Original Article

Isokinetic and isometric strength after electrical stimulation on Judo players

AKEF M. TAIFOUR¹; ALI AL NAWAISEH²; AMAN S. KHASAWNEH³

^{1, 2}Department of Sport Rehabilitation/ Hashemite University, ZARQA, JORDAN

³Department of Coaching and Sport Management, , ZARQA, JORDAN

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Abstract:

This study investigated the effects of electrical stimulation (ES) on isometric and isokinetic strength of Judo athletes. Four subjects from the judo national team performed strength tests in three different occasions are: pre-training (Pre), Post after 28 days of training (Post1) and 45 days after the termination of the training (Post2). After signing the informed consent and finishing the Pre strength test, the subjects underwent 20 sessions of titanic and tonic ES contraction for the lower extremity over 28 days. The stimulation protocol was conducted to both agonist and antagonist muscles were contracted bilaterally. Strength was measured by a (CYBEX II) dynamometer at 0°, 60°, 90°, and 120°/s velocities. Two protocols of surface electrical stimulation SES was studied in the 28 days of the experimental period. Strength post-tests were performed 45 days after the termination of the exercise protocol. The comparisons were between pretest vs. posttest 1, pretest vs. posttest2, posttest 1 vs. posttest 2 for all the events of the strength test. The results indicate that ES conducted over (28) days have significantly affected strength in national team judo players.

Key words: electrical stimulation, isokinetic strength, isometric strength, Judo players.

Introduction

In recent years there is an increasing interest in electrical stimulation of skeletal muscles in athletes. Achievement of a top level in sports and the increasing intensity of the struggle for the high rank and gold medals needs more than super performances for athlete aiming at international champion, evidence were provided that former Soviet Union have been used the method of electrical stimulation in preparing national teams for the 1972 Munchen Olympics game and other important competition (Ward & Shakuratova, 2002).

In the sphere of sports the method of electrical stimulation as a training protocol is studied most intensively by Soviet authors such as (Kotz & Chullon, 1975., Adrianova, Koz, Martjanova & Chwilon, 1974) this work is concerned above all with the problem of selection of suitable parameters for electrical stimulation of muscle, their aim being to obtain artificial maximum muscular contraction as a response to electrical stimulation involve stimulating the muscle with a complex protocol that is designed to minimize the pain and discomfort associated with this procedure. The Soviets reportedly use electrical stimulation with their best athletes in sports where strength is a limiting factor for example weight lifting, wrestling, sprinting, and throwing events. Steib, Schoene, Pfeifer (2010) demonstrated that the greatest effect as regards an increase in muscular strength and perseverance of strength is obtained by intensive electrical stimulation applied daily, in sedentary subjects not engaged in sports they achieved an increase of muscular strength by a mean of 16%, of dynamic strength, by 25% and perseverance of achieved strength by 94%, contrary to electrical stimulation applied only twice a week, when the corresponding increments were only 9%, 6% and perseverance of achieved strength by 32%.

Interestingly, some authors have observed that an electro stimulation training program carried out in isometric conditions can increase both isometric and dynamic strength (Martin, Cometti, Pousson & Morton, 1993; Pichon, Chatard, Martin & Comtti, 1995; Colson, Martin & Hoeck, 2000). This non specificity of the isometric contraction mode in training sessions might be ascribable to the nonselective recruitment of motor units (i.e., a partial reversal order as compared with voluntary contractions) (Solomonow, 1984; Knaflitz, Merletti & Deluca, 1990; Feiereisen, Duchateau & Hainaut, 1997; Gregory & Bickel, 2005).

Halbach & Straus (1980) demonstrated in a sedentary group of young healthy subjects that electrical stimulation is a suitable method not only for developing muscle strength and tonus but that it may become also a suitable method for reduction of subcutaneous fat. Anzil, Modotto & Zanon (1974) achieved considerable improvement of the explosive strength during the start in 100 m sprinters after electrical stimulation of the muscles of the sole of the foot.

This method is particularly very important and valuable, although not yet fully appreciated in the sphere of rehabilitation, e. g. the case of the top jumper Enzo del Forno who after surgical operation of the right knee meniscus used one third of the time given by his doctors for convalescence for electrical stimulation to preserve the standard of his static and dynamic strength.

Also among the therapeutic modalities, neuromuscular electrical stimulation (NMES) is presented as a non-invasive technique used by physical therapists to promote muscle strengthening, to minimize muscle hypotrophy, to reduce muscle spasm and spasticity and to increase range of motion in the joint. Particularly, with respect to knee osteoarthritis (OA) treatment, neuromuscular electrical stimulation (NMES) has been suggested as an alternative therapy for quadriceps muscle strengthening, mainly when elderly present chronic pain and joint stiffness, which prevent them from engaging in voluntary exercises. Also using (NMES) early after total knee arthroplasty (TKA) surgery may enhance recovery of physical function such as walking. (Oliveira, Fernando & Marco, 2013; Burch, Tarro, Greenberg & Carroll, 2007)

Electrical stimulation method was used under isotonic condition during a certain close dynamic movement as (Anzil & et.al,1974)) used this method in javelin throwers and elite athletes from deferent sports. Kots & Chullon (1975) recommends the ES training to promote and hasten in this way the rebound strength, the aim of this method is not so much the development of static muscular strength but rather to hasten the training of a certain correct position or hastening of a certain component of a movement in a complex of movements or to enhance the explosive strength. Brocherie, Babault, Cometti, Maffiuletti & Chatard (2005) quoted by Lagasse & Boucher (1979) in their study on the training effects of the functional electrical stimulation on the performance of novice weightlifters, demonstrated that functional electrical stimulation is an efficient technique for the learning of physical skills requiring muscular coordination in weight lifting events. Paillard (2008) developing muscle power by electrical stimulation and mention that the response to strengthening by electrical stimulation is not the same in all sport subjects and individuals, even muscle groups respond in a different manner for example in extensors of the elbow (triceps brachia muscles) immediately after stimulation a decline of muscle strength occurred, only 8 days after completed stimulation of muscle strength increased on the left side by a maximum of 20%, and on the right side by 13%. In the extensors of the knee joint (quadriceps femora's muscle) after electrical stimulation in three subjects a marked increase of the muscle strength was recorded on both extremities, and in two subjects a decline of muscle strength was observed; a certain improvement occurred after 8 days. Maximum increments of muscle strength of the knee extensors were on the left extremity 24% and on the right by a mean of 49%. In a group of subjects not engaged in sports, immediately after electrical stimulation in all pro bands a marked improvement of the strength of the stimulated muscles occurred from 6% to 51% and the greatest improvement of muscle strength was achieved in a subject not engaged in any sports activity. Maffiutetti (2010) studying the effect of the training using a technique of imitational electric stimulation on high level swimmer, the result showed that the thickness of the sub skin layer cells decreased after the first 5 training unit, and after 25 training unit, there was an intense increase in muscle mass by a mean of 1.5 to 3 cm in circumference, and in cross sectional area which was accompanied by an increase in strength by 16% to 23%.

Also Colson, Martin & Hoecke (2009) were find that the isometric torque gains of EMS (electromyostimulated group) were greater than those of VOL (voluntary isometric group) and that the eccentric and concentric torque gains were equivalent. They can be concluded that electromyostimulation training would be more efficient than voluntary isometric training to improve both isometric and dynamic strength

Thus, a difference in strength gains could also be expected between electro stimulation and voluntary isometric training (i.e., identical isometric muscle contraction but different motor unit recruitment). In addition, recent reports about hybrid muscle activation (i.e., electromyostimulation superimposed onto voluntary contraction) have demonstrated that the muscle strength produced during a muscle contraction induced by electromyostimulation is also dependent of the central nervous system (Langzam, Nemirovsky, Isakov & Mizrahi, 2007).

Kotz & chullon (1975) documented the use of electrical stimulation for the treatment of muscle disuse atrophy, pain, and posttraumatic edema. Throughout the history of the search for enhanced muscle performance, electrical stimulation was considered an option in the development of enhanced muscle strength. (Currier, Lehman & Lightfoot, 1979; Eriksson, 1976; Eriksson & Haggmark, 1979) found no significant difference in isometric strength training regimens using maximum intensity electrical stimulation. Similarly, (Halback & Straus, 1980) found no difference in isokinetic strength development with electrical stimulation. Strength improved with electrical stimulation, but no advantage was found over training, and isometric strength gains from electrical stimulation did not carry over to dynamic tasks.

Delitto, Rose, Mckowen, Lehanan, Thomas & Shively (1998), Dawn, John, Francis, & David (2000) showed a significant improvement in strength and Isokinetic Torque During High Speed Movement for Elite Judo Athletes.

Taifour et al, (1988) used the electrical stimulation method in preparing Tsukuba University soccer team in preparation period, pre-competition period and competition period, the results achieved a significant improvement in sprinting power, dynamic strength, isometric strength, and vertical jump abilities improvement.

According to that the current study discuss the possibilities of promoting muscular strength by means of electrical stimulation to healthy and well trained subjects engaged for judo players and its importance to

increased muscular strength without a concomitant increase in muscular bulk . And also the importance of the study was used electrical stimulation in the same time for the agonist and antagonists muscles.

Statement of Problem

Several studies have emphasize the important of electrical stimulation in strength training in many different field such as training, treatment and rehabilitain with many different way like (Ward & Shkuratova, 2002; Hortobagyi & Malliuletti 2009; Martin & et al; 1993; Pichon & et al; 1995; Colson & et al; 2000). Thorstensson, Karlsson, Viittusalo & Komi (1976); Kitai & Sale (19890; Weir & Weir (1995); Behm & Sale (1993); Rich & Cafarelli (2000); Maffiuletti & Martin (2001) which provides evidence that electrostimulation strength training (EST) increases the force of a maximal voluntary contraction (MVC) through neural adaptations in healthy skeletal muscle, Although electrical stimulation and voluntary effort activate muscle differently, there is substantial evidence to suggest that EST modifies the excitability of specific neural paths and such adaptations contribute to the increases in MVC force. Similar to strength training with voluntary contractions, EST increases MVC force after only a few sessions with some changes in muscle biochemistry but without overt muscle hypertrophy, and the interest for the electrical stimulation increasing achievement, and also its increasing both isometric and dynamic strength.

However bax , staes, & verhagen (2005); Oliveira & et.al (2013); Burch & et.al (2007); Kotz & Chullon (1975) focused on the important of electrical stimulation in rehabilitation which there studies show that Electrical stimulation for rehabilitation purposes is usually conducted in isometric conditions and specific isometric strength improvements have been observed. Using neuromuscular electrical stimulation (NMES) early after total knee arthroplasty TKA surgery may enhance recovery of physical function such as walking. NMES has been suggested as an alternative therapy for quadriceps muscle strengthening, and finally the use of electrical stimulation for the treatment of muscle disuse atrophy, pain, and posttraumatic edema.

From the survey of these studies it is well observed that increased muscular strength is associated with the enlargement of muscle fibers (hypertrophy) as well as an increase in the number of motor units activated (recruitment), this kind of strength lead for increase in body weight, and this is undesired for weight category sport. The data generated by this study seems to evaluate the possibility of gain an isometric and isokinetic strength without a concomitant increase in muscular bulk, using electrical stimulation with short contraction time less than 5 second, the electrical stimulation was applied in the same time for the agonist and antagonists muscles very similar to the super set technique in the weight training protocols.

Study Aims

1. The main aim of the present study was to demonstrate the possibilities of promoting muscular strength by means of electrical stimulation for national team judo players.
2. The secondary aim was derived to evaluate the possibility of gain isometric and isokinetic strength without a concomitant increase in muscular bulk.

Method

The design

A quasi-experimental, pretest-posttest experimental group design using a sample of intact groups was used in this study.

The Sample

Four male Judoka athletes from the Jordanian national Judo team were recruited to participate in the study. Table (1) shows the descriptive statistic of the sample.

Table 1. Descriptive statistics of the subjects

	Men	SD
1 Age (years)	20	1
2 Height (cm)	176	7
3 Weight (kg)	81	13
4 BMI (kg/m ²)	26.1	2.2
5 Body fat (%)*	14	2
6 Experience years of competition	5	2

Note: n = 4

* Sub of 4 skin fold treated with BH formal

Training program

The electrical stimulation program consisted of isometric electrical stimulation contraction both titanic and tonic contraction of the muscles. The electrodes were placed at the proximal and distal margins of the belly of the agonists muscles, using a bipolar technique, another electrodes were placed on the antagonists muscles, using the same bipolar technique, i. e. the electrical stimulation was applied in the same time for the agonist and antagonists muscles very similar to the super set technique in the weight training protocols in all cases of the

treatment expect the (Gluteus maximums muscles), surface stainless steel sheet metal electrodes cover with water-soaked foam rubber were used for stimulation, the skin was cleaned with alcohol and abraded with redux electrode paste applied with a gauze pad to reduce the skin's electrical impedance. Occasionally, the electrodes pads were adjusted slightly to achieve a more forceful contraction.

Prior to their participation, each subject signed on informed consent that was approved by the instigators, and the strength of the knee flexors and extensors of both leg was measured using (CYBEX II) isokinetic dynamometer.

Subjects were fitted into the CYBEX protocol according to the manufactures instructions, all the subjects complete a warm up, each subject completed (four) to (six) sub-maximal knee flexion and extension to be familiarize to the (CYBEX) at 180°deg/sec with 60 sec intervals between each trials and a static stretching for five minutes before testing processes.

However encouragement was given to the subjects during the testing protocol. The testing velocities were 60° deg/sec, 90° deg/sec, 120 deg/sec, and 0 deg/sec this same testing protocols was applied in the pre-test, post 1 and post 2 test, the post-test 2 result were served as the control period, the post-test 2 were conducted after 45 days from E.S termination. Variables examined in this study and the test of the 4 velocity (0°, 60°, 90°, 120°).

At the beginning of each electrical stimulation treatment, subjects were placed in a seated position, for stimulating the lower limbs muscles, both legs were positioned in 110 degree of knee flexion and stabilized at this angle with straps. This procedure prevented movement of the legs during the treatment so that the muscles contracted isometrically in the same time the Stimulation intensity was slowly increased until the muscles of agonist and antagonists exhibited equally strong visible contractions with minimal discomfort. The 2Hz frequency was applied at the beginning for three minutes as muscles warming up, flowed by the 70Hz frequency with a sex minutes total stimulation time, flowed by the 2Hz frequency for three minutes stimulation as a cool down. Intense titanic contractions were experienced with the 70Hz stimulation, while gentle pulsating contraction were produced by 2Hz stimulation e. i. the subjects received 360 tonics contraction as a warming up, 72 titanic contraction as a training treatment, and 360 tonic contraction as cool down, the training treatment stimulation was 4 seconds stimulation and 4 seconds interval. Each subject determined the intensity of the stimulation, but was encouraged to make this as high as was tolerable. The electrical stimulation training was daily; all subjects accomplished a total of 20 titanic and tonic ES contraction for the lower extremity over 28 days in the experimental period.

Pre-post training measures

The pre tests were formed from the four velocities (60°, 90°, 120°, and 0 deg/sec) of the strength of the knee flexors and extensors of both leg by using (CYBEX II) is kinetic dynamometer.

The same testing protocols was applied in post test 1 after 20 titanic and tonic ES contraction for the lower extremity over 28 days in the experimental period and the post test 2 after 45 days from the termination of the training, the post-test 2 result were served as the control period. The comparisons were between pretest vs. posttest 1, pre-test vs. post-test 2 and post-test 1 vs. post-test 2 for all the events of the strength test.

Data analysis

Analysis of variance for repeated measure (ANOVA) was used to achieve the main and the secondary aims of the study as following:

1. To detect statistically differences in muscular strength by means of electrical stimulation for national team judo players in the pre-test vs. post-test1, pre-test vs. post-test 2 and post-test 1 vs. post-test 2.
2. To evaluate the possibility of gain isometric and isokinetic strength without a concomitant increase in muscular bulk for national team judo players.

Results

The main aim of the present study was to demonstrate the possibilities of promoting muscular strength by means of electrical stimulation for judo national team players, analysis of variance for repeated measures (ANOVA) was used to achieve this aim and assess the differences in strength variables. Tables 2 and 3 show that.

Table 2. Descriptive statics of mean peak torque variables after the experiment in the pre-test, post-test 1, and post-test 2 (N = 4)

Velocity Degree/Seconds	Pretest		Post 1		Post 2	
	Mean Nm	SD	Mean Nm	SD	Mean Nm	SD
RL EXT 60°	130.750	2.217	156.250	1.500	131.500	2.380
RL EXT 90°	109.750	1.893	121.000	2.160	112.250	3.403
RL EXT 120°	88.250	1.708	101.000	1.155	90.750	1.500
RL EXT Isometric 0/S	218.500	6.245	237.250	2.062	219.750	6.186
RL FLX 60°	108.250	21.793	127.500	35.341	110.500	23.216
RL FLX 90°	90.000	24.000	100.750	23.557	90.750	22.765
RL FLX 120°	73.250	19.379	88.750	24.568	75.000	21.463
RL FLX Isometric 0/S	209.750	14.385	223.500	15.351	211.000	15.384
LL EXT 60°	119.500	2.082	151.500	8.104	123.000	4.967
LL EXT 90°	103.750	6.238	120.250	2.679	107.000	6.481
LL EXT 120°	85.750	4.349	100.750	2.754	87.000	6.055
LL EXT Isometric 0/S	225.500	3.873	245.000	6.377	227.500	2.082
LL FLX 60°	95.000	30.210	120.000	33.506	96.500	31.332
LL FLX 90°	90.750	17.289	99.250	18.626	91.750	16.998
LL FLX 120°	70.000	20.944	84.000	27.289	72.000	21.463
LL FLX Isometric 0/S	227.250	6.500	245.750	8.694	229.250	6.292

From the table it appeared that there were differences between means for the tests, (ANOVA) test for repeated measures used to make sure that the differences statistically significant as table 3 show that.

Table 3. Effects of E.S training on strength peak torque variables after the experiment in the pre-test, post-test 1, and post-test 2 (N = 4)

Source	Between subjects	Pre-test vs. Post-test 1	Pre-test vs. Post-test 2	Post-test 1 vs. Post-test 2
Peak Torque at 60/second	RLEXT p = 0.001 F = 28022.76, df = 3	-25.500*	Ns	24.75*
	RLFIX p = 0.003 F = 74.866, df = 3	Ns	Ns	Ns
	LLEXT p = 0.001 F = 40496.348, df = 3	-32.000*	Ns	28.500*
	LLFIX p = 0.007 F = 43.022, df = 3	-25.000*	Ns	23.500*
Peak Torque at 90/second	RLEXT p = 0.001 F = 14406.00, df = 3	-11.250*	Ns	8.750*
	RLFIX p = 0.004 F = 64.031, df = 3	-10.250*	Ns	9.500*
	LLEXT p = 0.001 F = 2073.710, df = 3	-16.500*	3.250*	13.250*
	LLFIX p = 0.002 F = 114.265, df = 3	-8.500*	Ns	7.500*
Peak Torque at 120/second	RLEXT p = 0.001 F = 36184.615, df = 3	-12.750*	-2.500*	10.250*
	RLFIX p = 0.005 F = 52.535, df = 3	-15.500*	Ns	13.750*
	LLEXT p = 0.001 F = 1767.486, df = 3	-14.500*	Ns	13.250*
	LLFIX p = 0.007 F = 42.084, df = 3	-14.000*	-2.000*	12.000*
Peak Torque at 0/second	RLEXT p = 0.001 F = 9202.644, df = 3	-18.750*	Ns	17.500*
	RLFIX p = 0.001 F = 840.659, df = 3	-13.750*	Ns	12.500*
	LLEXT p = 0.001 F = 35219.566, df = 3	-19.500*	Ns	17.500*
	LLFIX p = 0.001 F = 5151.565, df = 3	18.500*	-2.000*	16.500*

- Note: RLEXT = Right Leg Extension.
RLFLX = Right Leg Flexion.
LLEXT = Left Leg Extension.
LLFLX = Left Leg Flexion.
Experimental Period between the Pre-test and Post-test 1 = (28 days).
Control period between the Post-test 1 and Post-test 2 = (45 days).
Fisher's Protected Least Significant Difference (PLSD) was fixed at < 0.005 level.
(n = 4)

The preceding presentation of data has shown that in some areas tested in this study there were decisive differences, while in others there were no significant differences between the treatments groups tested.

An examination of the CYBEX variables indicated that both isometric strength and isokinetic strength were significantly developed, during the electrical stimulation training in the experimental period. Isometric strength peak torque at 0 degree/second and isokinetic strength peak torque tested at 60°, 90°, 120 degree/second, were development for right / lift knee extension and flexion.

The differences between tests show that the significant differences noted by post test1 vs. pre test, and between post test 1 vs. post test 2 for favor to the post test 1 which refereed to the period which the subjects used electrical stimulation.

After testing these variables 45 days after termination of the electrical stimulation, in the control period the results show a significant decrease in the strength gains in both isometric and isokinetic strength as shown in tables 2 and 3. However, as it was discussed previously in regard to the girth variables, this kind of strength increase could be the results of the neural adaptation that has occurred. An alternative explanation is that muscle quality increased; that is, the intrinsic strength of muscle per unit cross-sectional area (specific tension) increased after electrical stimulation training i.e. a process takes place that is term by athletes and couch awakened of awakening muscle. This implies that sportsmen are more aware of a muscle which was subjected to electrical stimulation. During training they are more capable of using this muscle under voluntary control.

From the literature and physical training practice it is known that massive muscular contraction in particular under conditions of an isometric regime, leads to an increase of the muscle mass and improvement of muscle strength (Hainaut & Duechateau, 1992). Therefore, it is necessary to select such parameters of electrical stimulation of muscle which lead to maximum muscle contraction which does not cause pain. In the present experiment, there was a wide modification of the method described by (Kotz & Chullon 1975), and the method described by (Enoka, 1988) i.e.the overload principle states that the mechanism for strength augmentation is the load exereted at the tendon measured as an external force, it must be stressed to the maximal contraction than in normal training, the placement of the electrodes in the agonist and antagonists muscle in the present study leads for a maximum artificial contraction with more tolerance to the electrical stimulation current. The duration of the contraction time in this study was modified to prevent hypertrophy in muscles mass.

And to make sure of that the secondary aim was derived to evaluate the possibility of gain isometric and isokinetic strength without a concomitant increase in muscular bulk. A repeated measure (ANOVA) was used to achieve this aim and assess the differences in body compositions variables. Tables 4 and 5 show that.

Table 4. Descriptive statics of body composition parameters during the experiment and control period

Variables	PRE-TEST		POST-TEST 1		POST-TEST 2	
	Mean	SD	Mean	SD	Mean	SD
BODY WEIGHT	81	13.441	81.925	13.442	81.85	12.499
BODY FAT (%)	14	2.00	14.00	3.00	14.00	3.00
RIGHT ARM GIRTH	34	1.786	35.525	1.097	35.225	1.763
LEFT ARM GIRTH	35.15	1.561	35.75	1.708	35.325	1.7
RIGHT FORARM GIRTH	29.875	1.548	29.95	1.196	30.25	1.323
LEFT FORARM GIRTH	29.65	2.336	30.05	1.891	29.625	1.109
RIGHT THIGH GIRTH	58.275	4.626	58.75	3.8	58.625	4.328
LEFT THIGH GIRTH	57.65	4.396	58.425	4.014	58.625	4.385
RIGHY CALF GIRTH	39.7	4.202	39.925	3.664	39.925	3.776
LEFT CALF GIRTH	39.5	4.183	40.45	3.368	40.000	4.378

Note: experiment period (between the pre-test and post-test 1) = 28 days.

Note: Control period (between the post-test 1 and post-test 2) = 45 days.

Note: n = 4

From the table it seems that the differences between means for the tests were little and simple, (ANOVA) test for repeated measures used to make sure that the differences statistically not significant as table 5 show that.

Table 5. Repeated Measurement Test of the E.S training effect on body composition

Source	F	Sig	Pre-test VS Post- test1	Pre-test VS Post- test2	post-test 1 VS Post- test2
BODY WEIGHT	1.99	0.216	NS	NS	NS
BODY FAT (%)	0.49	0.643	NS	NS	NS
RIGHT ARM GIRTH	1.503	0.296	NS	NS	NS
LEFT ARM GIRTH	2.488	0.163	NS	NS	NS
RIGHT FOR ARM GIRTH	1.45	0.306	NS	NS	NS
LEFT FOR ARM GIRTH	0.46	0.652	NS	NS	NS
RIGHT THIGH GIRTH	0.905	0.454	NS	NS	NS
LEFT THIGH GIRTH	2.654	0.149	NS	NS	NS
RIGHT CALF GIRTH	0.544	0.607	NS	NS	NS
LEFT CALF GIRTH	2.823	0.137	NS	NS	NS

As indicated in the tables 4 and 5 the body composition variables have no significant difference's in the three tests conducted at the pre, post 1, and post 2 tests.

The data generated by this study seems to support that it could be gain an isometric and isotonic strength without a concomitant increase in muscular bulk. This result conflict with previous studies which referred that increased muscular strength is associated with the enlargement of muscle fibers (hypertrophy) as well as an increase in the number of motor units activated (recruitment).

Short-term training studies have demonstrated increases in voluntary strength without increases in muscle size (Stevens, Mizner, Snyder-Mackler, 2003; Kyung-Min, Ted & Susan, 2010; Kotz, 1976; Bickel, Gregory & Dean, 2011). And thus data shows to be very important finding in certain athletic events in sports such as Judo, Taekwondo, Wrestling, Boxing, Weightlifting and all weight category sports. Previous research in the field shown that strength gains by the method of electrical stimulation often was a companied by an increase of the girth (hypertrophy). In summary the present investigators found that the muscle hypertrophy occurred when the duration of the contraction time is within 5-12 second and more. However, a duration contraction time of less than 4 second may cause an increase in strength level without hypertrophy. For this reason, the present investigators used the 70Hz frequency with a duration time contraction of 4 seconds to prevent hypertrophy in muscle size bulk, but in the same time the strength gain was developed progressively in both dynamic and static strength.

Discussion

The results of this study indicated that 20 sessions of electrical stimulation conducted over a 28 days had a marked effect on isometric and isokinetic strength in a well trained judo player. The results agree in part with (Zhan, Mantilla & Sieck, 2003) that an electrical stimulation with 4 second contraction duration time, have no significant influence at girth, and disagree with the same investigator, that, the electrical stimulation procedure had no effects as the speed of movement increased. However, the present investigators tested the subjects at 60°, 90°, 120 degree/second using the same CYBEX, and found a significant development greater than the strength gains that occurred in isometric strength tested at (0 degree/second). An inspection of the (Zhan, Mantilla & Sieck, 2003) study shows that the test order effected their results, and the electrical stimulation was conducted 10 sessions over 5 weeks, which is considerably long, and the effects of the training is doubtful. This study disagrees with (Eriksson & Haggmark, 1979) that electrical stimulation had no benefit when electrical stimulation was added to the training program of well trained athletes. Similar studies in the former Soviet Union support the results of this study using a well developed strength subject's e. g (Kotz & chullon, 1970., Pandyan, Granat & Stott, 1997). The present study agrees with (Cabric & Apple, 1987), that a contraction time of 5 second had no effects on girth thickness. At the same time it had significant effects on strength level.

A relatively large increase of maximum isometric strength after electrical stimulation was demonstrated by a number of investigators (Cabric & Apple, 1987, Hainaut & Duchateau, 1992., Durmus, Alayli & Cantürk, 2007., Paillard, 2008., Pandyan, Granat & Stott, 1997., Adrianova & et.al, 1974., Currier & et al. 1979., Eriksson & Haggmark, 1979., Selkowitz 1985). The values reported for increase of strength in the above mentioned studies were mainly within limits of 10% - 40%. Some studies shows increase of about 200% (Duclay, Martin, Robbe & Pousson, 2008). It is difficult, to compare the results of this experiment with those mentioned before, because of methodological differences, the duration of experiment, the variables tested, if the results are compared with the results of those authors (Cabric & Appell, 1985., Kotz & Chullon, 1975., Andrianova & et.al, 1974., Gabriel, Kamen & Frost, 2006., Paillard, 2008) whose experimental protocols closely resembled that of the present study, one can observe that increase of maximum isokinetic force (at 60°, 90°, 120 degree/second) was higher in the present study, and researchers reported much higher isometric strength (at 0 degree/second) increase, than in this study.

This difference can probably be explained by the E.S superset of the agonist and antagonist stimulation initiated number of contraction given to the subjects, in the present study (72 titanic contraction + 720 tonic contraction) in other studies 10-25 contraction with 5-10 second duration, and by the duration of the pause between each contraction (in this study 4 second) in other studies was 20-50 second.

Conclusions

It recommended that the ES method of the type described here can be applied when the demands for high level performances by elite athletes are limited by traditional training methods and when the demands of the training are beyond the individual possibilities of the athletes.

We recommended the ES method similar to that used in this study electrode placement, intensity, and volume to well trained athletic training program specially in the pre competition period.

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