The Effect of Active Rest and Stretching on some Biochemical Variables during Anaerobic Workouts as a Measure of Fatigue Terminal

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The present study identifies the effect of active rest and stretching on some biochemical variables in the blood and peripheral fatigue through the performance of anaerobic glycolysis exercises in football players. The study aims at identifying the concentration levels of Acetylcholinesterase (AChE), Nicotinamide adenine dinucleotide (NAD+), Glucose-6-phosphate dehydrogenase (G6PDH), Lactate dehydrogenase (LDH) in the blood in the post-test measurements of both the experimental and control groups; comparing and identifying the differences in the concentration of these variables in both groups; comparing and identifying the differences between the effects of anaerobic glycolysis exercises and active rest on the concentration levels of the variables in the experimental and control groups in the immediate post-test measurements and after 45 minutes. The sample consists of 12 football players, purposively selected and divided into two groups each one composed of 6 players. The study has found an effect of anaerobic glycolysis exercises on the concentration of all research variables. The recovery of all variables continued during passive and active rest periods and stretching (45 minutes) for both groups. In the experimental group, active rest and stretching result in the decline of AChE, NAD+, and LDH, while no significant differences between the immediate post-test measurement and after 45 minutes in G6PDH exist. Active rest between repetitions have not increased recovery of the research variables in the experimental group. Meanwhile active rest and stretching have increased the recovery of all research variables.

Keywords: Football training, peripheral fatigue, biochemical variables.

Introduction

Football requires a high level of aerobic fitness that enables players of performing training and games with high physical competence. It also requires endurance of fatigue that results from lack of oxygen during performance, and quickly recovering oxygen debt and deficit during low play rate, stopping the game, or rest intervals, or during rest intervals between physical load repetitions (Abdel Fattah, Shaalan, 1994; Al-Houfi, 2014).

This leads to a variety, diversity, and overlap of energy generation systems within muscular cells, including aerobic energy during jogging or walking, and anaerobic energy during running at high speed and speed endurance. Thus, it is a combination of maximum speed and less than maximum speed, jogging and walking with respect to what the circumstances during the training and competitions require (Salama, 2000 ; Hammouda et al., 2012).

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Additionally, these changes and diversity in energy generation systems puts a physiological strain on the different systems of the body, the ability of the muscles to consume oxygen (VO2Max), muscle fatigue endurance, and speed of recovery processes during low play rate during training and competitions as well as rest intervals. These factors, as well as other factors, are among the crucial physiological indicators of the competence of football players (Abdel Fattah, Shaalan, 1994; Salama, 2000: Hammouda et al., 2012).

Several scientific views consider that the nature of performance in football trainings and competitions is characterized by fast and strong muscle performance through reliance on an anaerobic energy phosphate generation system. The main energy generation system, however, is the lactic acid system (Abdel Fattah, Shaalan, 1994; Salama, 2008; Al-Houfi, 2014; Shei et al., 2013).

Therefore, this leads to muscle fatigue during training and competitions. Since training and its different components are a means of adapting players to cope with fatigue, to improve the players' competence of fatigue endurance under any circumstances during performance, the repetition of performance load during recovery intervals allows the success of physiological adaptation process and developing the performance of players. Thus, recovery processes should be attended to by giving players rest intervals that match their physical load, especially active rest (Abdel Fattah & Shaalan, 1994; Salama, 2008; Al-Houfi, 2014; Shei et al., 2013).

Consequently, the research problem can be summarized as follows: the nature of football performance is physiologically strenuous to the body systems, which emphasizes the importance of physiological preparation of football players through their training programs. The current research identifies the effects of active rest intervals and stretching exercises on a number of biochemical variables in the blood. It achieves this through the performance of a set of anaerobic glycolysis exercises, and increasing peripheral fatigue of football players. In the present study, the researchers try to determine empirical measures to deduce signals of peripheral fatigue of football players through these biochemical variables; the effectiveness of using active rest and stretching exercises between repetitions, after doing a round of anaerobic glycolysis exercises, on some biochemical variables; and identifying the effect of one of the most recovery processes, namely active rest, and stretching exercises on the speed of recovering from peripheral fatigue during football trainings and competitions.

The purpose of the study are:

a) Identifying the concentration levels of certain biochemical variables, namely Acetylcholinesterase (AChE), Nicotinamide adenine dinucleotide (NAD+), Glucose-6-phosphate dehydrogenase (G6PDH), Lactate dehydrogenase (LDH), in the blood in the following measurements of the experimental and control groups:
    - Pre-test measurement (before the start of anaerobic glycolysis exercises).
    - Immediate post-test measurement (after finishing anaerobic glycolysis exercises)
    - Post-test measurement after 45 minutes (after finishing anaerobic glycolysis exercises, active rest, stretching exercises, and passive rest) for both the experimental and control groups.

b) Comparing and finding differences in the concentration levels of these biochemical variables in the blood for both the experimental and control groups between the following measurements:
   - Pre-test and immediate post-test measurements.
   - Pre-test and post-test after 45 minutes measurements.
   - Immediate post-test and post-test after 45 minutes measurements.

c) Comparing and finding differences between anaerobic glycolysis and active rest on the concentration levels of these biochemical variables in the blood for the control group in the immediate post-test measurement.

d) Comparing and finding differences between the effect of active rest and stretching exercises on the concentration levels of these biochemical variables in the blood between the experimental and control groups in post-test measurements after 45 minutes.

It was hypothesized that would be:

a. Significant differences in the concentration levels of biochemical variables in the blood exist within the control group among the following measurements:
   - Pre-test and immediate post-test measurements in favor of the immediate post-test measurement.
   - Pre-test and post-test measurement after 45 minutes in favor of the post-test measurement after 45 minutes.
   - Immediate post-test measurement and post-test measurement after 45 minutes in favor of the immediate post-test measurement.

b. Significant differences in the concentration levels of biochemical variables in the blood exist within the experimental group among the following measurements:
   - Pre-test and immediate post-test measurements in favor of the immediate post-test measurement.
   - Pre-test and post-test measurement after 45 minutes in favor of the post-test measurement after 45 minutes.
   - Immediate post-test measurement and post-test measurements after 45 minutes in favor of the immediate post-test measurement.

c. Significant differences in the concentration levels of biochemical variables in the blood exist between the control and experimental groups in the immediate post-test measurements in favor of the experimental group.

d. Significant differences in the concentration levels of biochemical variables in the blood exist between the control and experimental groups in the post-test measurements after 45 minutes in favor of the experimental group.

Methods

Participants

The research sample consisted of 12 football players selected by purposive sampling. The participants are students at the Faculty of Physical Education for Boys at Helwan University, who have motivation to participate in the study (attachments 1 and 2). Participants are divided into two groups: a control group and an experimental group. Each group consisted of six players.

Procedures

An exploratory experiment was conducted on Sunday, 22 February 2015 from 8:00 a.m. until 12:00 p.m. in the athletics track at the Faculty of Physical Education for Boys, Helwan University.

The main experiment of this study was conducted on Sunday 1 March 2015, from 8:00 a.m. until 12:00 p.m. in the athletics track at the Faculty of Physical Education for Boys, Helwan University.

The control group performed anaerobic glycolysis exercises, specifically 6 repetitions of running 400 meters with 5-minute rest between repetitions (Abdel Fattah & Sayed, 2003).

The control group received passive rest intervals between repetitions and a 40-minute passive rest after finishing the six repetitions.

The experimental group performed anaerobic glycolysis exercises, specifically 6 repetitions of running 400 meters with 5-minute active rest of slow pace running between repetitions.

After finishing the six repetitions, the experimental group received a 40-minute active rest of performing stretching exercises and slow pace running (attachment 5).

The six 400-meters running were performed at the maximum possible intensity. The duration and intensity of each repetition was recorded. The intensity of running 400 meters in the exploratory experiment was considered the maximum intensity of all players (Abdel Fattah, 2003).

Results

Table 1 shows Significance of differences between pre-test and immediate post-test measurements of the research variables within the control group

Table 1 Significance of Differences between Pre-Test and Immediate Post-Test Measurements of the Research Variables within the Control Group N=6

Variables	Measurement	Mean of ranks	Total of ranks +	Total of ranks -	Z value	Sig. 0.05
AChE	Pre-test	3.5	21	0	-2.201	significant
	Immediate post-test	9.5				
NAD+	Pre-test	3.5	21	0	-2.201	significant
	Immediate post-test	9.5				
G6PDH	Pre-test	3.5	21	0	-2.201	significant
	Immediate post-test	9.5				
LDH	Pre-test	3.5	21	0	-2.201	significant
	Immediate post-test	9.5				

Table 2 shows Significance of differences between pre-test measurement and post-test measurement after 45 minutes of the research variables within the control group.

Table 2 Significance of Differences between Pre-Test Measurement and Post-Test Measurement after 45 Minutes of the Research Variables within the Control Group N=6

Variables	Measurement	Mean of ranks	Total of ranks +	Total of ranks -	Z value	Sig. 0.05
AChE	Pre-test	9	0	21	-1.992	significant
	Post-test after 45 minutes	4				
NAD+	Pre-test	9	0	21	-2.207	significant
	Post-test after 45 minutes	4				
G6PDH	Pre-test	3.5	21	0	-2.207	significant
	Post-test after 45 minutes	9.5				
LDH	Pre-test	3.5	21	0	-2.201	significant
	Post-test after 45 minutes	9.5				

Table 3 shows Significance of differences between immediate post-test measurement and post-test measurement after 45 minutes of the research variables within the control group.

Table 3 Significance of Differences between Immediate Post-Test Measurement and Post-Test Measurement after 45 Minutes of the Research Variables within the Control Group N=6

Variables	Measurement	Mean of ranks	Total of ranks +	Total of ranks -	Z value	Sig. 0.05
AChE	Immediate post-test	9.5	0	21	-2.201	significant
	Post-test after 45 minutes	3.5				
NAD+	Immediate post-test	9.5	0	21	-2.207	significant
	Post-test after 45 minutes	3.5				
G6PDH	Immediate post-test	3.5	21	0	-2.207	significant
	Post-test after 45 minutes	9.5				
LDH	Immediate post-test	3.5	0	21	-2.201	significant
	Post-test after 45 minutes	9.5				

Table 4 shows Significance of differences between pre-test and immediate post-test measurements of the research variables within the experimental group.

Table 4 Significance of Differences between Pre-Test and Immediate Post-Test Measurements of the Research Variables within the Experimental Group N=6

Variables	Measurement	Mean of ranks	Total of ranks +	Total of ranks -	Z value	Sig. 0.05
AChE	Pre-test	3.5	21	0	-2.201	significant
	Immediate post-test	9.5				
NAD+	Pre-test	3.5	21	0	-2.201	significant
	Immediate post-test	9.5				
G6PDH	Pre-test	3.5	21	0	-2.214	significant
	Immediate post-test	9.5				
LDH	Pre-test	3.5	21	0	-2.201	significant
	Immediate post-test	9.5				

Table 5 shows Significance of differences between pre-test measurement and post-test measurement after 45 minutes of the research variables within the experimental group.

Table 5 Significance of Differences between Pre-Test Measurement and Post-test Measurement after 45 Minutes of the Research Variables within the Experimental Group N=6

Variables	Measurement	Mean of ranks	Total of ranks +	Total of ranks -	Z value	Sig. 0.05
AChE	Pre-test	9	0	21	-1.992	significant
	Post-test after 45 minutes	4				
NAD+	Pre-test	9.5	0	21	-2.207	significant
	Post-test after 45 minutes	3.5				
G6PDH	Pre-test	3.5	21	0	-2.201	significant
	Post-test after 45 minutes	9.5				
LDH	Pre-test	3.5	21	0	-2.201	significant
	Post-test after 45 minutes	9.5				

Table 6 shows Significance of differences between immediate post-test measurement and post-test measurement after 45 minutes of the research variables within the experimental group.

Table 6 Significance of Differences between Immediate Post-Test Measurement and Post-Test Measurement after 45 Minutes of the Research Variables within the Experimental Group N=6

Variables	Measurement	Mean of ranks	Total of ranks +	Total of ranks -	Z value	Sig. 0.05
AChE	Immediate post-test	9.5	0	21	-2.201	significant
	Post-test after 45 minutes	3.5				
NAD+	Immediate post-test	9.5	0	21	-2.201	significant
	Post-test after 45 minutes	3.5				
G6PDH	Immediate post-test	5.5	21	0	-2.201	significant
	Post-test after 45 minutes	7.5				
LDH	Immediate post-test	9.5	0	21	-2.201	significant
	Post-test after 45 minutes	3.5				

Table 7 shows Significance of differences between immediate post-test measurements of the control and the experimental groups.

Table 7 Significance of Differences between Immediate Post-Test Measurements of the Control and the Experimental Groups N=6

Variables	Group	Mean of ranks	Total of ranks +	Total of ranks -	Z value	Sig. 0.05
AChE	Control group	6	13	8	-0.524	insignificant
	Experimental group	7				
NAD+	Control group	5.5	5	1	-1.069	insignificant
	Experimental group	7.5				
G6PDH	Control group	7	15	6	-0.946	insignificant
	Experimental group	6				
LDH	Control group	3.5	0	21	-2.201	significant
	Experimental group	9.5				

Table 8 shows Significance of differences between post-test measurements after 45 minutes of the control and the experimental groups.

Table 8 Significance of Differences between Post-Test Measurements after 45 Minutes of the Control and the Experimental Groups N=6

Variables	Group	Mean of ranks	Total of ranks +	Total of ranks -	Z value	Sig. 0.05
AChE	Control group	3.5	21	0	-2.201	significant
	Experimental group	9.5				
NAD+	Control group	6.5	9.5	11.5	-0.211	insignificant
	Experimental group	6.5				
G6PDH	Control group	3.5	21	0	-2.207	significant
	Experimental group	9.5				
LDH	Control group	9.5	0	21	-2.207	significant
	Experimental group	3.5				

Discussion

Discussion of the results of the first hypothesis

Al-Fawal (2002) notes that the nervous system sends neurological signals to the muscle; it is transmitted from the end of the nerve to the muscle fiber by Acetylcholine and the AChE enzyme as a result of sport activity. This enzyme is particularly important in the process of the contraction of muscle fibers so that the process of nervous signals transmission from the nervous cells to the muscle fibers continues. Thus, an increase in the level of AChE in the blood takes place. This is consistent with Mohamed & Eker's (2010) study, which points out to an increase in the level of AChE enzyme after wrestling players performed an intensive training module of anaerobic exercises. The continuous muscle contraction during these exercises lead to an increase of the AChE enzyme in the immediate post-test measurement after finishing this maximum physical load.Owaid & Khalaf's (2011) study demonstrate that basketball female players' anaerobic glycolysis exercises of speed endurance contributed to the increase of NAD+ and LDH enzyme levels in the blood in the immediate post-test measurement.

On the other hand, Abdel Fattah (2003), Al-Kobeissy & Thiab (2011), and Nonaka & Iwata (2011) indicate that G6PDH enzyme is a factor in the primary reaction for carbohydrates consumption in order to generate energy during anaerobic exercises so that the glycogen stored in the liver is broken into glucose, transmitted to the muscle, then transformed into G6PDH to be used in the anaerobic glycolysis process. The G6PDH enzyme helps maintain reduced glutathione, thus preserve red blood cells and hemoglobin from an increase in oxidation factors and internal burning wastes due to an increase in physical loads to a degree that exceeds the biological capacity of athletes. Hence, it helps maintain the normal hemoglobin level.

Mohamed (2009) notes that LDH enzyme works on extracting the Hydrogen atom from the lactic acid, therefore preventing the accumulation of lactic acid, which is one of the reasons of peripheral fatigue. Additionally, she notes that Hypoxia plays an important role in the increase of LDH. Studies by Hammouda & Souissi (2013), Hammouda et al. (2012a) and Hammouda et al. (2012b) show the existence of significant differences in the level of LDH enzyme between the pre-test and immediate post-test measurements after the youth football players performed a variety of exercises, and after finishing 30 seconds of Wingate Test in favor of the immediate post-test measurement.

Smith et al. (2012) demonstrate significant differences in the concentration level of AChE between the pre-test measurement and post-test measurement after 60 minutes, after performing intensive training on the treadmill for 60 minutes with 60% capacity of VO2max, in favor of the pre-test measurement for healthy youth. Moreover, Shehata's (2011) study indicates that the level of NADH/NAD+ contribute to the completion of oxidation and reduction balancing reactions in the muscle cells. It is influenced by the activity of a number of Hydrogen-extracting enzymes use in transforming Hydrogen ions, as the reduced form NADH is oxidized into NAD+ by electron-transmission chain. Inadequacy of Oxygen results in the reduction of NAD+ level. , Additionally, Al-Hazzaa (2008) notes that G6PDH enzyme increases during anaerobic training through carbohydrate metabolism. This is consistent with a study by Dashtiyan et al. (2014) that points out an increase in the concentration level of G6PDH enzyme in healthy active men and those who sit for long periods in the immediate post-test measurement and post-test measurement after 120 minutes. This difference between the pre-test measurement and post test measurement after 120 minutes is significant in favor of the post-test measurement after 120 minutes. Bieuzen et al. (2012) also show significant differences between pre-test measurement and post-test measurement after 60 minutes in the concentration of LDH levels, after football players performed a set of anaerobic exercises and a recovery interval, in favor of the post-test measurement after 60 minutes. Theodorou et al., (2009) show significant differences between the pre-test and 60-minute post-test in the concentration level of G6PDH between pre-test measurement and post-test measurement after 60 minutes, after performing isokinetic exercises for 120 minutes, in favor of the latter in healthy men. Moreover, a study by Marin et al., (2013) show an increase in LDH levels in three post-test measurements, and identifies the concentration levels of some anti-oxidant enzymes during 6 months of handball training and competitions.

Discussion of the results of the second hypothesis

The researchers explain these results through Abdel Fattah & Shaalan's (1994) observation that at the beginning of football training and competitions players performance is characterized by high quality and speed, then after repeating this way of performance, the level of player's performance declines especially at the end of first half, the match or the training. The players who get an active rest interval, however, are able to perform competently again due to the increase in lactic acid disposal that results from training and anaerobic performance.

Al-Fawal (2002) shows in his study significant differences between the pre-test and post-test measurements in the concentration levels of AChE enzyme, after the performance of a set of aerobic and anaerobic physical exercises for first-class basketball players for an experimental group that uses a carbohydrate drink, in favor of the post-test measurement. Furthermore, Mohamed & Eker (2010) show an increase in the concentration level of AChE enzyme after the performance of a high-intensity anaerobic training module for wrestling players. The increase in muscle contraction during these exercises results in an increase in the level of AChE enzyme in the post-test measurement immediately after finishing the performance of this maximum physical load , On the other hand, Heshmat et al. (2013) and Heshmat et al. (2003) emphasize the importance of NAD+ during anaerobic exercises and the decomposition of glucose, as the production of lactates results in the maintenance of NADH/NAD+ levels, sugar decomposition, and production of adenosine triphosphate . Shehata (2011) notes a significant increase in the level of NADH/NAD+ after performing dynamic exercises compared to rest. He also notes an increase in the NADH/NAD+ level after performing both maximum intensity and nearly maximum intensity exercises, and an increase in NAD+ level , Additionally Salama (2008) demonstrates that glucose is transformed into glucose-6-phosphate during anaerobic exercises through G6PDH enzyme to contribute in energy generation during anaerobic glycolysis exercises. Abdel-Fattah & Sayed (2003) observe that the activity of the LDH enzyme contributes to lactic acid metabolism; therefore, any increase in the activity of this enzyme is accompanied by an increase in lactic disposal, which emphasizes the importance of aerobic endurance exercises and speed endurance exercises for sprint and short-distance athletes.

The researchers also explain these results through the findings of Smith et al. (2012) that significant differences are found in the concentration of AChE between the pre-test measurement and post-test measurement after 60 minutes after performing intensive training on the treadmill for 60 minutes with a 60% capacity of VO2max in favor of the pre-test measurement. Moreover, Mach et al. (2010) found significant differences in the level of NAD+ between the pre-test measurement and the post-test measurement after 60 minutes, after performing physical load with a capacity of 50% and 70% of VO2max on the bicycle ergometer, in favor of the pre-test measurement.

Dashtiyan et al. (2014) note the increase of G6PDH level in the post-test measurement after 24 hours in a group of active men. The increase of G6PDH enzyme is related to the efficiency of red blood cells and the increase in the concentration levels of hemoglobin. This enzyme is also associated with the activity of certain enzymes related to free radicals. The decrease in the level of G6PDH leads to an increase in the dissolution of red blood cells, oxidative stress, and anemia, in case of high-intensity exercises that exceed the biological capacity of the athlete.

Furthermore, Aok & Sawaki (2012) have found significant differences in LDH level between the pre-test measurement and post-test measurement after 120 minutes, after football players performed physical training, in favor of the post-test measurement. Ramallo & Galatti (2013) have found significant differences between pre- and post-test measurements in the concentration level of LDH, after conducting intensive training with weights composed of nine sets of weight exercises with 6-10 repetitions and 75% intensity in favor of the post-test measurement.They also identify the effect of glutamine consumption on muscle damage, delay of muscle fatigue, increase of muscle power ,Additionally, Smith et al. (2012) note significant differences between the immediate post-test and post-test after 60 minutes after performing 60-minute training on the treadmill with 60% capacity of VO2max in the concentration of AChE enzyme in favor of the immediate post-test measurement. Additionally, Mach et al. (2010) note significant differences in the NAD+ level between the immediate post-test measurement and the post-test measurement 60 minutes after finishing physical performance on the bicycle ergometer with 50% and 70% VO2max capacity, in favor of the immediate post-test measurement. Dashtiyan et al. (2014) also show an increase in the level of G6PDH in the post-test measurement after 24 hours in a group of active men. The increase in G6PDH level is associated with the efficiency of red blood cells and increase in hemoglobin levels. This enzyme is also related to the activity of some enzymes related with free radicals. The reduction in G6PDH level leads to dissolution and oxidative stress of red blood cells, and the occurrence of anemia when high-intensity exercises exceed the biological capacity of the athlete. Bieuzen et al. (2012) also note an increase in LDH level in the immediate post-test measurement, and the decline of LDH level in elite football players in both the post-test measurement 60 minutes and the post-test measurement 24 hours after performing high-intensity exercises and receiving 60-minute recovery interval.

Discussion and explanation of the results of the third hypothesis

The researchers explain these results in light Al-Fawal's (2002) findings, as he has found insignificant differences between the post-test measurements of two groups in the AChE levels, despite the noticeable increase in the activity of this enzyme in the post-test measurement of the first group that took a 6% carbohydrate drink. Moreover, Shehata (2011) has not found any significant differences in the post-test measurements in the concentration level of NADH/NAD+ among the three examined training approaches of long-distance athletes. Theodorou et al. (2009) have also found insignificant differences in the concentration levels of G6PDH enzyme between two groups of healthy men in the immediate post-test measurement after performing a set of physical exercises. Individuals who are deficient in G6PDH and perform these exercises more likely get muscle fatigue and have higher oxidative stress than those who have a better concentration level of G6PDH enzyme. The latter group can proceed with their training better than the former group. Maguid (1996), Al-Naimy & Hashim (2004), and Shehata (2011) emphasize that the use of active rest during intensive training helps reduce the effects of fatigue resulting from high-intensity physical performance, increases blood flow to the muscles to get rid of internal burning outputs, and increases myoglobin and oxygen flow to the muscles. In football, the performance of stretching exercises and slow running during or after training and competitions improves the somatic functional status and helps get rid of internal burning outputs, compared to passive rest.

Discussion and explanation of the results of the fourth hypothesis

The researchers explain these results in light of what Abdel-Fattah & Sayed (2003) have found, that during anaerobic exercises, relatively long rest intervals should be given in order to allow recovery processes. Rest intervals may range between 2 to 15 minutes, preferably active rest where the player does jogging (slow running) and stretching exercises. Abdel-Fattah (1999) also points out that recovery processes increased by 100% after a few minutes of performance, and increased to 400% after 20 minutes of active rest in a group of runners compared to another group that used passive rest. On the other hand, Abdel-Fattah (1999) and Al-Beik, et al. (1995) indicate that the physiological effects of active rest include the increase in blood flow to the muscles, and overcoming oxygen debt quickly. Active rest also influences the central nervous system. Al-Nemr, et al. (1999) note that performing stretching exercises helps in the quick recovery after performing various physical loads. Stretching exercises also help in getting rid of inflammations that may occur in the muscle tendons, reduce the sensation of pain and muscle fatigue. They also help recover the nervous system, alleviate stress and tension. Keshk & Abdel-Razeq (2008) have also found that using a combination of cold water and ethyl chloride during rest led to a decline in the concentration level of LDH after handball competitions, and also helped in reducing muscle fatigue and pain, helped with speed recovery in a more effective way than using passive rest only. Gravina et al (2012) point out that LDH level declined in the post-test measurements of the experimental group that took vitamins, thus a decline in muscle fatigue in female footballers after intensive and high-intensity football competitions occurred. Takeda et al. (2013) have also found a decline in the concentration level of LDH in the second post-test measurement of the experimental group which used immersion in cold water as a means of recovery after rugby training.

Conclusions

- Anaerobic glycolysis exercises increased the concentration levels of all research variables.
- Recovery of all research variables continued in both the experimental and control groups during the passive and active rest intervals and during the performance of stretching exercises, which took 45 minutes.
- Passive rest did not affect the recovery of all research variables in the control group.
- Active rest and stretching exercises helped reduce the concentration levels of AChE, NAD+, and LDH. Insignificant differences in the concentration levels of G6PDH were shown between the immediate post-test measurement and the post-test measurement after 45 minutes.
- Active rest between repetitions did not help speed the recovery process of some research variables in the experimental group.
- Active rest and stretching exercises helped increase the recovery of all research variables.

References

Abdel-Fattah, A. (2012). Contemporary sports training (physiological bases, training plans, youth training, long-term training, training load faults, Cairo: Dar Al-Fikr Al-Arabi.

Abdel-Fattah, A. (2003). Physiology of sports and training, Cairo: Dar Al-Fikr Al-Arabi.

Abdel-Fattah, A. & Sayed, A.N. (2003). Physiology of physical fitness, Cairo: Dar Al-Fikr Al-Arabi.

Abdel-Fattah, A. (1999). Recovery in sports, Cairo: Dar Al-Fikr Al-Arabi.

Abdel-Fattah, A. & Shaalan, I. (1994). Physiology of football training 650 exercises for physiological and kinetic competence and physical preparation, Cairo: Dar Al-Fikr Al-Arabi.

Abdel-Qader, N.M. & Aref, M.M. (2009). The effect of speed swimming and endurance swimming on certain biochemical and physiological variables in 15-17 years old swimmers. Scientific Journal of Physical and Sports Education. Alexandria University, vol. 38.

Al-Beik, A. et al. (1995). The athlete's rest, Alexandria, Monshaat Al-Maarif.

Al-Fawal, A.I. (2002). The impact of carbohydrate consumption on central and peripheral fatigue and berformance efficiency in basketball, Unpublished Ph.D. Thesis. Tanta University, Faculty of Physical Education.

Al-Hazzaa, H.M. (2008) Practical procedures in the physiology of physical effort, circulatory and respiratory systems and physical effort, and the anaerobic threshold, Journal of Sports Medicine Sciences. Arab Federation of Sports Medicine, Bahrain.

Al-Houfi, M.H. (2014). The effect of using endurance exercises with diverse motor paths on certain physical capacities and delaying fatigue in football youth players, Scientific Journal of Physical Education and Sport. Helwan University (70).

Al-Kobeisy, R.S. & Thiab, R.T. (2011). Fast ballistic strength training and its effect on the increase of certain oxidation and reduction enzymes in female basketball players, Sports Science Journal, Diyala University (2).

Al-Naimy, T.H. & Hashim, M.A. (2004). The effect of active and passive rest during training modules on performance level, Journal of Sports Education. Electronic Iraqi Academy of Sports. 13 (1).

Al-Sherbini, Z. (2001). Non - parametric statistics and using spss in education, psychology and social sciences, Cairo: Anglo - Egyptian Bookstore.

Anugweje K.C. & Ayalogu E.O. (2014) Effect of training on the lactate dehydrogenase (ldh) levels of athletes, http://www.Sciencepub. Net/Researcher. Researcher, 6(9).

Aok, K. & Sawaki, K. (2012). Post - training consumption of wheat gluten hydrolysate suppresses the delayed onset of muscle injury in soccer players, Experimental and Therapeutic Medicine, 3: 969-972.

Baker, J.S & Robergs, R.A. (2010). Interaction among skeletal muscle metabolic energy systems during intense exercise, Journal of Nutrition and Metabolism.

Bieuzen, F. et al. (2012). Recovery after high-intensity intermittent exercise in elite soccer players using veinoplus sport technology for blood flow stimulation, Journal of Athletic Training, pp 498 - 506.

Dashtiyan A. et al. (2014). The Effect of progressive aerobic exercise on g6pd activity among active and sedentary men, International Journal of Kinesiology, Sports Science, 2(4).

Fergani, E.F. (2005). The effect of a combined diet on the concentration of Monoamine oxidase and cholinesterase in short-distance athletes, Unpublished M.A. Thesis. Tanta University, Faculty of Physical Education.

Gravina, L. et al. (2012). Influence of nutrient intake on antioxidant capacity, muscle damage and white blood cell count in female soccer players, Journal of the International Society of Sports Nutrition, 9(32): 2-11 .

Hammouda, O. & Souissi, N. (2013). Biochemical responses to level-1, yo-yo intermittent recovery test in young tunisian football players, Asian Journal of Sports Medicine, 4(1): 23-28.

Hammouda, O. et al. (2012a). High intensity exercise affects diurnal variation of some biological markers in trained subjects, Int J Sports Med, 33:1- 6.

Hammouda, O. et al. (2012b). Effect of short-term maximal exercise on biochemical markers of muscle damage, total antioxidant status, and homocysteine levels in football players, Asian Journal of Sports Medicine, 3(4): 239-246.

Heshmat, H.A. et al. (2013). Encyclopedia of sport physiology, Cairo: Dar Al-Fikr Al-Arabi.

Heshmat, H.A. & Shalabi, N.M. (2003). Physiology of muscular fatigue, Cairo: Dar Al-Fikr Al-Arabi.

Hussein, S.M. (2009). The effect of some biokinematical variables on the activity of enzymes in the flood for running 110 meters hurdles, Sports Science Journal. Diyala University (1).

Keshk, M.S. & Abdel-Razeq, M.Q. (2008). The effect of ethy chloride as a healthy way of recovery for CPK, GOT, TBARS, and LDH enzymes that indicate muscular pain and fatigue. Scientific Journal of Physical and Sports Education Sciences. University of Mansoura. Vol. 10.

Mach, J. et al. (2010). The Effect of antioxidant supplementation on fatigue during exercise, Potential Role for NAD^+ (H), Nutrients, pp, 2:319 – 329.

Maguid, R.K. (1996). Muscular fatigue and recovery processes in athletes, Amman: Dar Al-Shorouq for publication and distribution.

Marin, D.P. & Ottonb, R. (2013) Oxidative stress and antioxidant status response of handball athletes: Implications for sport training monitoring, International Immunopharmacology, pp, 17: 462-470.

MartínezAmat A., et al. (2010). Release of muscle α-actininto Serum after intensive exercise, Biol. Sport, pp, 27: 263-268.

Mohamed, I.S. & Eker, S.A. (2010). The effect of maximum physical load on the level of minerals and cholinesterase as indicators of peripheral fatigue in wrestling players. Paper submitted to the International Conference of Arab Universities Sports. Cairo, Egypt.

Mohamed, M.A. (2007). The effect of developing anaerobic threshold on the level of performance in youth wrestlers. Unpublished M.A. Thesis. Zagazig University, Faculty of Physical Education for men.

Nonaka, K. & Iwata, A. (2011). Thermal preconditioning attenuates exercise induced muscle injury in mice, J.Phys.Ther.Sci, pp, 23: 409- 411.

Othman, M.A. (2000). Training load and adaptation (biophysiological responses to training loads theory and application), Cairo: Dar Al-Fikr Al-Arabi.

Owaid, I. & Khalaf, Z.M. (2011). The Impact of speed endurance training of basketball female players on the concentration of lactic acid in the blood, Sports Science Journal, Diyala University (2).

Radwan, M.N. (1988). Non-Parometric statistics in sports education research, Cairo: Dar Al-Fikr Al-Arabi.

Ramallo B. & Galatti L. (2013) ACUTE glutamine supplementation does not affect muscle damage profile after resistance training, International Journal of Sports Science, pp, 3(1): 4-9.

Salama, B.I. (2008). Biochemical characteristics of sports physiology, Cairo: Dar Al-Fikr Al-Arabi.

Salama, B.I. (2000). Physiology of Sport and Physical Performance (blood lactate), Cairo: Dar Al-Fikr Al-Arabi.

Shehata, A.H. (2011). Examining the effect of two different approaches of interval training on certain biochemical variables and performance levels of long-distance runners. The Scientific Journal of Physical Education and Sports. Helwan University (62).

Shei, R. et al. (2013). Relative contributions of central and peripheral factors in human muscle fatigue during exercise, A Brief Review, Journal of Exercise Physiology online, pp, 6-16.

Smith, C. J. et al. (2013). Regional relation between skin blood flow and sweating to passive heating and local administration of acetylcholine in young, healthy humans, Am J Physiol Regul Integr Comp Physiol, pp, 304: 566 – 573.

Takeda, M. & Radak, Z. (2014).The Effects of cold water immersion after rugby training on muscle power and biochemical markers, Journal of Sports Science and Medicine , 13: 616-623 .

Theodorou A.A. et al. (2009). Comparison between glucose-6-phosphate dehydrogenase–deficient and normal individuals after eccentric exercise, Medicine and Science in Sports and Exercise.

Wali, M.S. (2011) Evaluation of some training programs of team sports in light of the adaptation of blood lactates, certain enzymes and hormones, Al-Qadesiya Journal of Sports Education Sciences, 11.