The Effect of Hypoxic Training on Some Skills and Physiological Variables of Tennis Players

Nasser Abuozeid Ali Ibrahim

Assistant Professor, Department of Elderly Sport, Faculty of Physical Education for Boys, Helwan University.

The purpose of the current research is to identify the effect of hypoxic training on certain skills and physiological variables among tennis players. The research used the experimental method. The core sample was purposive and was composed of three players (number 1 to 3 in Egypt). Two other players participated in the exploratory study. The most important results are that hypoxic exercises, which depend on anaerobic training, had positive effects on both skills and physiological variables (resting heart rate, effort heart rate, VO2 max, and vital capacity) among tennis players in favor of post-test measurement. Therefore, the researcher recommends that hypoxic training should be used in the training of tennis players to improve some of their skills and physiological variables.

Key words: hypoxic training, tennis, skills variables, physiological variables**.**

Introduction

Tennis is a physical and skill activity that results in an increase in the player's reaction, and increases the efficiency of the circulatory and respiratory systems as the player has to react swiftly in an attempt to hit the ball from different places under the high speed of the ball, which leads the player to play without oxygen. Tennis is one of the most recent individual sports, and racket sports in Egypt. It requires a high degree of anaerobic work and continuous performance without oxygen, especially in individual games which require a high level of performance to win the game. This necessarily requires that the performance is in the appropriate motor track to achieve the requirements of the individual performance without a decline in the performance level or speed. Therefore, the tennis player should be used to the performance in the lack of oxygen because it is difficult to maintain the correct technical performance of acceleration for a long time in the lack of oxygen.

Rodrigues (2000) notes that physical performance depends on the ability of the blood to carry oxygen, hemoglobin level, and the number of red blood cells in circulation and their ability to function. Allawi and Abdel Fattah (2000) state that the training by oxygen debt (Hypoxic Training) is a one of the new training methods to raise the athletic performance level, since training in the lack of oxygen leads to the increase in oxygen debt by reducing the number of breaths during performance, which leads to an increase in the body's ability to adapt to the oxygen debt. The Medical Academy in Russia (2002) confirms that the studies on athletes have proven that hypoxic training led to a decrease in heart beat rate, as well as the improvement of physiological and endurance levels among tennis players, runners and

swimmers. Neubauer (2001) indicates that the use of hypoxic training led to the increase in the number of red blood cells and the improvement of athletes' performance. Casas et al. (2000) state that regular and short exposure to lack of oxygen leads to the physiological responses that improve physical abilities, as they lead to an increase in red blood cells and hemoglobin level. Moreover, the lack of oxygen exercises lead to improved aerobic and anaerobic endurance of players.

Despite the importance of the anaerobic exercises for tennis players, especially higher level players, the researcher believes that the available information on the changes which they cause in some physiological variables (including resting heart rate, effort heart rate, VO2 max, and vital capacity) as a result of working without oxygen needs further study, especially as tennis is characterized by anaerobic performance of certain skills (e.g., defense against drop shots, lobs, forehand and backhand shots), which distinguish elite players, and the player who masters them will be able to ensure outstanding performance during the games.

Through review of previous literature in the field of study, and to the researcher's knowledge, no previous study has been conducted in Egypt about the impact of hypoxic training on some skills variables (defense against drop shots, lobs, forehand and backhand shots) and some physiological variables (resting heart rate, effort heart rate, VO2 max, and vital capacity) among tennis players. Therefore, the researcher has decided to conduct this study.

The present study aims at identifying the impact of hypoxic training on some skills and physiological variables among tennis players through, (1) identifying the effect of hypoxic training on some skills variables of tennis player; and (2) identifying the effect of hypoxic training on some physiological variables (resting heart rate, effort heart rate, VO2 max, and vital capacity) among tennis players.

The researcher examined two main hypotheses, (1) There are significant differences between the pre- and post-test measures in the skills variables examined (defense against drop shots, lobs, forehand and backhand shots) among tennis players in favor of post-test measure; and (2) There are significant differences between the pre- and post-test measures in the tested physiological variables (resting heart rate, effort heart rate, VO2 max, and vital capacity) among tennis players in favor of the post-test measure.

For the purposes of the current study, the researcher defines hypoxic training as training in the lack of oxygen during the performance of physical effort in which breathing processes are intentionally controlled, which leads to some physiological changes resulting from lack of oxygen in the muscle tissues.

Materials and Methods:

Participants

The researcher used the experimental method on one group, as it is deemed the most appropriate for the purposes of the present study. He applied pre- and post-test measurements. The sample has been selected purposefully from tennis players. Participants are the first five players in Egypt. The core sample is a purposive sample of players one to three. Players four and five participated in the exploratory study, used for structuring the skills and physiological tests used in the study.

Measures

The researcher has determined the appropriate tools and tests for the research topic through reviewing references and previous research. He

used a number of tools for measuring the pre- and post-test results, including, a stopwatch to measure the time estimated per second, medicine balls, hand weights, dumbbells, barriers of different heights, cords, and a device for measuring vital capacity. The researcher has not been able to find tests that examine the skills variables under investigation. Therefore, he designed two measures to measure each skill separately, (1) Defense Against the Drop Shots and Lobs Test; and (2) Continuity of Forehand and Backhand Shots Test.

The Defense Against the Drop Shots and Lobs Test aims at testing the player's ability to defend all sides of the tennis court. The participant stands behind the net and when the test starts, the coach (or ball launcher) launches 20 consecutive balls in a timed sequence, so that the first ball is a lob shot in the right side of the court, the second is a drop shot to the left of the net, the third is a lob shot on the left side of the court, the fourth is a drop shot on the right side of the court, and so forth. The Continuity of Forehand and Backhand Shots Test aims at testing the continuous defense of the court. The participant stands behind the baseline on his side, and when the test starts the coach (or ball launcher) launches 40 consecutive balls in a timed sequence, so that the first ball is forehand shot on the right side of the court, and the second is a backhand shot on the left side of the court, and so forth.

The researcher applied the tests twice to calculate the reliability of the studied (skills and physiological) variables. Two participants from the research population completed the tests, with each player completing five trials, thus the total number of trials for the players is 10. The first application was on 10 February 2014, the second application was three days later. The researcher used the Pearson's correlation coefficient to find a correlation between the results of the first and the second measurements, in order to indicate the reliability of the used tests.

Table 1 shows high correlation between the first and second measurements in the mean, standard deviation, and the value of Pearson's correlation coefficient among (skills and physiological) variables of the sample. The correlation coefficient ranges between 0.82 and 0.89, which indicates the reliability of the variables under consideration.

Table 1

The Means, Standard Deviations, and the value of the Pearson's correlation coefficient to a check reliability of (skills and physiological) variables of the research sample *n = 10*

Variables		First application		Second Application		Correlation Coefficient
		M	SD	M	SD	
Skills variables	Defense against drop and lob shots test	12.36	1.15	12.50	1.24	0.84
	Continuity of forehand and backhand shots test	25.64	2.74	25.71	2.31	0.89
Physiological variables	Resting heart rate	88.83	6.76	88.80	6.72	0.82
	Effort heart rate	98.11	18.25	98.10	18.10	0.89
	VO2 max	21.72	4.13	21.75	4.18	0.86
	Vital Capacity (liter)	2.62	0.58	2.60	0.49	0.87

* Value of tabular *r* at significance level of 0.05 = 0.632

Table 2

Correlation coefficients between the (skills and physiological) variables of the research sample

n = 10

	Variables	Internal consistency
Skills variables	Defense against drop and lob shots test	0.91
	Continuity of forehand and backhand shots test	0.83
Physiological variables	Resting heart rate	0.91
	Effort heart rate	0.88
	VO2 max	0.89
	Vital Capacity (liter)	0.88

* Value of tabular *r* at significance level of 0.05 = 0.632

The researcher used internal consistency test to determine the validity of the (skills and physiological) variables. Table 2 demonstrates the internal consistency coefficients between skills and physiological variables of the sample, indicating the validity of the used tests.

The researcher conducted an exploratory study on 15 and 16 February 2014, with two players from the research population, but outside the core sample, participating. The exploratory study aims at (1) introducing the goal of the research, research methods, measures, and data recording in the appropriate forms to the assistants (three assistants); (2) checking the devices used; (3) experimenting with one of the modules of the proposed training program; and (4) The researcher designed forms to record the different research measurements to ensure accurate results.

Procedures

The researcher conducted a pre-test measurement of the core sample's physiological variables being examined, on 2 February 2014. Skills variables were also measured. The researcher applied a proposed hypoxic training program using the hypoxic exercises described below for four weeks from 21 February to 20 March 2014. The training constituted of five training modules per week, totaling 20 modules, each one was 120 minutes.

The hypoxic training program aims at identifying the impact of hypoxic training on some skills and physiological variables of tennis players. The researcher presented the content of the hypoxic training program to a group of experts and specialists in order to ensure that the exercises will achieve their goal**.** The exercises of the training program were designed according to the following criteria: (a) setting and trying to achieve the goal of each training module; (b) the hypoxic exercises should be proportionate with the specified time and a purpose; (c) the psychological, health and social conditions of the sample should be taken into consideration, and participants should be encouraged to exert further efforts; (d) determining motor positions that add fun and pleasure element to the training; (e) hypoxic exercises should match the skills and capacities of participants; (f) hypoxic exercises should correspond with the available equipment and existing spaces of the court; (g) factors of security and safety of the research sample should be taken into consideration; (h) hypoxic exercises should be flexible, allowing amendments if necessary; (i) extreme caution while applying hypoxic exercises, not using them for a long period of time, and regular observation during performance of the training should be taken into consideration; (j) the principle of gradual load increase should be taken into consideration; (k) the hypoxic exercises should be simple and uncomplicated; (l) hypoxic exercises should be evenly distributed

on the number of modules; (m) necessary resources and tools should be available; (n) hypoxic exercises should correspond with the participants' age; (o) hypoxic training should correspond with the tendencies and desires of the research sample; and (p) participants should not be pushed to fatigue.

Through reviewing Arabic and foreign literature that dealt with hypoxic training, getting feedback from experts in the field of sports, and experts' views on the content of the training program in terms of duration, the number of training modules per week, and duration of each module, the researcher designed the proposed hypoxic training program. The proposed training program was applied for four weeks using hypoxic exercises. The training modules were limited to only five modules per week, thus, the total modules of the program were 20 training modules. The duration of the daily module was 120 minutes. The gradual method in designing the modules was used. The loading level was distributed to the training weeks.

Table 3

Sample of the Training Module

Module duration	**Warm-up**	**Main training**	**Cool down**
120 minutes	30 minutes 25% General exercises, flexibility and stretching	80 minutes 66.67% Speed, speed endurance, and endurance	10 minutes 8.33% Arms and Legs stretching, swings, and relaxing exercises

After the completion of the proposed training program, the researcher conducted a post-test measurement of variables under consideration on 21 March 2014, under the same conditions and specifications of pre-test measurements.

Analysis

The researcher used the SPSS program analyze the collected data. The Mean, Standard Deviation, Median, Skewness, Internal Consistency Correlation Coefficient, and T-test were used to analyze the data.

Results

Table 4 shows the existence of significant differences at the level (0.05) between the pre- and post-test measurements in the skills variables (defense against drop shots and lobs test, continuity of forehand and backhand shots test) among tennis players participating in favor of the post-test measurement.

able 4

Significance of the differences between pre- and post-test measurements of the research sample's tennis players skills variables n = 3

Variables	**Measurement Unit**	**Pre-test**		**Post-test**		**Difference**	**t**
		M	**SD**	**M**	**SD**		
Defense against drop and lob shots test	Number	12.34	1.01	18.54	1.04	6.20	6.08*
Continuity of forehand and backhand shots test	Number	26.54	1.17	35.24	1.15	8.70	7.50*

* Value of tabular *t* at significance level of 0.05 = 4.303

Figure 1

Differences in the Means of the pre- and post-test measurements of the skills variables

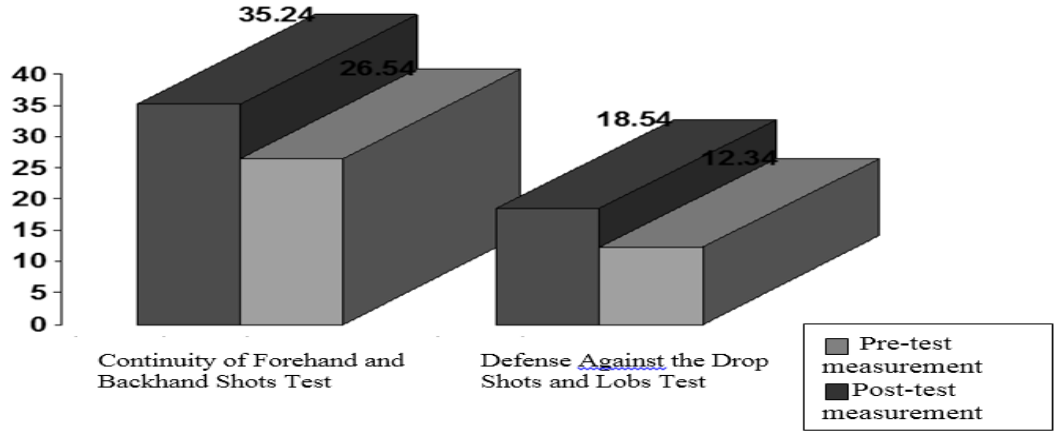


Table 5

Significance of the differences between pre- and post-test measurements of the research sample's tennis players physiological variables n = 3

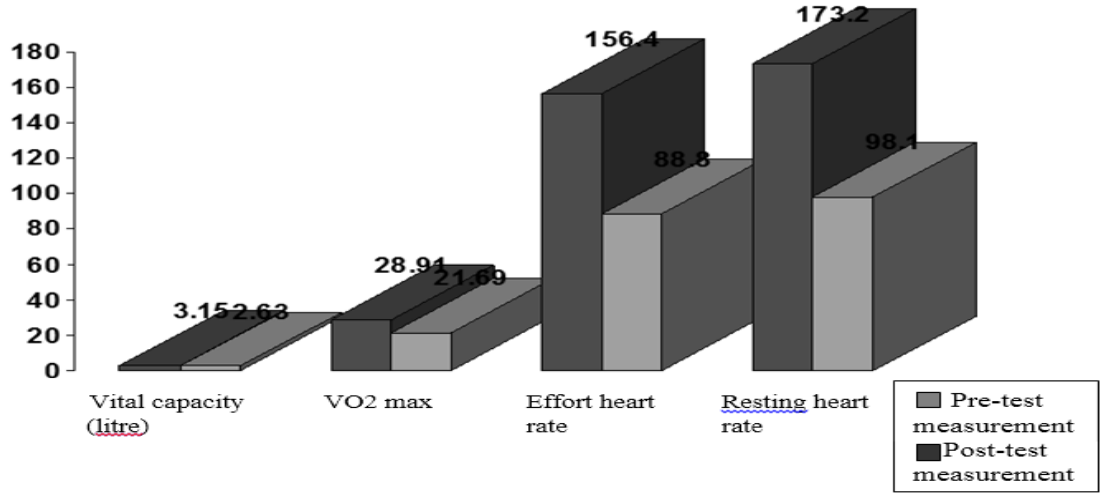
Variables	Pre-test		Post-test		t
	M	SD	M	SD	
Resting heart rate	98.10	18.66	173.20	19.35	*7.932
Effort heart rate	88.80	6.80	156.40	9.56	*16.361
VO2 max	21.69	4.07	28.91	4.54	*7.701
Vital Capacity (liter)	2.63	.54	3.15	.49	*6.500

* Value of tabular *t* at significance level of 0.05 = 4.303

Moreover, table 5 demonstrates that significant differences exist at the level of (0.05) between the pre- and post-test measurements in physiological variables among tennis players participating in this research in favor of the post-test measurement.

Figure 2

Differences in the Means of the pre- and post-test measurements of the physiological variables of the sample



Discussion

Table 4 indicates the existence of significant differences between pre- and post-test measurements in skills variables among participants, in favor of the post-test measurement. The researcher explains this increase in the skills variables to sample by the positive impact of the hypoxic training, which depends on anaerobic training. These findings are consistent with the results of Farag Allah (2001), who found a 4.48% improvement in the digital level of 400 meters race. They are also consistent with the results of Ahmad's study (2004), which showed a positive effect of hypoxic training on the effectiveness of the skills performance of judo players for the experimental group.

Thus, the first hypothesis which states that "statistically significant differences exist between the pre- and post-test measurements in skills variables among tennis players in favor of the post-test measurement" is satisfied.

Table 5 indicates the existence of significant differences between the pre- and post-test measurements of the research sample with respect to physiological variables (resting heart rate, effort heart rate, VO2 max, and vital capacity) in favor of the latter. The researcher suggests that this increase in the physiological variables (resting heart rate, effort heart rate, VO2 max, and vital capacity) among participants is due to the positive impact of the hypoxic training which depends on anaerobic training. These findings are consistent with the results of Mohammed's study (1996), which showed significant differences between the pre- and post-test measurements in the lactic acid levels in the blood, heart rate, vital capacity of the lungs, and in the digital level of 100-meter freestyle swimming. These results are also consistent with the results of Bailey et al's (2000) study which showed no changes in the level of folic acid in red blood cells, and a lower level of lactic acid during training. Furthermore, these findings are also consistent with the results of a study by Farag Allah (2001), which showed improvement in heart rate by 7%, improvement of blood pressure by 3.75%, an increase in the efficiency of anaerobic capacity by 43.33%, and an increase in vital capacity by 4.68%. The results are also consistent with the results of the study of Robinson et al. (2003) which showed an increase in the number of red blood cells and an improvement in maximum amount of oxygen.

Additionally, the results are consistent with of a study by Ahmed (2004), which showed a positive effect of hypoxic training on some physiological variables (systolic blood pressure, diastolic blood pressure, heart rate, the size of the strike, Cardic Out Put (C.O.P), vital capacity, aerobic capacity) for judo players in favor of the experimental group. These findings are consistent with the results of Baldum's study (2005), which showed a positive effect of hypoxic exercises on improving the circulatory system efficiency and the level of performance of young boxing players. These findings are also consistent with the results of Omar's study (2005), which indicated statistically significant differences in lactic acid levels, the number of red and white blood cells, and the hemoglobin levels in the blood in favor of the experimental group. The experimental group also improved in resting heart rate, vital capacity, (absolute and relative) physical efficiency, and maximum oxygen consumption compared to a control group. The findings of the present research are consistent with the results of Khattab's study (2005), which showed statistically

significant differences in maximum oxygen consumption and anaerobic capacity in favor of the experimental group.

These results satisfy the second hypothesis, which states that "statistically significant differences exist between the pre- and post-test measurements in some physiological variables (resting heart rate, effort heart rate, VO2 max, and vital capacity) among tennis players in favor of the post-test measurement."

The findings of the present research indicate that hypoxic training, which relies on anaerobic exercises, has a positive effect on both skills variables and physiological variables (resting heart rate, effort heart rate, VO2 max, and vital capacity). This is evident from the pre- and post-test measurements which show an improvement in favor of the post-test measurement. The most important limitation of the current study is the necessity of conducting the training 7 times per week instead of 5 times. Therefore, we highly recommend (a) the use of hypoxic training, which depends on anaerobic training, in the training of tennis players; (b) the use of hypoxic exercises, which depend on anaerobic exercises, on some skills and physiological variables among tennis players; and (c) the use of hypoxic training, which depends on anaerobic training, in the training activities of players in other sports that rely on anaerobic activities.

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