The Effects of Electrostimulation and Core Exercises on Recovery After High-Intensity Exercise

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ABSTRACT: Introduction and objectives: The purpose of this study was to determine the effects of electrostimulation and core exercises on recovery after high-intensity exercise. Methods: The participants of this study consists of 12 male bodybuilders who regularly train and between the ages 18-30. Tabata high intensity interval training (HIIT) was applied with different recovery methods to the athletes on three different days and the recovery levels of athletes were analyzed. Heart rate and blood lactate levels were measured at baseline (PRE) at immediately after the HIIT (POST), at the 1 minutes after HIIT (1min), at the 5 minutes after HIIT (5min), and at the 10 minutes after HIIT (10min). On the rest days, serum lactate dehydrogenase (LDH) and serum creatine kinase (CK) measurements were done to determine the muscle damage. Results: The in-group comparisons for lactate levels showed no significant difference (p>0.01). The level of lactate on the 10min was found to be significantly lower than the 5min in the core exercise group (p<0.01). Similarly in the electrostimulation group, 10m lactate levels are significantly lower than 5min (p<0.01). There were no statistically significant differences in the heart rate measurements (p<0.01). The results showed no statistically significant difference between the groups although the averages of LDH and CK showed variations (p>0.01). These results show that the lactate level reaches to the maximum level after HIIT, and the level of lactate decreases between the 5th and the 10th minutes. Discussion and conclusion: These indicate that the active recovery methods are more effective than the passive. It was found that the active recovery methods accelerate the lactate removal from the metabolism and provide effective recovery in short time during the recovery period after exercise.

KEY WORDS: HIIT, recovery, electrostimulation, core exercise, lactate, heart rate

INTRODUCTION

Training is a complicated activity that is organized based on principles and methods for athletes to reach the maximum muscle mass and to help being functional within the limits of possibility [1]. High intensity interval training has been a complement part of training programs in improving athletic performance since the early 19th century. High intensity interval trainings are short, intense and interval activities that are distributed in between resting and low intensity exercises. This
training method is defined by several factors including the nature of exercise stimulators and it is a training that has high variables (intensity, the number and duration of intervals, recovery, etc.) due to certain physical adaptations [2]. High intensity interval training can continue from a few seconds to a few minutes depending on the intensity of the training [3]. It affects the level of physiological change more compared to a moderate intensity training. Although the energy spent is the same in interval and continuous, it can provide an effective alternative for routine endurance trainings [4, 2]. On the contrary to short but intense strength trainings that increase skeletal muscle mass, high intensity interval training is generally associated with cycling, running, or trainings that do not cause hypertrophy. It provides gain on the total exercise time and a more efficient training [3].

A large number of intense training and competitions, particularly with the minimum recovery time, can affect the demands of the next training performance negatively, and may lead to injuries due to overload. That is why, the recovery process after an intense training and competition is important in the next training [5]. As the exercise intensity increases based on the maximum oxygen consumption, the anaerobic energy metabolism will be involves more and the production of lactic acid will increase. The lactic acid produced by the working muscles goes above the level of lactic acid removed by blood, and the level of blood lactate starts to increase. Lactic acid is one of the metabolites that cause fatigue and when it’s accumulated in muscles, it would lead to a decrease in the exercise performance [6].

Many athletes, train 2-3 times a day (or sometimes even more) with a severe program. In these conditions, athletes can go beyond the physiological and psychological measures and disrupt the functions of the organism, and decrease the work capacity. Also, problems stemming from business and personal life styles can be seen in athletes. Each situation creates physiological, psychological, and psycho-social tension which affects training, competition, and the quality of an athlete to repeat a skill in short intervals. Therefore, in order to overcome this, an athlete should create a good balance between training, societal life, and recovery level [7].

It was shown through repeated high intensity short exercises that active recovery is more advantageous than passive recovery in terms of performance [8]. The recovery after the exercise can be done only with resting and active recovery methods. Low intensity exercises during the recovery phase after heavy exercises help removal of lactic acid faster. Recovery done by jogging is the recovery method that has the highest level of lactic acid removal. It would be more advantageous for athletes to do light but longer exercises during the recovery phase such as jogging rather than short loads with intervals [9]. Since it is known that high intensity exercises increase the lactate threshold, it is required to have recovery intervals after training repeats for the lactate that would accumulate heavily in skeletal muscle in exercises. Studies show that active recovery is more effective in the cleaning of oxidated lactate accumulated in the skeletal muscle and redistribution via blood flow compared to passive recovery. Although it is not generally accepted, the common strategy that is believed is that the active recovery at an appropriate intensity is more positive in cleaning the accumulated lactate [10, 11].

Core exercises is a method used in training muscles that keeps the spine and hip in balance [12]. Core exercises became an important trend in rehabilitation. Core exercises is a program preferred by individuals who want to stabilize the central part, and improve the control of surrounding muscles, moto-control exercises, controlling weight, spine and musculoskeletal injuries, and to improve performance. Another function of core exercises which is a multi-functional technique is to help the active recovery [13, 14].

One of the many recovery methods that emerged with technological improvements is electrostimulator. The effects of this device on recovery is being researched and it is a new device in this field. Research showed that this popular method heals post-exercise muscle damage. Although there is very few research, the studies conducted focused on post-exercise muscle injuries and showed different results in terms of its effectiveness [15, 16].

This study aims to examine the effects of electrostimulation and core exercises on recovery after intensive exercise.

**METHODS**

The participants of the study consist of 12 male body builders between the ages of 18 and 30 who train regularly. Subjects with any diseases and injuries (hypertension, thyroid, diabetes, cardiac, etc.) were not included in this study. This study was approved by the Clinical Research Ethics Committee in Ondokuz Mayis University (Number: B.30.2.ODM.0.20.08/1533).

All athletes were subject to Tabata HIIT protocol every other day, a total of three times. Measurements were taken in the same time period and physical conditions. Firstly, the heart rate and lactate levels of athletes were taken at rest. Then, athletes were subjected to Tabata protocol. The exercises in the protocol were shown by the researcher after the warm-up. The protocol consisting of 8 repetitions in 4 minutes were applied in 4 sets with the method of loading for 20 seconds, resting for 10 seconds. 2 minute resting breaks were taken between the sets. Heart rate and lactate levels were determined at baseline (PRE), at immediately after the HIIT (POST), at the 1 minutes after HIIT (1min), at the 5 minutes after HIIT (5min), and at the 10 minutes after HIIT (10min). On the rest days (2nd, 4th, and 6th days), serum lactate.
dehydrogenase (LDH) and serum creatine kinase (CK) measurements were performed to determine the muscle damage level.

After the HIIT protocol applied to the athletes, several recovery methods were applied for 10 minutes. On the first day, no recovery methods were applied to the athletes during the recovery but only lactate levels and heart rates were determined. On the third day, core exercises, one of the active recovery methods were applied and lactic acid levels and heart rates. After the final load, electrostimulation device (muscle improvement and rehabilitation) was used for active recovery. Tabata HIIT protocol was applied to the athletes and no exercise or method to accelerate the recovery was applied at the end of the training.

The biochemical tests in this study were performed in a well-equipped official health institution that has calibrated devices. 15 cc venous blood samples were taken by nurses, and the analysis were done by biochemistry specialists. Biochemistry analysis was studied from the serum samples acquired by 3500 cycle/minute and 15 minute centrifuge speed of venous bloods at Abbott Architect c16000 biochemistry auto analyzer. The upper phases were transferred to eppendorf tubes and kept at −80 °C until the use. Three blood samples were performed on the resting days, and serum lactate dehydrogenase and serum creatine kinase levels were analyzed.

The exercises like basic plank, one side plank, leg raised plank, reverse plank and plank jacks were done with the athlete’s own body weight, and it started after the 1st minute lactate measurement at the end of HIIT protocol (Table 1). Core exercises lasted 10th minute, when the last lactate measurement was taken.

| Exercises         | Duration /Rest                  |
|-------------------|---------------------------------|
| Basic Plank       | 30 sec x 2 rept / 30 sec rest   |
| One Side Plank    | 30 sec x 2 rept / 30 sec rest   |
| Leg Raised Plank  | 30 sec x 2 rept / 30 sec rest   |
| Reverse Plank     | 30 sec x 2 rept / 30 sec rest   |
| Plank Jacks       | 30 sec x 2 rept / 30 sec rest   |

Active recovery is performed with a Norotrac brand, portable muscle development and rehabilitation device. Electrostimulation was performed via electrodes placed on the skin, and electrical current was given to the areas where the most actively working muscles are. When electrodes are connected, as the active muscle group continued contracting, the energy to be applied was adjusted automatically by the device accordingly to the big and small muscle groups. The function of the device was adjusted to the athlete wellness and active recovery option.

Data obtained in this study are presented in arithmetical average and standard deviation. Parameters that show normal distribution were analyzed with the Paired Samples T Test while parameters for not normal distribution were analyzed with Mann Whitney U test. The statistical significance was accepted as p<0.01. SPSS v.22 packet program was used in the statistical analysis of data.

**STATISTICAL RESULTS**

The changes in lactate level, heart rate, and biochemical tests at the end of active and passive recovery methods were statistically analyzed and compared in this study. Some parameters showed statistically significant differences while others did not.

Data obtained from the control group during recovery period showed no significant difference (p>0.01). The lactate level was 7.03±2.66 on minute 5 while it decreased to 5.31±2.09 at minute 10. A significant difference was found in recovery period of the core exercise group (p<0.01). In the electrostimulation group during recovery period, the lactate measurement was 7.01±1.23 at minute 1 and it increased to 8.70±1.58 and a significant difference was found (p<0.01). Again, in the electrostimulation group, the lactate level was 8.70±1.58 at minute 5 and it decreased to 5.88±1.05 at minute 10 and A significant difference was found (p<0.01) (Table 2).

Table 3 presents the levels of heart rates from rested and recovery periods. The results of the three groups are compared according to the minutes and showed similarities. No statistically significant difference was found in the heart rates (p>0.01).

The changes in the biochemical test results after high intensity interval training in three groups are presented in Table 4. When the LDH and CK levels are compared between the groups, no statistically significant difference was found between the control, core exercises, and electrostimulation groups (p>0.01).
Table 2. Lactate levels of athletes during resting and recovery phases and the comparison of variables within groups

| LACTATE LEVELS (mmol/L) | Control Group Recovery Values | Core Exercise Group Recovery Values | Electrostimulation Group Recovery Values |
|-------------------------|--------------------------------|-----------------------------------|------------------------------------------|
| Time (min)              | n    | Mean         | Mean         | Mean         |
| Pre                     | 12   | 1,38±0,84    | 1,33±0,23    | 1,71±0,46    |
| 1min                    | 12   | 9,71±1,48    | 6,43±2,69    | 7,01±1,23    |
| 5min                    | 12   | 9,50±1,87    | 7,03±2,66    | 8,70±1,58    |
| 10min                   | 12   | 8,46±1,51    | 5,31±2,09    | 5,88±1,05    |

Comparison of variables

| Lactate Values during the Recovery Phase and In-Group Comparison | t    | p      | t    | p    | t    | p    |
|------------------------------------------------------------------|------|--------|------|------|------|------|
| 1min & 5min                                                      | 1,117| 0,315  | -1,034| .349 | -4,063| 0,010|
| 1min & 10min                                                    | 3,818| 0,012  | 1,599 | 0,171 | 2,745| 0,041|
| 5min & 10min                                                    | 3,128| 0,026  | 4,409 | .007 | 7,725| 0,001|

Table 3. Heart rates of athletes during resting and recovery periods and the comparison of variables between the groups

| HEART RATE MEASUREMENT (beat/mn) | Control Group Recovery Values | Core Exercise Group Recovery Values | Electrostimulation Group Recovery Values |
|----------------------------------|-------------------------------|-----------------------------------|------------------------------------------|
| Time (min)                       | n    | Mean         | Mean         | Mean         |
| Pre                              | 12   | 69,00±15,16  | 66,00±13,49  | 69,50±13,08  |
| 1min                             | 12   | 170,16±10,28 | 164,66±10,17 | 174,83±9,15  |
| 5min                             | 12   | 100,33±7,60  | 99,66±7,14   | 101,66±8,71  |
| 10min                            | 12   | 89,00±3,22   | 88,83±1,94   | 91,16±2,99   |

Comparison of Variables

| Control Group & Core Exercises Group | Control Group & Core Exercises Group | Core Exercise Group & Electrostimulation Group | Core Exercise Group & Electrostimulation Group |
|-------------------------------------|-------------------------------------|-----------------------------------------------|-----------------------------------------------|
| z                                  | p                                  | z                                  | p                                  |
| Pre                                | -0,241                             | 0,810                             | -0,161                             | 0,872                             | -0,561                             | 0,575                             |
| 1min                               | -0,727                             | 0,467                             | -1,292                             | 0,196                             | -1,848                             | 0,065                             |
| 5min                               | -0,161                             | 0,872                             | -0,561                             | 0,575                             | -0,482                             | 0,630                             |
| 10min                              | -0,327                             | 0,744                             | -1,311                             | 0,190                             | -1,532                             | 0,126                             |

p<0,01
Table 4. The changes in the biochemical test results of athletes after HIIT

| Test               | Control Group | Core Exercises Group | Electrostimulation Group | Total Values |
|--------------------|---------------|----------------------|--------------------------|--------------|
|                    | n             | Normal Value         | Mean                     | Mean         | Mean                      | Mean                   |
| LDH                | 12            | 125.243 U/L          | 218.16                   | 215.66       | 210.66                    | 214.83±44.29           |
| CK                 | 12            | 30.200 U/L           | 559.83                   | 732.16       | 485.66                    | 586.22±361.37          |

Comparison of Variables

|                    | Control Group & Core Exercises Group | Control Group & Electrostimulation Group | Core Exercises Group & Electrostimulation Group |
|--------------------|--------------------------------------|------------------------------------------|-----------------------------------------------|
| z                  | -0.961                               | -0.641                                   | -1.281                                        |
| p                  | 0.337                                | 0.522                                    | 0.200                                         |
| Lactate Dehydrogenase (LDH) | -0.320 | 0.749 | 0.000 | 1.000 | -0.320 | 0.749 |

p<0.01

DISCUSSION

There are many factors that affect an athlete’s performance. Training and recovery are two of the most important factors. A high performance is possible only with a balanced planning of these two factors. High intensity trainings cause a chronic imbalance between training and recovery in athletes and create weeks or months-long different physical and psychological performance decreases. Therefore, high intensity trainings should be considered apart from short interval intensity loads and local muscle strains [17]. High intensity interval training is a frequently used exercise in training programs that aims to develop maximum oxygen consumption and the anaerobic capacity [18]. One of the sports that requires high intensity training is body building. This sports which requires a detailed, comprehensive, and highly intense, uses strength and endurance elements in trainings primarily. As the primary goal of this sport is skeletal muscle hypertrophy, recovery has an important part in this branch [19].

Two main metabolically phases affect healing during recovery after maximal training. The first one is the creatine phosphate stocks, and the second one is the acid-base balance in working muscles. These two processes occur differently, and re-synthesis of creatine phosphate takes half the time compared to muscle lactate and pH recovery time [20].

Muscle recovery after physical activity, particularly in sports and rehabilitation, is very important. Especially, short resting periods after several intense activities made fast muscle recovery important for high performance. These activities require the repetition of muscle performance and short resting periods follow these exhausting exercises. Moreover, fast muscle recovery decreases the risk of injuries during sports activities and increases the muscle tension in joints at the minimal level. As a result, fast recovery has an important role both for sports and for rehabilitation [21]. Fast recovery after training is a positive element for athletes, and is another important element after training and performance. Therefore, athletes, trainers and sports scientists, focus on researching and developing several and creative fast recovery methods to improve athletes during training in terms of quality and quantity [22, 23].

There are many studies on fast recovery of athletes and several different methods are used. The emerging recovery strategies include nutrition [24, 25], cryotherapy methods [26], thermotherapy, hydrotherapy, hot/cold/contrast water applications, massage and low intensity exercise [22, 21, 27, 28, 29].

Atan et al. (2013) compared the effects of jogging and core exercises on recovery in basketball players after supramaximal exercise, and measured lactate and heart rates. They did not found a significant difference in lactate values of recovery period at minute 1, 5, and 10. However, they identified that core exercises decreases the heart rate and they found a statistically significant difference [29].

In this study, core exercises and electrostimulation active recovery methods were applied to the athletes, however, no positive effects on the
heart rate were found compared to the passive recovery methods. Connolly et al. (2003) compared active and passive recovery methods post-high intensity exercise and they did not find any decrease in the lactate levels in both groups. There was no significant difference [30]. In another study conducted by Tessitore et al. (2007), several recovery strategies were applied on soccer players and found that electrostimulation and low intensity aerobics exercise are more beneficial in recovery, decreasing the muscle pain, and increasing performance compared to the passive recovery and renewal exercises done in water. They found a significant difference [31]. Vanderthommen et al. (2010) asked athletes to do supramaximal isometric knee extension exercise in the study they conducted. Then, they applied electrostimulation and passive resting methods to athletes during the recovery period but they did not find a significant healing in muscle recovery [14].

The results in this study show a statistically significant decrease of lactate levels both in the core exercises and the electrostimulation groups during the recovery phase. Tessitore et al. (2008) examined active and passive recovery methods on athletes, and found statistical significance on the electrostimulation recovery method being more beneficial than passive resting. However, they could not find any significant difference of recovery methods on the levels of anaerobic performance, hormones (catecholamines, cortisol) and muscle regeneration [32]. In this study, we analyzed LDH and CK to determine the muscle regeneration on the day after the high intensity training. We found a decrease in the LDH enzymes. In the second analysis, we found an increase in the CK enzyme in the second analysis while we found a decrease in the CK enzyme on the third analysis. However, we did not find a statistically significant difference in the data. We think the reason for this finding is due to the uncontrolled life styles of the athlete participants of this study, malnutrition, delayed muscle renewal, and muscle damage.

The findings show that core exercises and electrostimulation recovery methods provide a faster removal of lactate from the blood and muscles after high intensity interval training. These findings indicate that recovery methods with fast recovery will prepare athletes faster to the next load and will have a positive effect on performance. The similarity in heart rates after active and passive recoveries, and the fact that there was no positive effect of active recovery make us think that this is due to the characteristics of this sports field. The results of biochemical analysis and performance measures for identification of muscle damages indicate that having better controlled life styles and a regular nutrition program would have better results. When these are combined with recovery methods, we think that it will be more effective on performance. This study shows that active recovery methods are more effective than passive recovery methods. Although the methods used and the data obtained provide an important result that can be used to improve recovery and renewal strategies in performance sports, there is still a need for further research in this field.

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