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Electro Muscle Stimulation (EMS) or Resistance Training? Which one is More Effective for Reducing Creatine Kinase (CK) Levels

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Abstract: To determine the effects of Electro Muscle Stimulation (EMS) in comparison with Resistance Training (RT) on reducing Creatine Kinase (CK) levelsof university students. The 90 male students were participants of this study. They were classified into 3 groups as EMS (n = 30), RT (n = 30) and control (n = 30).

Key words: Resistance training, overweight, electrical muscle stimulation, CK, students

INTRODUCTION

Fatness is one of the most global problem people faces in their lives in the modern era. Overweight and obesity are common in older adults and are increasingin prevalence (Mokdad *et al*., 1999). In 2000, 40% of adults aged ≥65 years were overweight and 18% were obese which reflect respective increases of 10 and 50% since 1990. Larger percentages (30.6%) of older adults report the desire to lose weight. However, little is known about the attributes of older adults attempting to lose weight. Population differs in the level of risk associated with a particular waist circumference. South Asian Indians have high levels of abdominal obesity, although, they may not be considered overweight or obese by conventional BMI criteria. Although, the recent WHO report suggests that 94 cm waist circumference in man and 80 cm for woman should be the appropriate measures in Europe, these cut-offs are not for the Asian population (WHO, 1995).

Weight reduction is typically successful up to 6 months, regardless of whether the technique is diet (Willett *et al*., 1995) exercise or a combination of both (Jeffery and French, 1998). Unfortunately, maintenance of the reduced body weight is difficult and a majority of weight-reduced individuals will return towards or even beyond their initial body weight within a few years.

Electro muscle stimulation: Electro stimulation of muscles is a technology that has been around for over 30 years. The first evidence that electrical changes can cause muscles to contract was provided by Galvani. Galvani's ideas about 'animal electricity' were explored during the 19 and 20th century when it was firmly established that 'electricity' is one of the most important mechanisms used for communication by the nervous system and muscle. These researches lead to the development of even more sophisticated equipment that could either record the electrical changes in nerves and muscles or elicit functional changes by electrically stimulating these structures. It was indeed the combination of these two methods that elucidated many of the basic principles about the function of the nervous system.

STATEMENT OF THE PROBLEM

The purpose of the study was to evaluate the effect of Electro Muscle Stimulation (EMS) and resistance training to know which training method is beneficial to lose weight in overweight people.

RESEARCH HYPOTHESIS

The EMS is effective for reducing Creatine Kinase (CK) levels than resistance training.

SIGNIFICANCE OF THE STUDY

- This study will help provide information about overweight people and the effective way to lose weight
- This study will compare resistance training and electro muscle stimulation to estimate the level of creatine kinase

LITERATURE REVIEW

Background of overweight and resistance training: Donnelly and Smith (2005) was founded in their research "The effect of home-based resistance exercise in overweight and obese adults" that it is possible to decrease weight during resistance training in over weight individuals.

McTiernan in their topic "Exercise effect on weight and body fat in men and women" was shown that

Exercisers exercised a mean 370 min/week (men) and 295 min/week (women) and seven dropped the intervention. Exercisers lost weight (women, -1.4 vs. +0.7 kg in controls, p = 0.008; men, -1.8 vs. -0.1 kg in controls, p = 0.03).

The 35% of those in the optimal group were hefting small weights or using resistance machines to strengthen muscle, compared with 14% or fewer of those in heavier group large muscle mass helps burn calories, another researcher explains. More muscle means a faster metabolism.

Seo *et al.* (2011) had shown in research topic "Effects of 12 weeks of combined exercise training on visfatin and metabolic syndrome factors in obese middle-age woman" that the training group had significant decreases in body weight, % fat while the control group remained unchanged.

Although, most research studies have examined the effect of endurance exercise on weight loss, weight training has recently become an important component of a successful weight loss program by helping to preserve FFM and maximizing fat loss (Osterberg and Melby, 2000).

Gettman and Pollock (1981) summarized the effects of five weight training and six circuit weight training studies on changes in body composition. The studies showed a mean decrease in body weight of 0.12 kg, increase in lean body mass of 1.5 kg and a decrease in fat mass of 1.7 kg.

Rahimi (2006) carried out in twenty overweight men (age: 27±0.5 years; body weight: 84±1.43 kg; BMI: 28.23±1.11 kg/m^2) who did not participate in any organized exercise were recruited to participate in a 12 weeks weight training program. The test showed statistically significant decreases in BMI (HI = 21.5%, $p<0.001$; MI = 13.7%, p = 0.03) and body weight (HI = 21.58%, p = 0.001; MI = 13.82%, p = 0.01) after participation in a 12 weeks weight training program.

Resistance exercise training is the most effective way to increase muscle strength and muscle mass (Tarnopolsky *et al.*, 2001). Resistance exercise training is usually done with free weights or weight machines, however, sprints on an ergometer at high resistance can also achieve increases in strength and mass.

Background of EMS: Porcari *et al.* (2005) in their study have founded that the use of the Slendertone FLEXTM belt significantly increased abdominal strength and endurance, decreased waist girth and improved self-perceived abdominal firmness and tone. The results probably can be attributed to the strength of the electrically induced muscle contractions made possible by the quality of the electrodes utilized in the belt system as well as the stimulator itself. Electrical Muscle Stimulation devices (EMS) have been advertised to increase muscle strength to decrease body weight and body fat and to improve muscle firmness and tone in healthy individuals.

This study sought to test those claims. Twenty seven college-aged volunteers were assigned to either an EMS (n = 16) or control group (n = 11). The EMS group underwent stimulation 3 times per week following the manufacturer's recommendations whereas the control group underwent concurrent sham stimulation sessions. Bilaterally, the muscles stimulated included the biceps femoris, quadriceps, biceps, triceps and abdominals (rectus abdominus and obliques). An identical pre and post-testing battery included measurements of body weight, body fat (via skinfolds), girths, isometric and isokinetic strength (biceps, triceps, quadriceps, hamstrings) and appearance (via photographs from the front, side and back). EMS had no significant effect on the any of the measured parameters. Eriksson and Haggmark (1979) and Gibson *et al.* (1989) in their study have shown that EMS training produces similar effects to resistance training (e.g., increases in muscle strength and size) or minimizes muscle atrophy caused by disuse.

SUBJECTS

A group of 60 overweight male between the ages of 19-25 years (mean age = 22±3 years) with $1\leq$ WHR ≥ 0.9 randomly selected from the Islamic Azad University of IRAN those selected should not have been involved in any recruitment program for at least 6 months prior to the study not had any injury in their body. Subjects were required to be physically suitable for a program of Electrical Muscle Stimulation (EMS) and program of Resistance Training performed in the Gym's university. So, prior to final selection they are checked out by a physician. Subjects were randomly assigned to one of the following three groups:

Group EMS (N = 20) (electro muscle stimulation groups): Subjects received electric muscle stimulation of 6 muscle groups (rectus abdominis, internal and external obligue, transvers abdominal obligue, gluteal, quadriceps, hamestring) with 60-70% maximum tolerated intensity, 1 h session (30 min for waist area and 30 min for hip area, 3 time per week for 16 weeks).

Group RT (N = 20) (resistance training groups): Subjects were trained at 60-70% maximum strength. The 6 muscle groups (rectus abdominis, internal and external obligue, transvers abdominal obligue, gluteal, quadriceps femoris, hamestring) will exercise with 3 sets of 10 repetition in each muscle group, 1 h session, 3 times per week for 16 weeks.

Group control (N = 20) (control group): In order to enhance compliance, personal follow-up phone calls were made and a motivation session was conducted every Thursday evening over the duration of the study.

Table 1: Mean Cratine Kinase scores of EMS, RT and control groups from pre-testing to 16 weeks

	PRE		4 weeks		8 weeks		12 weeks		16 weeks	
Groups	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
EMS	79.07	18.74	155.57	68.58	159.27	62.85	154.33	57.05	163.67	55.60
RT	80.00	11.23	106.50	56.05	99.90	38.46	96.80	32.04	94.80	28.54
Control	79.97	12.76	78.70	11.30	78.00	11.75	77.33	9.75	77.77	8.44
Total	79.68	14.45	113.59	60.16	112.39	54.83	109.49	50.07	112.08	51.87

PROCEDURE

All potential subjects were provided with detailed written and oral descriptions of the study procedures. They were familiarized with the facilities and equipment to be used. The following specific exclusion criteria were applied:

- A history of orthopedic, cardiovascular, pulmonary or metabolic disease, hypertension, epilepsy, neurological and neuromuscular disorders which could have contra-indicated exercise testing
- Diabetes for those who could not follow the test
- Vegetarianism and the presence of specific food allergies
- Medication usage

Those interested in participating were required to obtain a doctor's approval prior to beginning the study. The subjects completed an informed consent form prior to initiation of the study.

RESULTS OF THE STUDY

When the increase in Cratine Kinase scores was verified across 3 groups from pre testing to 16 weeks following results were obtained. Repeated measure ANOVA revealed a significant increase of Cratine Kinase from 79.68-112.08 U L^{-1} from pre testing to 16 weeks irrespective of the group which was statistically significant. F-value of 39.806 was found to be significant at 0.000 level. Further, when the increase in Cratine Kinase was verified across 3 different groups-EMS, RT and control; again a significant F-value was observed ($F = 23.206$; $p = 0.000$) indicating a differential increase among groups from pre testing to 16 weeks in their Cratine Kinase values. From the mean values, it is clear that EMS group had an increase of 84.6 U L^{-1} (from 79.07-163.67 U L^{-1}) in the case of RT group we find an increase of 14.80 U L^{-1} (80.00-94.80 U L^{-1}) and lastly in the case of control group we find a decrease of 2.2 U L^{-1} (from 79.97-77.77 U L^{-1}). On the whole we find that EMS group increased its Cratine Kinase maximum followed by RT group and control group at least from pre-test to 16 weeks (Table 1 and 2).

Table 2: Results of repeated measure ANOVA for mean Cratine Kinase scores of EMS, RT and control groups from pre-testing to 16 weeks

Source of variation	Sum of squares	df	Mean square	F-values	p-values
Within subject effects					
Change	75495.333	4	18873.833	39.806	0.000**
Change x group	88022.747	8	11002.843	23.206	0.000**
Error (change)	165003.120	348	474.147		
Between subject effects					
Intercept	5003338.889	1	5003338.889	891.166	0.000
Group	329261.498	2	164630.749	29.323	0.000**
Error	488450.413	87	5614.373		

F: Fisher's value; p: probability; **Sig. at 0.01 level

In between subject effects a significant difference was observed between groups in their Cratine Kinase values where F-value of 29.323 was found to be significant at 0.000 level.

MAIN FINDING OF THE STUDY AND DISCUSSION

The resistance training was more effective in reducing Creatine Kinase (CK) levels than EMS and control groups.

Research hypothesis: The EMS is effective for reducing Creatine Kinase (CK) levels than resistance training. This hypothesis is presented as effectiveness of EMS over Resistance training in decreasing Creatine Kinase is rejected. We find an increased release of Creatin Kinase (CK) in the EMS and RT group from pre to post-test. Further, the increased release of (CK) was found to be highly significant in EMS group than RT group where we found an increase of 84.6 U L^{-1} from pre to post-test in the EMS group and increase 14.80 U L^{-1} in RT group. Findings indicate that both EMS and RT exercise increased the release of Creatin Kinase (CK) but finding clearly reveal that EMS is very much showed an increased release of CK which indirectly means more muscle damage and soreness in EMS training.

The major limitation of using EMS in training is the pain during stimulation (Ward and Robertson, 1998) and muscle damage (Butterfield *et al*., 1997). The occurrence of muscle damage after EMS has been well investigated (Brown *et al*., 1996). However, limited research has been conducted on muscle damage and recovery of muscle function after EMS-evoked isometric contractions. It has been documented that repetitive eccentric muscle contractions cause a significant increase in circulating Creatine Kinase (CK) and a decrease in muscle strength (Clarkson *et al*., 2006; Crameri *et al*., 2007).

Although, voluntary isometric exercise seems unlikely to induce muscle damage when performed at the same level of torque generated by EMS at maximal intensity (Jubeau *et al*., 2008), muscle damage has been reported in several studies following isometric exercise induced electrically (Butterfield *et al*., 1997; Jubeau *et al*., 2008). Muscle soreness and damage have been assessed before and after an EMS (70 Hz pulsed current with 40 μsec) session and concentric exercise of the quadriceps muscle for 12 male athletes. A significant increase in plasma CK activity and muscular soreness after EMS compared with concentric exercise was reported (Moreau *et al*., 1995).

Theurel *et al*. (2007) and Jubeau *et al*. (2008) reported a significant decrease in maximal voluntary force after EMS (75 Hz pulsed current with 400 μsec pulse duration) and a significant increase in serum CK activity and muscle soreness compared with voluntary RT contraction of the quadriceps muscle. These results have been supported by this study that showed that EMS increase serum CK activity in compared with the RT. Further, it was observed that Delayed-Onset Muscle Soreness (DOMS) was higher after EMS (125 Hz pulsed current with 40 μsec pulse duration) and was associated with muscular soreness and strength loss (Butterfield *et al*., 1997).

In contrast, Zorn *et al*. (2007) reported a non-significant increase in muscle soreness with no DOMS after EMS (63, 3 Hz pulsed current with 400 μsec pulse duration) in both knees extensor muscles of five trained subjects even though a significant increase was shown in serum CK. This result was expected to be seen in trained subjects who may have experienced a repeated bout effect in the early stages of a training program (McHugh *et al*., 1999). Nosaka *et al*. (2002) showed that eccentric contractions induced more muscle damage than isometric contractions. Another study reported that 30 isometric contractions evoked by EMS (70 Hz, duration 40 μsec, on-off ratio 6-20 sec) resulted in small increases in plasma CK activity and muscle soreness after EMS (Moreau *et al*., 1995). Myofibre damage has been investigated after applying EMS (35 Hz pulsed current with 300 μsec pulse duration) and muscle fibre necrosis and subsequent regeneration was observed with the EMS condition (Crameri *et al*., 2007).

Mackey *et al*. (2008) have recently shown histological evidence of muscle damage such as macrophage infiltration, desmin negative fibres and z-line disruption after 180 isometric contractions of the gastrocnemius muscle evoked by EMS (60 Hz, duration 300 μsec, on-off ratio 4-6 sec) which lasted for 30 min, together with increased plasma Creatine Kinase (CK) activity and muscle soreness. However, little is known about the effects of alternating current on muscle damage or how the EMS currents (alternating current and pulsed current) are different. Kianmarz (2011) have shown high CK level after eccentric RT in curl hamstring. In the study completed by other researcher found electrical stimulation at 1 Hz for 4 h increased the leakage of CK.

CONCLUSION

Analyses of these groups after 16 weeks exercise revealed that RT was more effective to reduce CK.

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