoglobin concentration.

This increase or improvement begins to appear after waiting up to three weeks, as indicated by the results of the following measurements. One day before the start of the program, the average VO2max values for the sample were around 60 ml/d.kg, but one day after its end, the rate increased to 65 ml/d.kg. However, two weeks after the end of the program, the rate returned to 61 ml/d.kg.

With regard to the values of maximum aerobic capacity (PMA), the results were as follows. One day before the start of the program, the average PMA values were around 300 watts/sec, but one day after the end of the internship, the rate increased to 320 watts/sec. During the program, the rate increased to about 325 watts / sec. This data aligns with the findings of Epthorp (2014), who found that the hypoxic mask helps in the occurrence of muscle adaptations to lack of oxygen, appearing in the enlargement of the alveoli in order to absorb the greatest amount of O₂. Furthermore, this increases the percentage of saturation of the blood at an estimated rate of more than 94%; this is a remarkable development because it is proof of the adaptation of the respiratory muscles. Under the light of these results, it is evident that there are statistically significant differences in the pre- and post-measurement between the experimental and control groups in the VMA /VO₂max measurement in favor of the former.

3.2. RSA repetition speed efficiency test and Myo test to measure explosive muscle power

Observing the results of the Table 3, it becomes clear to us that the control group obtained 7.07 ± 0.26 in the pre-test, while the post-test was 7.01 ± 0.21 , the calculated (T) value was 3.78, which is higher than the tabular (T) estimated at 2.37, and it is at the level of significance 0.01 and a degree of freedom of 9. This means that the difference between the pre-test and the post-test is statistically significant in favor of the post-test.

As for the experimental group, during the pre-test, it reached 7.19 ± 0.37 , and in the post-test it reached 6.93 ± 0.19 , the calculated value (T) reached 5.87, which is higher than the table (T) estimated at 2.37 at the level of significance 0.01 and 9 degrees of freedom. Thus, the difference between the pre-test and the post-test is statistically significant in favor of the post-test.

Table 3. Comparison of the results of the pre- and post-test for the two research groups in the RSA repetition speed efficiency test.

Variable	Test	Experimental group		Control group		p
		Mean	SD	Mean	SD	
RSA	Pre-test	7.19	0.37	7.07	0.26	<0.01
	Post-test	6.93	0.19	7.01	0.21	

Observing the results of the Table 4, it becomes clear to us that the control group obtained 51.86 ± 1.81 in the pre-test, while the post-test was 58.64 ± 2.29 , and the calculated (T) value was 9.71, which is higher than the tabular (T) estimated at 2.37, and it is at the level of significance 0.01

and a degree of freedom of 9. This means that the difference between the pre-test and the post-test is statistically significant in favor of the post-test.

The experimental group reached 50.78 ± 2.56 during the pre-test and 65.60 ± 4.58 during the post-test, and the calculated value (T) was 9.85, which is higher than the tabular (T) estimated at 2.37 at the significance level 0.01 and a degree of freedom of 9. This means that the difference is statistically significant between the pre-test and the post-test, in favor of the post-test.

Table 4. Comparison of the results of the pre- and post-test of the two research groups in the Myo test to measure explosive muscle power

Variable	Test	Experimental group		Control group		p
		Mean	SD	Mean	SD	
Myo test	Pre-test	50.78	2.56	51.86	1.81	<0.01
	Post-test	65.60	4.58	58.64	2.29	

Hypoxic exercises are a modern training method that employ lower oxygen levels than necessary to supply the body's cells to obtain positive effects. This is done by generating a hypoxic environment during normal physiological functions of the vital organs. This environment is used to lower the amount of oxygen required for the cells and tissues of the body (Gething et al., 2004).

Numerous foreign studies have proved, summarizing their results, that training with the help of hypoxic masks has very positive effects on the functional state of the limbs involved in the activity. In the study of Porcari et al. (2016) a training program consisting of a six-week monthly plan at the rate of two sessions per week on high-level athletes was implemented. The sample of this study was divided into two groups, one of which trained at a high altitude and the other using the training mask. After carrying out the post-tests, it was found that there were no statistically significant differences between the two groups in each of the lung function tests and blood variables. However, there was an improvement of 12.6% in the muscle capacity tests in the group that trained with the masks. This confirms the reliability and effectiveness of this training mask simulating altitude training through the convergence of the results of the post-tests between the two groups.

A previous study, similar to the resistance study, showed various exercise strategies using hypoxia to develop muscle size and capacity. Manolova (2017) performed this study on a group of high-level athletes specialized in speed, using mixed training by simulating heights using modern

hypoxic training masks. She conducted the training program that used hypoxic masks for 8 consecutive weeks. The first 4 sessions were used to get the athletes accustomed to the mask, the next 2 sessions for muscle strength development, the next 2 sessions for speed development, and 1 session of aerobic work in which the mask is not used. The results obtained show that it has an effect in the development of muscle strength characteristics, and this automatically affects the development of speed characteristics by 9%. This evolution is considered statistically significant compared to the difficulty in developing this trait.

The study conducted by Porcari et al. (2016) showcased the effect of a training course using the hypoxic method with a mask for the development of certain special physical abilities. In this research 32 training units were applied to the experimental group, which were carried out in the span of eight weeks, at a rate of four training units per week. The most important result of this exercise was that it proved that using the hypoxic mask had a positive effect on the development of the strength of the arms and legs for the group who trained with it greater than the control group. On top of that, it helped to improve the transition speed and endurance, especially for the muscles of both legs.

The researchers attribute this effect to the fact that modern respiratory masks help to develop the anaerobic abilities of football players, as the use of the hypoxic training mask has shown to be involved in the improvement of biochemical processes in the cytoplasm of muscle cells. This is explained in the fact that neurons have abundant energy reserves that are specialized in oxidation and energy production in the areas of neuromuscular communication. To increase the efficiency of this process, it is required to increase oxygen demand, which in turn helps to improve neuromuscular work. This leads to the improvement and development of muscle abilities, which is evidenced through the development of muscle capacity and speed endurance in the tests of our research and study sample. Furthermore, this confirms that there are statistically significant differences in the measurements made before and after the training program between the experimental and control groups in the effectiveness of the repetition rate (RSA) and muscle capacity, in favor of the experimental sample of football players under 21 years of age.

4. CONCLUSIONS

There were non-statistically significant differences for the results of the pre-tests between the experimental and control groups in the tests that were evaluated, which indicates homogeneity among the groups before starting to implement the proposed training program for the research group.

The proposed training program using the hypoxic training mask obtained a positive development between the pre- and post-tests. The training of aerobic and anaerobic abilities with a mask is considered a very effective training for competitions, thanks to the diversity of the way of breathing and the oxygen inhaled, which are situations that players encounter inside the field, and these strong and fast movements are often the decisive factor in matches.

The control and experimental groups obtained positive results between the pre- and post-tests in the tests of aerobic capacity. This was shown through the effectiveness of the repeated speed VMA / VO₂max, RSA, explosive force and speed, but the improvement of the control group was a natural result of practicing, while the development of the experimental group was a relatively clear development. Moreover, the difference between the two averages indicates that there is a significant difference.

The researchers suggest conducting the study on different age groups, in addition to studying other physiological variables of the players. The study also hints at a need to raise the cognitive abilities of trainers in the field of sports training in a scientific way. This could be done by organizing a set of forums and internships under the supervision of executives specialized in the field of modern football.

The researchers also consider necessary to restructure the level of coaches, especially those who appreciate professional seniority and former players, who rely on their personal experience, and inform them of all the news concerning the physical preparation process.

We recommend that those responsible for Algerian football pay attention to younger groups, which are considered the core and reservoir of seniors, and to national teams, equipping them with the necessary capacities to raise the level and effectiveness of all factors of sporting success.

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CONFLICTS OF INTEREST

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