Effects of Training with Mask on some Biological Variables and Fatigue Indicators for Epee Fencers

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Abstract: The current research aims to identify the effect of training under hypoxia conditions using the mask on improving some biomarkers and fatigue indicators for fencers. The researcher used the experimental approach (two-group design) with control and experimental groups and pre- and post-measurements. Participants (n=30) were purposefully of chosen from epee fencers of Al-Qadesia sports club. Main sample included (24) players divided into two equivalent groups (experimental = control = 12). Another (5) fencers were recruited for the pilot study. Only (1) fencer was excluded for injury. Results indicated that: [1] The recommended program of hypoxic exercises with mask improved physiological variables including pulse, vital capacity, $VO2_{max}$ and others for fencers. [2] The recommended program of hypoxic exercises with mask improved blood variables including hemoglobin, RBC, WBC, platelets and LDH for fencers. [3] The recommended program of hypoxic exercises with mask improved the functions of the cardio-respiratory system and decreased fatigue in addition to improving the performance level of fencers.

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Key Words: hypoxic training – fencing – fencing mask – fatigue.

1. Introduction:

Sports training based on correct scientific principles improves physiological, physical and technical variables in addition to sports achievement.

Major advances in sports levels and digital records during world championships is mainly due to major advances in sports training and physiology. These advances helped initiating training and competition with preventive measures and health care for athletes. Physiological tests help evaluating physical and functional conditions of athletes. This helps identifying training loads according to the athlete's level and nature of sport (Abd El-Fattah, A. 2003: 28).

Fencing is characterized by quick technical performances based on specific physical qualities important not only to move the sword but also to generate enough speed and power to shift the fencer's trunk depending on foot work either to attack and win a touch or to defense and prevent an opponent's touch in addition to intermediary preparations, responses and reactions. This imposes huge physiological demands on fencers and affect their technical performance level especially with the requirement of wearing a mask. This means that technical performances are initiated under shortage of oxygen that may speed up fatigue. Fatigue indicators appear on fencers in the form of increasing complex reaction time and trying to achieve accuracy at the expense of time (Abd El-Fattah, A. 1999. 19).

Fencing requires the fencer to wear a mask in competitions. This exposes fencers to hypoxia as mask martials prevent air from coming in. therefore, it is important to simulate competition conditions in training to improve the physical performance level and functional capacity of internal body systems.

Human beings can live under hypoxia for years like in Ethiopia and Mexico as the population there lives above sea level by nearly 2300 m and they are always vulnerable to decreased levels of oxygen. The higher we get above sea level the less oxygen concentrations in air become. But several adaptations happen in human lung to overcome this shortage and increase the lung ability to extract oxygen from air as a result of improved efficiency of alveoli and increased concentrations of blood hemoglobin that carry more oxygen to body tissues (Albert, N. 2010. 225).

Anaerobic muscular work increases lactic acid accumulation in muscle tissues as a result of anaerobic glycolysis that increases fatigue and slows down performance. Improving anaerobic work endurance improves muscle ability to dispose lactic acid and endure fatigue (Abd El-Fattah, A. 2003. 228).

Diffusion of gases is proportionate to three other factors: gas pressure (from high to low) – temperature – the exposed surface. Pressure that pushes $O2$ into the lung is ten times the pressure that pushes $CO2$ out. For every (6) $O2$ molecules that inter the blood stream, only (5) $CO2$ molecules come out. Humans can tolerate $O2$ shortages but they can not tolerate $CO2$ increase as $CO2$ increases acidosis and changes Ph point (7.35 – 7.45). it is also soluble and turns into

H_2CO_3 (Carbonic Acid). CO_2 solubility in water is 20 times O_2 solubility (Albert, N. 2010. 229).

To prevent acidosis, God provides human bodies with vital systems that prevent accumulation of amino-acids.

Hypoxic exercises are common in fencing. This means training under conditions of low oxygen concentrations to improve the efficiency of cardio-respiratory system in pumping oxygenated blood to all body muscles and quick disposal of carbon dioxide and other acids including lactic acid that eventually leads to fatigue and decreases levels of technical and physical performance of fencers.

Research Problem:

Various training methods with various effects and the need for it by athletes during general and specific preparation according to their potentials, abilities and competitive requirements led researchers and coaches to invent new affordable methods to push their athletes' abilities to the max. through observing fencers in competitions, the researcher noticed indicators of early fatigue in addition to increase in breathing rate and decrease in performance level due to long durations of competitions especially in the finals.

During training, the fencers performs physical and technical performances including warm up, general preparation, specific preparation and foot work… etc. while wearing light sportive clothes and for a short time. This rarely happens while wearing the full suit and the mask. On the contrary, under competition conditions in general, and match conditions in specific, local competitions may last for 12 hours during which a fencer may wear the mask for 2-3 hours. This means that the fencer performs technical skills under hypoxia compared with training conditions.

This led the researcher to try to solve this problem depending on training and physiology. After revising training units of fencing team at Al-Qadesia sports club, the researcher tried to put fencers under competition-like conditions especially breathing drills and adaptation to hypoxia. This research used the mask in training for the longest possible duration and this puts fencers under hypoxia conditions accompanied by exercises for a specific duration inside the training unit. The research also tried to identify the effect of this method on some biomarkers and fatigue indicators for fencers performing technical exercises under hypoxia.

Aim:

The current research aims to identify the effect of training under hypoxia conditions using the mask on improving some biomarkers and fatigue indicators for fencers.

Hypotheses:

- There are statistically significant differences between the pre- and post-measurements of the control group on biomarkers and fatigue indicators in favor of post-measurements.
- There are statistically significant differences between the pre- and post-measurements of the experimental group on biomarkers and fatigue indicators in favor of post-measurements.
- There are statistically significant differences between the post-measurements of the control and experimental groups on biomarkers and fatigue indicators in favor of the experimental group.

Review of Related Literature:

Hypoxic training appeared during Mexico Olympic Games where games were played 2300 m above sea level. This trend tried to identify the effects of altitude competitions on the digital records of athletes. Several questions were raised about its effects on sports achievements and the required time for adaptation (Al-Beek, A. 1995: 290).

Hypoxic training was used in swimming and athletics and these studies improved VO2 max, economics of blood distribution in the muscle, glycogen deposit increase and increases in ATP enzymes aerobically and anaerobically (Allawy & Abd El-Fattah 2000: 310).

Short but regular exposure to hypoxia stimulates a physiological response that improves physical performance ability and leads to increasing cell size and RBC number which in turn increases hemoglobin and improves aerobic and anaerobic endurance (Scientific and clinical laboratory of hypoxia medical academy 2000: 66).

As a term, hypoxia looks as if it is composed of two syllables: the first "hypo" means low, less or shortage while the second "Oxia" is an abbreviation of oxygen. Therefore, hypoxia in sport means shortage of oxygen during performing continuous physical effort leading to increased oxygen dept as oxygen pressure in arterial blood drops and its distribution in tissues and muscles decreases (Ahmed, B. 1999: 32).

Hypoxia happens when body tissues can not get its needs of oxygen. There are four reasons for hypoxia:

1. Hypoxia resulting from shortage in blood oxygen.
2. Anemia-induced hypoxia. This type is characterized by decreased levels of hemoglobin that delivers oxygen to tissues.
3. Hemostasis- induced hypoxia. This type is characterized by a decrease in blood amount passing through tissues. This can result in:

- Arterial blood hypotension and vinous blood hypertension as in cardiac infraction.

- Constriction of blood vessels as in cases of exposure to severe cold weather.

4. Poison- induced hypoxia. This can result from poisoning with cyanide or alcohol as tissue can not use oxygen in spit of its availability in arterial blood due to the affected breathing enzymes in cells.

Terminology:

Hypoxic Training:

A type of training with holding breath and decreasing breathing rate. This decreases the amount of blood reaching cells and leads the body to adapt with increased oxygen dept (Allawy & Abd El-Fattah 2000: 311).

Previous Studies:

Arabic Studies:

Rahouma E. (2003) performed a study titled " Effects of using breath control exercises on some physiological and physical variables and digital record of weight lifters". The study aimed to identify the effects of breath control exercises on some physiological and physical variables in addition to the digital record of weight lifters. The researcher used the experimental approach (two-group design) on a sample of (32) light weight lifters. Results indicated that breath control exercises improved the respiratory system and increased blood hemoglobin in weight lifters.

Ahmed, I. (2004) performed a study titled " Effects of hypoxic exercises on some physiological variables and effectiveness of technical performance in judokas". The study aimed to identify hypoxic exercises on some physiological variables and effectiveness of technical performance in judokas using the experimental approach (two-group design) on a sample of (24) female judokas. Results confirmed the improvement of all physiological variables under investigation in addition to the technical performance of some specific physical abilities.

Rabia, M. & Imam, F. (2008) performed a study titled " Comparison of three different training programs in hypoxic environment and their effects on functional effectiveness and some physical fitness components and the digital record of 400 m running". The study aimed to identify the effects of the three programs on functional effectiveness and some physical fitness components and the digital record of 400 m running. The researchers used the experimental approach (three-group design) on a sample of (15) female runners. Results confirmed the positive effects of the three programs with significant improvement in favor of water-based hypoxic exercises.

Foreign Studies:

Clark et al (2001) performed a study titled " Effects of live high, train-low hypoxic exposure on lactate metabolism in trained humans" aiming to identify the effects of intermittent hypoxic training on blood lactate. The researcher used the experimental approach on a sample of (29) athletes. Results indicated the intermittent hypoxic training decreased lactate levels during extensive training.

Katayama (2001) performed a study titled " Intermittent hypoxia improves endurance performance and submaximal exercise efficiency". The study aimed to identify the effects of IHT on endurance. The researcher used the experimental approach on a sample of (12) athletes. Results indicated that IHT improved endurance and mechanical efficiency during sub-maximal training loads on sea level in addition to improving the digital record of 3000 m running.

Saunders (2003) performed a study titled " Improved running in elite runners after 20 days of moderate simulated altitude exposure". The researcher tried to identify the effects of IHT on running economics among elite runners for (20) days. The researcher used the experimental approach on a sample of (22) runners. Results indicated that VO2 max and pulmonary respiration increased with the delay of lactate accumulation.

Dawe, J. (2005) performed a study titled " Exercise training in normal hypoxia in endurance for swimming players". The study aimed to identify the effects of hypoxic training on sea level on the physiological efficiency of swimmers. The researcher used the experimental approach (two-group design) on a sample of (16) swimmers (10 males and 6 females) trained for (5) weeks (3 units per week). Results indicated that hypoxic exercises significantly improved physiological variables of swimmers, their ability to extract oxygen, their tolerance to lactic acid and their performance time.

Pierce, D. (2013) performed a study titled " Repeated pre-season hypoxic sprint training may improve rugby performance". The study aimed to identify the effects of repeated use of the mask during training on the performance level of rugby players in England. Participants (n-24) were trained with the mask for (4) weeks (3 units per week). Results indicated that metabolic level of aerobic and anaerobic energy improved significantly with increased depth of breathing and endurance of players.

2. Methods:

Approach:

The researcher used the experimental approach (two-group design) with control and experimental groups and pre- and post-measurements.

Participants:

Participants (n=30) were purposefully of chosen from epee fencers of Al-Qadesia sports club. Main sample included (24) players divided into two equivalent groups (experimental = control = 12).

Another (5) fencers were recruited for the pilot study. Only (1) fencer was excluded for injury.

Homogeneity of all participants was performed using squewness of the following variables: age – weight – height – biochemical variables.

Table (1) shows that squewness values were between (±3) indicating homogeneity of participants.

Table (1): Homogeneity of participants (n=24) on all Growth Variables

Variable	Measurement	Mean	Median	SD	Squewness
Age	Year	20.0417	20.0000	.62409	-.024-
Weight	Kg	70.4583	70.5000	5.77083	-.310-
Height	Cm	173.46	174.00	3.41326	.065

Table (2) shows that squewness values were between (±3) indicating homogeneity of participants.

Table (2): Homogeneity of participants (n=24) on all Physiological Variables

Variable	Measurement	Mean	Median	SD	Squewness
Vital Capacity	L / min	3.8729	3.9000	.17875	-.716-
Exhale rate in the first second FEU1	ml / sec	4.5979	4.6500	.56731	.360
Breath holding rate	Sec	47.3333	48.0000	2.20013	-.491-
Breathing rate	Breath / min	14.9583	15.0000	.90790	-.293-
Pulse rate	P / min	74.6667	75.0000	2.20013	-.498-

Table (3) shows that squewness values were between (±3) indicating homogeneity of participants.

Table (3): Homogeneity of participants (n=24) on all Biochemical Variables

Variable	Measurement	Mean	Median	SD	Squewness
Hemoglobin	g/ml.l	12.1000	12.0000	.51330	.461
RBC	U/million	3.9683	3.9950	.15530	-.175-
Platelets	U/million	186.50	1.83.50	15.07	.208
WBC	U/thousand	5.1371	4.9500	.87871	.486
VO2 max	L / min	320.38	322.00	67.99	.621
LHD	U	22.2917	22.0000	2.62892	.531

Table (4) indicated no statistically significant differences between the experimental and control groups on all researcher variables. This indicates the equivalence of the two groups.

Table (4) Difference Significance between the Experimental and Control Groups on all Research Variables (n 1 = n 2 = 12)

Variable	Measurement	Sum of Ranks		Mean of Ranks		Z value	P
		Control	Experimental	Control	Experimental		
Year	Age	12.08	12.92	145.0	155.0	0.335	0.738
Kg	Weight	12.29	12.71	147.5	152.5	0.145	0.885
Cm	Height	11.08	13.92	133.0	167.0	0.999	0.318
Vital Capacity	L / min	11.38	13.62	136.5	163.5	0.795	0.427
Exhale rate in the first second FEU1	ml / sec	11.92	13.08	143.0	157.0	0.405	0.686
Breath holding rate	Sec	12.0	13.00	144.0	156.0	0.350	0.726
Breathing rate	Breath / min	11.04	13.96	132.5	167.5	1.063	0.288
Pulse rate	P / min	12.71	12.29	152.5	147.5	0.147	0.884
Hemoglobin	g/ml.l	12.96	12.04	155.5	144.5	0.319	0.750
RBC	U/million	13.08	11.92	157.0	143.0	0.409	0.683
Platelets	U/million	13.08	11.92	157.0	143.0	0.406	0.685
WBC	U/thousand	11.83	13.17	142.0	158.0	0.463	0.643
VO2 max	L / min	10.58	14.42	127.0	173.0	1.330	0.184
LHD	U	12.08	12.92	145.0	155.0	0.293	0.770

Pilot Study:

Pilot study was performed on (5) participants from the same research community and outside the main sample, on 6-3-2017. Participants were asked to wear the mask and perform while monitoring them results indicated that:

1- Fencers reached full exhaustion and stopped after (30) minutes

2- Max pulse rate was reached after nearly (25) minutes.

3- Max breathing rate was reached after nearly (27) minutes.

4- Duration for using the mask was estimated by 15-25 minutes.

5- Masks should be fixed firmly.

6- Pulse rate immediately after exhaustion was (178-184) P/Min.

7- Breathing rate immediately after exhaustion was (25-28) times per minute.

According to these results the following issues were identified:

- Duration of anaerobic exercises was estimated.
- Recovery time after using the mask (100-120 sec till pulse rate reaches 120-130 P/M).
- Places were suitable for exercises and tests.
- All difficulties that may face the main experiment were identified and resolved.

Tests Used:

1- **Breath Holding Test:**	
Aim:	To measure max duration for breath holding
Explanation:	The fencer sits on the chair with extended back without any curves. Palms are on thighs. The fencer takes a deep breath and holds it for the longest possible period.
Calculation:	Time to exhale is measured two time and the best trial is recorded.
2- **Pulse Test:**	
Aim:	Measure heart rate in one minute
Explanation:	Pulse was counted from the radial artery for ten seconds and repeated several times.
Calculation:	Number of pulses in 10 seconds is multiplied by 6.
3- **Breathing Rate Test:**	
Aim:	Number of breathes taken in one minute
Explanation:	The fencer sits comfortably and inhales and exhales normally
Calculation:	Judge puts his hands on the fencer's chest to count the inhale/exhale rate in one minute

Principles of the Recommended Program:

After identifying and testing the exercises, the research designed the program according to relevant programs available on the internet and related literature. The program is based on the design of anaerobic training programs. The researcher concluded that the acceptable duration should be (2) months (3 units per week).

Main Study:

The main study was performed according to the following steps:

1- The recommended anaerobic exercises program was applied for two months from 15-3-2017 to 14-6-2017 (3 units per week) with total of (26) units.

2- Recommended exercises were applied for (12-15) minutes during regular training.

3- Total duration of the unit was 65-70 minutes.

4- The recommended program was applied to the experimental group on Sunday, Tuesday and Thursday while the control group followed the regular training program.

Post-measurements:

Post-measurements were taken on 17/18-6-2017 following the same protocol of pre-measurements.

Statistical Treatment:

The researcher used SPSS software to treat data statistically using parametric statistics (mean and SD) due to the small number of participants.

3. Results:

Table (5) shows statistically significant differences between the pre- and post-measurements of the control group on all biological variables in favor of post-measurements as P was less than 0.05.

Table (5): Difference Significance Between the Pre- and Post-measurements of the Control Group on All Biological Variables (n=12)

Variable	Measurement	Number of Ranks		Sum of Ranks		Mean of Ranks		Z value	P
		-	+	-	+	-	+		
Vital Capacity	**L / min**	**5**	**6**	**26.0**	**40.0**	**5.2**	**6.67**	**0.64**	**0.522**
Exhale rate in the first second FEU1	**ml / sec**	**2**	**9**	**16.5**	**49.5**	**8.25**	**5.5**	**1.468**	**0.142**
Breath holding rate	**Sec**	**0**	**12**	**0.00**	**78.00**	**0.00**	**6.5**	**3.07**	**0.002***
Breathing rate	**Breath / min**	**7**	**1**	**28.5**	**7.5**	**4.07**	**7.5**	**1.54**	**0.124**
Pulse rate	**P / min**	**5**	**2**	**25.0**	**3.0**	**5.00**	**1.5**	**1.88**	**0.06**
Hemoglobin	**g/ml.l**	**2**	**9**	**10.5**	**55.5**	**5.25**	**6.17**	**2.015**	**0.044***
RBC	**U/million**	**0**	**11**	**0.00**	**66.0**	**0.00**	**6.00**	**2.93**	**0.003***
Platelets	**U/million**	**12**	**0**	**78.0**	**0.00**	**6.5**	**0.00**	**3.05**	**0.002***
WBC	**U/thousand**	**0**	**12**	**0.00**	**78.0**	**0.00**	**6.5**	**3.05**	**0.002***
VO2 max	**L / min**	**0**	**12**	**0.00**	**78.0**	**0.00**	**6.5**	**3.05**	**0.002***
LHD	**U**	**0**	**8**	**0.00**	**36.0**	**0.00**	**4.5**	**2.55**	**0.01***

Table (6) shows statistically significant differences between the pre- and post-measurements of the experimental group on all biological variables except LHD in favor of post-measurements as P was less than 0.05.

Table (6): Difference Significance Between the Pre- and Post-measurements of the Experimental Group on All Biological Variables (n=12)

Variable	Measurement	Number of Ranks		Sum of Ranks		Mean of Ranks		Z value	P
		-	+	-	+	-	+		
Vital Capacity	L / min	0	12	0.00	78.00	0.00	6.5	3.071	0.002*
Exhale rate in the first second FEU1	ml / sec	0	11	0.0	66.0	0.00	6.00	2.937	0.003*
Breath holding rate	Sec	0	11	0.00	66.00	0.00	6.00	2.943	0.003*
Breathing rate	Breath / min	10	1	63.5	2.5	6.35	2.5	2.745	0.006*
Pulse rate	P / min	11	0	66.0	0.00	6.00	0.00	2.989	0.003*
Hemoglobin	g/ml.l	0	12	0.00	78.00	0.0	6.5	3.06	0.002*
RBC	U/million	0	11	0.00	66.0	0.00	6.00	2.93	0.003*
Platelets	U/million	1	11	1.00	77.0	1.00	7.00	2.98	0.003*
WBC	U/thousand	2	10	7.00	71.0	3.5	7.1	2.51	0.012*
VO2 max	L / min	12	0	78.0	0.00	6.5	0.00	3.06	0.002*
LHD	U	5	5	30.0	25.00	6.0	5.0	0.257	0.79

Table (7) shows statistically significant differences between the post-measurements of the control and experimental group on all biological variables except LHD in favor of the experimental group as P was less than 0.05.

Table (7): Difference Significance Between the Post-measurements of the Control and Experimental Group on All Biological Variables (n 1 = n 2 =12)

Variable	Measurement	Sum of Ranks		Mean of Ranks		Y value	P
		Experimental	Control	Experimental	Control		
Vital Capacity	L / min	199.5	100.5	16.62	8.38	22.5	0.004
Exhale rate in the first second FEU1	ml / sec	184.5	115.5	15.38	9.62	37.5	0.044
Breath holding rate	Sec	113.0	187.0	9.42	15.6	35.00	0.025
Breathing rate	Breath / min	117.0	183.0	9.75	15.25	39.0	0.049
Pulse rate	P / min	217.0	83.0	18.08	6.92	5.00	0.00
Hemoglobin	g/ml.l	213.0	87.0	17.75	7.25	9.000	0.00
RBC	U/million	212.0	88.00	17.67	7.33	10.00	0.00
Platelets	U/million	222.0	78.0	18.5	6.5	0.000	0.000
WBC	U/thousand	78.00	222.0	6.5	18.5	0.000	0.000
VO2 max	L / min	78.00	222.0	6.50	18.5	0.00	0.00
LHD	U	126.5	173.0	10.54	14.46	48.5	0.164

4. Discussion:

Considering the **first hypothesis** stating: " There are statistically significant differences between the pre- and post-measurements of the control group on biomarkers and fatigue indicators in favor of post-measurements":

Table (5) shows statistically significant differences between the pre- and post-measurements of the control group on all biological variables except for breathing rate, WBC and LDH, in favor of post-measurements. The researcher thinks that these improvements resulted from the regular training program followed the the control group that depends mainly on running and jogging to improve the cardiorespiratory system efficiency. Al-Takriti & Al-Haggar (2012) indicated that continuous and intermittent training using running and jogging for long distances increase blood volume in the left ventricle. This increases blood flow to muscles and in turn increases hemoglobin and VO2 max as indicators of heart adaptations to training loads.

Kheribat & Abd El-Fattah (2016) indicated that sports training programs increase VO2 max considering that improvement percentage depends on several factors including the nature of training and program formation in addition to other genetic factors.

This is also consistent with Dawe, J. (2005) and Ahmed, I. (2004) who indicated that anaerobic exercises with training aids improved VO2 max, vital capacity and other variables.

Considering the **second hypothesis** stating: " There are statistically significant differences between the pre- and post-measurements of the experimental group on biomarkers and fatigue indicators in favor of post-measurements":

Table (6) shows statistically significant differences between the pre- and post-measurements of the experimental group on all biological variables except LHD in favor of post-measurements as Z calculated value was higher than its table value. The researcher thinks that these improvements resulted from exposure to hypoxic exercises with the mask for (8) weeks. This is consistent with Al-Kashef, E. (1990) who indicated that physiological adaptations resulting from training support the heart volume and increases its functional efficiency. Using hypoxic exercises improves the efficiency of cardio-vascular system.

This is consistent with Al-Kabi, G. (2007) who indicated that high intensity hypoxic exercises improve vital organs efficiency and increases VO2 max in addition to improving the ability of RBC to carry more oxygen and tolerate the accumulation of fatigue by-products.

Pierce, D. (2013) indicated that hypoxic exercises improve metabolism on cellular level and increases athletes' tolerance to fatigue.

Accordingly, the recommended training program with hypoxic exercises had a significant and positive effect on improving some biological variables of participants. This proves the second hypothesis correct.

Considering the **third hypothesis** stating: " There are statistically significant differences between the post-measurements of the control and experimental groups on biomarkers and fatigue indicators in favor of the experimental group":

Table (7) shows statistically significant differences between the post-measurements of the control and experimental group on all biological variables in favor of the experimental group as Z calculated value was higher than its table value. The researcher thinks that these improvements resulted from the recommended hypoxic exercises program with mask. Bard, W. (2004) indicated that VO2 max is between 95:98% of max heart rate. This means that improved heart rate is reflected on improving VO2 max.

Biochemical variables also improved including hemoglobin, RBC and WBC. This is consistent with Eliwa, M. (2006) who indicated that sports training improves muscle ability to extract oxygen from blood in addition to increasing blood volume, RBC, WBC and platelets. Altitude training improves blood components compared to normal to compensate shortage of oxygen in air. This increase has positive effects on improving performance level.

LDH also improved as it decreased in the experimental group compared to the control group. This indicates adaptations of blood components and muscles to tolerate acidosis and Ph changes. This is consistent with Bean, A. (2002) who indicated that intensive training provides the body with opportunity to adapt to oxygen shortage. Altitude training may increase muscles ability to store glycogen and use it later to produce energy. This helps the liver to store higher amounts of glycogen and contributes in decreasing fatigue resulting from glucose shortage in blood. It also speeds up muscle recovery from acidosis through expelling hydrogen using LDH. This is consistent with Ahmed, I. (2004). This is also consistent with Abd El-Fattah & Radwan (2003) who indicated that during muscular work under anaerobic endurance conditions, the main problem is shortage of oxygen coming to the muscle as this increases lactic acid accumulation and with continuous performance, the athlete feels fatigue. Training improves muscles efficiency.

Accordingly, the recommended training program with hypoxic exercises had a significant and positive effect on improving some biological variables and fatigue by-products of participants. This proves the third hypothesis correct.

Conclusions:

According to this research aim, hypotheses, methods and results, the researcher concluded the following:

- The recommended program of hypoxic exercises with mask improved physiological variables including pulse, vital capacity, $VO2_{max}$ and others for fencers.
- The recommended program of hypoxic exercises with mask improved blood variables including hemoglobin, RBC, WBC, platelets and LDH for fencers.
- The recommended program of hypoxic exercises with mask improved the functions of the cardio-respiratory system and decreased fatigue in addition to improving the performance level of fencers.

Recommendations:

- Using hypoxic exercises with mask inside the training plan of Epee fencers.
- Simulating competition environment during training with mask to simulate low oxygen levels so that fencers can perform under the same game conditions.
- Performing more studies to identify the effects of hypoxic exercises on biological variables of epee and file fencers.

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