サッカー競技選手のプレシーズンにおける 2 Hz の断続電流を用いた電気刺激筋力トレーニングプログラムの効果

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The Effects of an Electrical Stimulation Training Program Using an Intermittent 2 Hz Frequency on the Lower Limbs of Soccer Players in the Pre-Competition Period

by

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ABSTRACT

This study attempted to investigate the effect of an electrical stimulation training program on the function of the quadriceps,

biceps femoris, gastrocnemius, soleus and flexor digitorum longus muscles in male soccer players.

Subjects were assigned to two groups, the experimental group who experienced both electrical stimulation and weight training and the control group who experienced only weight training program. The experimental group was under an electrical stimulation and weight training program. The control group had only the same weight training program, in a same condition, same intensity, load and volume as the experimental group. All subjects were members of the intercollegiate soccer team of University of Tsukuba in Japan.

One protocol of surface electrical stimulation training was studied in the experimental group with the legs flexion position 90 degree and with ankles restrained. The muscle of lower limbs were stimulated at maximally tolerable intensity using an intermittent 2 Hz (n = 8) frequency.

When results were compared between the experimental group and the control group before and after the training program, no significant differences ($P < 0.05$) were observed. For all events of the test, with one exception 30 m dash, sprint power was siginfcantly developed.

KEY WORDS (Electrical stimulation, Muscle performance, Weight training, Strength and power test)

要　旨

本研究では，男性のサッカー選手の大腿四頭筋，腓腹筋，ひらめ筋，長趾屈筋の機能における電気刺激トレーニングプログラムの効果を検討することを試みた．

被験者は実験および統制の2群に分けた．実験群の被験者は電気刺激とウェイトトレーニングのみの経験を，統制群の被験者はウェイトトレーニングのみの経験をもっていた．実験群は電気刺激とウェイトトレーニングを合わせたプログラムを実施した．統制群は，実験群と同一の条件，強度，負荷，量のウェイトトレーニングのプログラムを実施した．被験者は関東大学サッカーリーグに所属する筑波大学チームのメンバーであった．実験群の電気刺激トレーニングは，ひざ関節および足関節角度を90°に固定した体位で，表面電極を用いて行った．刺激は断続的な2 Hz周波数を用い，最大のトレランスで行なった．

実験期間の前後において実験および統制の両群間を比較した結果，30 m走を除く他のすべての項目において統計的に有意な（$P < 0.05$）差は得られなかった．

Introduction

Soccer coachs and athletes attempt to ac-

hieve high level performance in physical fitness and skill performance before competition. The problem lies in retaining training levels into competitive performance at an optimum level and to stabilize the training effects, enabling the athletic to achieve the best possible results in competition period.

Generally in the preparatory period individual abilities of strength in performance, speed or endurance, or coordination and flexibility have been developed. It's also necessary to use these training programs during the pre and competitive period for the stabilization of the achieved performance (Harre, 1982)[8]

As far soccer as a technical sport, this applies to sharpening tactic and technique training, considering that the volume of physical fitness performance training in pre competion period must be decreased.

Numerous studies and researches in the sphere of rehabilitation and sport have invesigated the effects of electrical stimulation (ES) in various directions. De villers et al. (1964)[5] achieved a significant effect on the respiratory capacity. Kots (1977)[11] did his research in using ES in the sphere of Soviet sport. In Vodovnik (1971)[15] restored motor patterns in disabled patients. Pierre et al. (1979)[13] reported in their study in weight lifting demonstrated that ES can be utilized to enhance the learning of physical skills requiring muscular coordination.

Most of these studies were used a continuous and intermittent ES frequency, which lead to a tetanic contraction, for more than ten seconds followed by an interval of 40 or 50 seconds rest and this cycle was repeated ten times or more daily for a period ranging from two or three weeks, i. e. this ES training of muscle, leads to morphological changes (reducation of subcutaneous fat, increase of muscular mass and to functional change). In our study we attempted to evaluate the effectiveness of surface ES using an intermittent 2 Hz frequency, and to find out if this program (ES and WT) is useful to stabilize the achieved strength level or not?

Furthermore we try to focus more light on ES usage.

Methods

Thirteen subjects participated this study after being informed of the nature of the procedures to be employed. The subjects were randomly assigned to two groups, the experimental group (n = 8) and control group (n= 5) shown in **Table 1**. Two electrodes 4 × 5 cm size were placed across the muscle, one on the muscle motor point, the other placed on the head of the muscle, the legs in flexion position 90 degree and ankles restrained. Each subject determined the intensity of the stimulation, but was encouraged to make this as high as was tolerable. The muscle were stimulated three minutes on each muscle motor point, three days per week for six weeks, using an EIDEN apparatus, weight training program was fixed for both experimental group and control group as follows.

1) Leg extension (machine).
2) Leg curl (machine),
3) Squat (deep knee bend). Free weight.

Table 1 The Characteristics of Subjects

Variables	Experimental group		Control group		p
	Mean	s. d.	Mean	s. d.	
Years of age	19.4	1.1	20.8	1.1	*
Years of competition	9.7	1.8	10.6	2.2	
Body height (cm)	175.5	7.2	176.5	4.0	
Body weight (kg)	70.9	6.8	67.7	5.4	

Note Number of subjects is 8 for experimental group, and 5 for control group. * $P<0.05$.

4) Toe raise (calf). Free weight.
5) Bench press. (Free weight).
6) Dumbbell curl.
7) Two hands curl. (Free weight).
8) Sit-up using weight (10 kg for all subjects).

The program of the weight training Organizational methodical procedure was 10 reps / 30% 1 RM + 10 / 40% + 10 / 50% + 10 / 40% for each exercise, with a very fast motor velocity (explosively) and 2 ~ 3 minutes interval. Three times a week, for six weeks. This cycle was followed by ES for experimental group only. Both of the Two groups were tested in body weight, vertical jump, 30 m dash, backward throwing of medicine ball, leg muscle strength (Electric dynamometer) , body flexion (hip joint flexibility) , bended thigh and calf girth for left and right side.

Statistical analysis of the data consisted of a repealed measures analysis of variance. The T-test was used to locate specific difference between control and experimental groups, the confidence level was set at $P< 0.05$.

Results

When results were compared between the experimental group and the control group at pre-training, there were no significant differences in the items of the test (**Table 2**). But the 30 m-Dash item had a significant difference in both groups, which is shown in the same Table. Therefore this results indicated that the subjects were divided into the experimental and control groups by randomization. After the experimental group in the same item (30 m Dash) shows a significant difference in the mean of sprint speed between pre-and post-Training (**Fig 1** and **Table 3, Table 4**) shows the results of T-test between pre-and post-Training in the control group. There were no significant difference in all events of the test items.

Discussion

Surface ES with an intermittent 2 Hz stimulation protocol used in the present study did not enhance maximum strength level, as was expected. From the literature and physical training practice it is known that massive muscular contraction, in particular

Table 2 Results of t-test between Experimental and Control Groups at Pre-training

Variables	Experimental group		Control group		p
	Mean	s. d.	Mean	s. d.	
Body weight (kg)	70.9	6.8	67.7	5.4	
Vertical jump (cm)	60.4	5.1	61.4	4.4	
30m dash (s)	4.46	0.20	4.24	0.09	*
Backward throwing of medicine ball (m)	10.7	1.2	14.1	0.9	
Leg power (kg)	162	21	160	30	
Body Flexion (cm)	8.4	8.4	9.8	8.3	
Bended thigh girth R (cm)	56.0	2.5	55.8	2.7	
Bended thigh girth L (cm)	56.3	2.5	55.7	2.4	
Bended lower limb girth R (cm)	38.0	1.5	37.7	2.5	
Bended lower limb girth L (cm)	38.0	1.6	37.4	1.9	

Note Number of experimental group is 8 and 5 for control group.
* : $P<0.05$ R : Right, L : Left

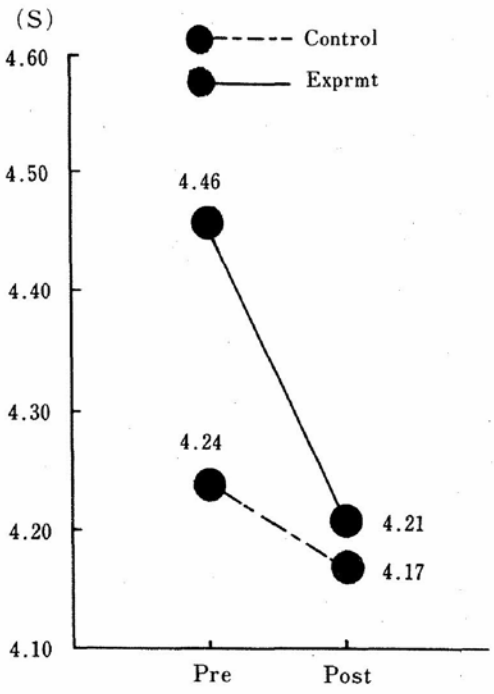

Fig .1 Training effect of 30 m-Dash

under conditions of an isometric regime, leads to an increase of the muscle mass and improvement of muscle strength (Kots 1977)[11] . These indicate that there must be a minimum period of time of about 15～20% of the maximum duration obtainable in the different training strengths, during which probably a chemical change occurs within the muscle, which in turn is the basis for increase in muscle strength. However, an intermittent 2 Hz current lead to a muscular contraction, (a toinc contraction with little change in muscle length and meets no apparent resistance from the antagonist to oppose the induced force) i.e. not enough to lead to maximum muscle contraction.

Muscle contractions of very short duration (i.e. less than one second in maximum training strength) have no effect–as is also the case with reflex contraction (Hettinger). But in the present study we notice development in sprinting power as showed in **Fig 1** for the experimental group, can be highly related to the ES effects. To verify this point, further studies of the model used here and of more complex intermittent contrac-

Table 3 Results of t-test between Pre and Post-training in Control Group

Variables	Pre-training		Post-training		p
	Mean	s. d.	Mean	s. d.	
Body weight (kg)	67.7	5.4	67.7	5.4	NS
Vertical jump (cm)	61.4	4.4	64.4	6.9	NS
30m dash (s)	4.24	0.09	4.17	0.12	NS
Backward throwing of medicine ball (m)	14.1	0.9	12.4	1.3	NS
Leg power (kg)	163	33	148	23	NS
Body Flexion (cm)	7.0	6.4	9.4	6.5	NS
Bended thigh girth R (cm)	55.8	2.7	56.0	2.2	NS
Bended thigh girth L (cm)	55.7	2.4	55.8	2.6	NS
Bended lower limb girth R (cm)	37.7	2.5	37.6	2.0	NS
Bended lower limb girth L (cm)	37.4	1.9	37.0	1.9	NS

Note Number of control group is 5. NS : Not significant.
R : Right, L : Left

Table 4 Results of t-test between Pre and Post-training in Experimental Group

Variables	Pre-training		Post-training		p
	Mean	s. d.	Mean	s. d.	
Body weight (kg)	70.9	6.8	71.2	6.8	
Vertical jump (cm)	60.4	5.1	62.4	4.5	
30m dash (s)	4.46	0.20	4.21	0.15	*
Backward throwing of medicine ball (m)	10.8	1.2	11.0	0.7	
Leg power (kg)	164	22	159	26	
Body Flexion (cm)	8.4	8.4	8.4	8.7	
Bended thigh girth R (cm)	56.0	2.5	56.9	2.6	
Bended thigh girth L (cm)	56.3	2.5	57.4	2.5	
Bended lower limb girth R (cm)	38.0	1.5	38.3	1.0	
Bended lower limb girth L (cm)	37.9	1.6	38.3	1.0	

Note Number of Experimental group is 8.
* : $P<0.05$. R : Right, L : Left

tion pattems are necessary. Because we have no direct evidence on the relation of the development of the sprinting power and the ES with an intermittent 2 Hz protocol. On the other hand subjects in the experimental group (after bein questionred) after every ES and WT, did not feel a muscular soreness which seems to be ever present after a routine work out i.e. 2 Hz intermittent ES effects was similar to the massage effects, which is known as the traditional means of restoring sports work capacity and decreasing muscle tonus, which probably can explain the development of the sprint-

ing power in the experimental group. Rather more the level of the achieved strength and power did not decrease, i. e. we achieved to a stabilization of training effects of the preparation period, when only 30～50% of the maximum muscle strength is used as in the present study **Table 2**. These findings are one of the important aims of the coache in this period, and that can be highly related to the influences of the WT program.

Most previous investigators such as Kots (1977)[11], Adrianova et al. (1974)[2], Anzil et al. (1974)[4], found used a continuous and intermittent ES current with varied frequency, and have a significant improvement for muscle strength.

Power and strength are defined as:

-Power is the abillity of an athlete to over come resistances by high speed of contraction

-maximum strength is the greatest force an athlete able to exert for a given contraction of muscles Harre, 1982.

Conclusions

From the investigations we mentioned so far, the following three conclusions could be obtained.

1) The intermittent ES 2 Hz frequency, had a significant influences in devoleping sprinting power.
2) The intermittent ES 2 Hz frequency, could be used as a successful technique to restoring sports work capacity and decreasing muscle tonus, similar to the massage effects.
3) The weight training program that we used in the present study, had a very good influences in the stabilization of the a achieved strength and power level.

This result is important for soccer and other events e.g. ball games, track and field e.t.c. This also ES method exceptional individualization and effectiveness. With smaller physical and time losses.

Thus data from the literature proper studies such as Kots (1977)[11], Adrianova et al. (1974)[2], Anzil et al. (1974)[4], and practical experiences, substantiate the possibility of using ES technique in sports practice, especially in Japan whereat the present study could be consider as the first in the sphere of Japanese sport.

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