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Investigation of effects of imagery training on changes in the electrical activity of motor units of muscles and their strength in the lower extremities

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ABSTRACT

The purpose of the present study was to Investigation the effect of mental imagery training on electrical fluctuation of muscles motor units and muscles strange in lower limb. 30 healthy, previously untrained subjects (mean ±SD; age =22.4±1.25years, height=176.18±5.62cm, weight=67.65 ±6.15) participated in this study. Subjects were randomly assigned to a mental practice group (n=15) or control group (n=15). Mental practice group trained mental contraction of plantar flexion movement for 4 weeks (5 day per week): and control group was not trained but participated in all measurement. Practice program were included 50 mental maximal voluntary contractions for 2 sets of 25 repetitions. Strength and electromyography of the gastronomies (GAS) and tibialis anterior (TA) muscle was measured at pre- post test. To determine the statistical difference in variables of the study the t-student test was used in significant level of $P \leq 0.05$. The results of this study indicated that mental practice group significantly increased their plantar flexor maximal voluntary contraction (MVC) but was not significantly in control group ($p \leq .05$). Also mental practice group significant increased their gastronomies muscle EMG but was not significant in control group ($p \leq .05$). Also the results of this study indicated that the tibialis anterior muscle EMG significantly decreased in mental practice group but was not significant in control group ($p \leq .05$). We concluded that mental practice can increase strength plantar flexor muscle, which strength gain is attributed the training-induced changes in programming central and increases activation level of agonist muscle and decreases of them in antagonist muscle. Results showed that the effect of imagery training on athletic performance has been very effective.

Keywords: mental practice, strength, electromyography, maximal voluntary contraction

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INTRODUCTION

Increase in maximal contractile force of the muscle is not justified only for increase in cross-sectional area or the muscle size. But an increase in neural drive of muscle fibers also contributes in increasing the maximum contractile force resulted from exercise [1]. Maximum strength development which is through increase in neural drive can be formed in lack of increase in size of muscle. In this way, not only the size and appearance of muscle but also consistency in neural structures are important factors in determining maximum power of muscle contraction [2].

Study of mental imagery is primarily concerned with the issue of how people mentally or symbolic visualize and analyze data. What is today referred to as mental imagery was called at first mental practice. The early purposes of mental practice studies was that whether this is a useful skill as a physical exercise or not [3, 4, 5]. Researchers began to research about variables which contributed in mental imagery. Mental imagery, even without having to move the muscles, causes learning; Though apparently such a thing seems impossible, but in fact, many studies have been done in this case and showed that one can conceive the mind and it can be very helpful in improving his skills and desired function [6, 7]. Feltz and Landurz stated that practicing mental imagery can even be as effective as physical practice that this reflects the power of mental imagery in doing physical activities [3]. Scientists are trying to advance theories in the field of real working of this process and giving complete description. In the past two decades, potential use of imagery and its efficiency in sport in the fields of training has been studied. As the scientific evidences supporting the efficacy of mental imagery, athletes implemented from imagery in sport and exercise contexts not only to help to their performance but also to create experiences in sport and its enjoyable experiences fields [8, 9, 10]. Ranganathan et al (2004) showed that mind has significant power beyond the body and its muscles and people can use from their minds to maintain or increase muscle nerve signals in order to maintain or increase muscle power [6]. By regarding to the increased power in the early stages of training due to neural non-adaptation, the phenomenon of increasing muscle strength and improving the performance of motor skills by mental practice, recent studies try to determine that whether the exercise of the mental practices on muscles causes more excitement in motor neuron or coordination of electromyography activity (EMG) is followed by performing that practical program [11, 12, 13]. In 2005 Ben Sideway et al showed that differences in power generation was observed after exercise in the two groups of physical and mental exercise (physical exercise, 25.28% and mental practice 17.12%), but in the control group, there was no significant improvement (-1.77%). These findings show that mental practice can increase power generation similar to the physical practice [11].

In a survey was performed by Ranganathan et al in 2004 on the abductor muscle of little finger and flexor muscles of the elbow he indicated that finger abduction strength is nearly increased 35% and elbow flexion strength is close to 13.5% in the control group. But there was no significant change in evident group [6]. A number of researchers have reported an increase in the integrated EMG after mental practices and have supported from the hypothesis of increased neural activation [13, 14, 15]. Since this is constantly has not been reported in all studies, this study aimed to examine the effects of imagery training on muscle strength and changes in the electrical activity of the motor units of the lower extremities.

MATERIALS AND METHODS

The subjects of this study were 30 healthy untrained male students with a mean age of 22.4 ± 1.2 years, height 176.2 ± 5.6 cm, weight: 67.6 ± 6.2 kilograms. Before conducting the survey questionnaire Medicine – Sports information and consent form were obtained from the subjects and they were become familiar with the details of test performing in correct form. They have no regular resistance training or any regular exercise during the past two years and also the history of pain or discomfort or surgery in the muscles of the lower extremity .The subjects of this study were selected purposely and then randomly were divided into two groups of mental practice (n=15) and controls (n=15). Pre-and post-test measurements, were repeated after four weeks practices. Experimental subjects performed for 4 weeks, 5 sessions per week, and in each session 50 plantar flexor contractions in ankle in their mind. The subjects in the control group did not perform any physical activity, but participated in all measurements. All of the subjects were asked to inform immediately any changes to their lifestyle and daily activities to the researcher. In the practice sessions, each subject lay on the bed and held his legs together without any tension. The subjects were asked to close their eyes and take a deep breath and relax the entire body for 2 minutes. Then by the contracting command by the person, the subject could create maximum contraction for 5 s by his mind and by inner imagery. After 5 seconds of contraction with the command to rest, subject rested for 5 seconds. Mental contraction was repeated 25 times alternatively, after 2 minutes of rest, subject then performed 25 contractions by his mind.

EMG measurements: To record the electrical activity of muscles it was used from bipolar electrodes (two signal electrode and a ground electrode). The distance between the electrodes was 4 cm and the place of electrodes according to the schematic software instructions was on the middle part of the abdominal muscles and the electrodes were connected to the desired points. EMG parameters were recorded in the computer, and were used for comparison and analysis.

Signal processing: For signal processing and calculation EMG it was used from software Mega win ver which were designed by the Mega Company. EMG was measured at time interval of 3 seconds using appropriate software markers.
Measure static power: the power of plantar flexion was measured by using a Load cell (America Lafayette plant construction) between a metal plate lever which was inserted in a fixed plate and were connected by a cable. In order to not using of other muscles, pelvis of subjects was kept at 80 degrees flexion, 10 ° of plantar flexion of the ankle and knee in a fully extended position and flat mode. After establishing the correct position and fix it and adjust the screen angle desired in joint plate (10 ° of plantar flexion), power of muscle was measured. To measure it was asked from Subjects to apply their maximum force gradually in 3 seconds, and after reaching to the maximum force, it kept for 3 seconds. Data were analyzed using t-test to compare in two groups of variables. Significance level of less than 0.05 was considered.

RESULTS

Comparison of mean maximal voluntary contraction of the triceps muscles, integral electromyography of twin muscle after intervention and integral electromyography of anterior muscle (opposite muscle) in both groups before and after of intervention are presented in table 1. In the experimental group, the mean maximal voluntary contraction (Mvc) of triceps muscles and mean integral EMG of twin muscle after 4 weeks intervention significantly increased, while the average of IEMG in gross anterior muscle (antagonist) significantly declined after intervention in experimental group ($p<0.05$).

Also the comparison of mean Mvc in triceps muscle of calf, IEMG of twin muscle and IEMG of gross anterior muscle (the opposite muscle) in control group was performed. (Table 1) show that there is no significant difference among average mentioned indicators before and after intervention. The comparison of mean Mvc in both groups after 4 weeks practice indicated that the experimental group had significantly higher mean Mvc than controls group. Percentage changes of Mvc in the experimental group were obtained 13.42% and in control group 52%, which is a significant difference between the two groups (Table 1). The percent of mean IEMG in twins muscle in the experimental group was 12.87% and in the control group was -0.22%. It is reported that these differences between the two groups shows that the percentage change in the experimental group was significantly higher than the control group. After 4 weeks practice in the experimental group, the electrical activity of IEMG for muscles of gross anterior (opposite muscle) had 6.16% reduction and in control group 0.65% increase was observed. Comparison of the percentage changes in electrical activity of anterior tibia in both groups indicated that the percentage changes were significantly higher in the experimental group than the control group.

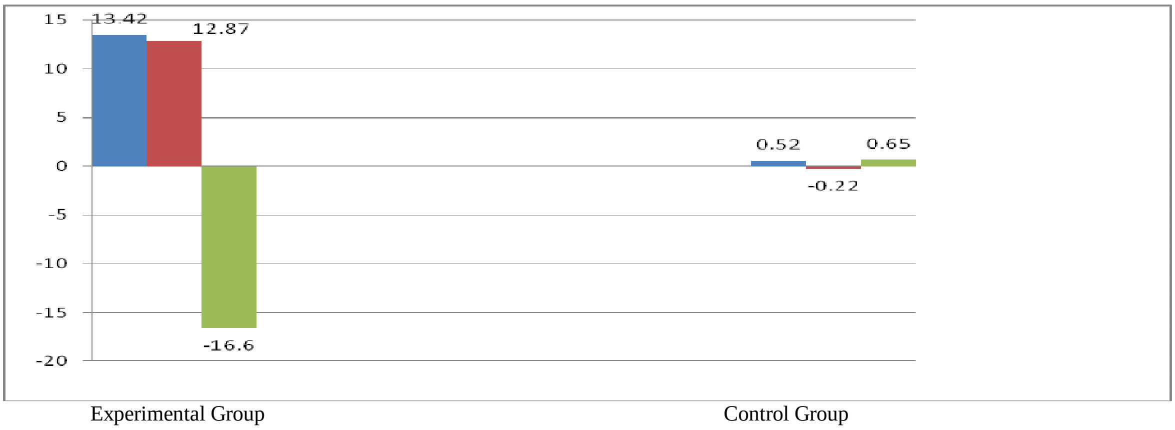

Figure1. Percent change of Muscle

Table1. The results of the experimental and control groups

Variable	Experimental Group		Control Group	
	Before	After	Before	After
Maximal voluntary contraction (MVC)	19.22 ± 2.08	21.8 ± 2.6	19.3 ± 3.4	19. 2 ± 2.5
Electrical activity of twin muscle (IEMG)	980.01 ± 60.8	1106.26 ± 60.3	1019.53 ± 61.01	1017.2 ± 60.9
Electrical activity of gross anterior muscle (IEMG)	610.5 ± 50.01	523.5 ± 40.03	608.3 ± 51.8	612.3 ± 50.6

DISCUSSION AND CONCLUSION

The statistical results showed that there are significant differences between measurements of EMG integral (IEMG) of Twin muscle in the experimental and control groups at post-test and experimental group showed significant increase in parameters than control group. Also there is a meaningful difference between EMG measurements of anterior muscle of leg related to the experiment and control groups at post-test, and there the experimental group showed a significant decrease in the parameters than the control group. The results of this study showed that there is a significant difference between measurements of maximal voluntary contraction of triceps muscle of leg related to control and experimental groups in post-test and the experimental group showed meaningful increase in intended parameters than the control group. In 2005 Sideway investigated the effects of mental practice on muscle strength of dorsal flexion ankle. In this study, 24 subjects were randomly divided into groups of mental and physical practice and control groups. In the exercise groups, subjects physically or mentally produced maximal voluntary isometric contraction for three to ten repetitions per exercise session and this was repeated for four weeks (three sessions per week). The results showed that the differences in power production between two mental exercise and physical exercise groups after exercise led to significant improvement for physical training group (25.28%) and (17.12%) for mental practice group. but in the control group, a significant improvement wasn't observed (-1.77%). These findings indicate that mental practice can increase the power production (torque) similar to the exercise (11). In a survey performed by Ranganathan et al in 2004 on the abductor muscle of the little finger and flexor muscles of the elbow 30 subjects were placed in 3 groups including mental contractions of the little finger abduction ABD group (n=8), group of mental contractions of flexed elbow ELB (n=8) and controls (n=8) and finally 6 people in physical practice group for abduction of the little finger. The training lasted 12 weeks, 5 days per week. The results showed that the ABD group, had nearly 35% increase in the strength of finger abduction and in ELB group the elbow flexion strength increased close to the 13.5%, but in the control group there was no significant changes. The results showed that increase in the strength of the ABD group had significant changes with the control group but increase in the power of strength in ELB group had no meaningful difference with changes in control group. In another study conducted by Smith and Collins in 2003, 18 men were randomly divided into three groups: physical, mental practice and control groups. Participants of physical and mental training were practiced for 4 weeks (2 sessions per week). Each session consisted of 20 maximal contractions for exercise group and 20 maximal imagery contractions of the abductor for little finger for mental practice group. There was no significant difference in pre-test for abduction force. However, scores of exercise and mental groups in post- test significantly were higher than the control group, thus findings supported from the efficacy of mental practice [16]. The primary mechanism for increasing the power through mental practice is probably due to the changes in the central nervous system to the muscle. The studies suggest that by repeated attempts to maximum activation of muscle, the brain activates to produce stronger signals. As the result it is possible that a stronger command in the central nervous system recruits inactive motor units or active motor units fired at a higher intensity, which is resulting in greater force production [16, 17]. Usually by activation of a muscle motor units are stimulated with a random asynchronous method and it simply means that acts of different motor units in a muscle are independent from each other. Possible power surge caused more motor units at the same time calling for a specific action, which may facilitate the contraction and increase muscle's power. Also increase in the amount of motor neurons by stimulating the central nervous system, causes more frequent stimulation of the motor unit. Change in frequency stimulation induces changes in motor unit force. In other words, an increase in frequency will produce more power [17, 18]. If electromyography of an agree muscle during maximal voluntary contraction to be recorded before and after the training program, the increase in the amount of EMG by regarding to the integral indicator of electromyography will show that more motor units are used or motor units with higher frequency stimulation or a combination of both have occurred [13]. So it seems that in the present study increase of EMG or muscle activation level of twin muscle is followed by mental practice and maximum voluntary contractions due to increased coordination in usage and frequency of motor units. Neural adaptation may be caused by mental practice and coordination between the muscle groups involved in the primary mover and fixer opposite may be less than desired level. But when the coordination of neuromuscular system was trained gradually by exercise, muscle coordination was developed and facilitated [13, 8]. Effect of learning on the development of power and ability was assessed by Radford and Jones. These researchers reported that 12 weeks of weight training increases 150 to 200 percent of the amount of weight lifted during training activities for the leg opening. The reason for increase of strength mainly is due to the more coordination of all muscle groups involved in the movement. Coordination at a joint is a potential mechanism for increase of power in the early stages of the exercise of power. Therefore the neural adaptation induced by exercise may be caused by improvement of muscle coordination such as a decrease in activity of opposite muscles during performing MVC of muscles [8, 11]. In the present study electromyography data of gross anterior muscle significantly changed (Figure1) and therefore reduce of muscle activity during the practice of twin muscle has an important role in increasing the strength (MVC) of triceps muscles of leg. The goal of advanced treatment programs for neurologic and orthopedic disorders is increase of muscle strength or a specific muscle groups. The techniques that are used by physiotherapists to improve include resistance training with weights, elastic bands and Iso kinetic machines for neuromuscular electrical stimulation and in most of these techniques the patient needs to contraction of muscles for practice. Due to some orthopedic and neurological injuries, contraction of muscle causes pain and even contraction is not possible, this study suggests that using mental exercises improves strength without muscle contraction. In this case Ranganathan at al showed that the mind has considerable ability beyond the body and its muscles and individuals can use from their mind to maintain or increase of nerve signals in order to maintain or increase muscle strength [6]. These findings have clinical relevance to improve motor function in patients who are unable to attend in strengthening programs due to weakness. Preliminary studies have shown that mental practice of motor activity is useful in improving the performance of patients with head trauma. Increasing power is helpful by imaging technique is a treatment technique to prevent from loss of strength after lack of use from muscles because of being stable of joint or damage to the peripheral nerves.

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