THE INFLUENCE OF ELECTRICAL STIMULATION TRAINING ON SWIMMING PERFORMANCE

F. Pichon, G. Cometti and S. Petiot

Laboratoire d'Etude et de Recherche del la Performance Sportive
UFR-STAPS, Université de Bourgogne, Dijon Cedex, France.

INTRODUCTION

The purpose of this study is to examine the influence of a three week cycle of electrostimulation of latissimus dorsi on strength development and swimming performance.

METHODS

Subjects

A group of fourteen swimmers training in a club agreed to take part in the experiment. Subjects were divided into two groups : the first one (23,1±1,9 years; 179,8±4,8 cm; 72,8±6 kg) was composed of seven swimmers who underwent three electrostimulation sessions a week during three weeks in addition to swimming training. The second one (23,1±1,9 years; 178,1±4,8 cm; 75,1±6 kg) was the control group composed of seven swimmers training only in the pool. They trained between five and ten hours a week. It was a group of regional and national standard sprint swimmers whose speciality was 50 and 100 meters. Therefore swimmers with dominant speed who must work their maximal strength in order to improve their performance.

Electrostimulation sessions

Sessions are carried out using a portable stimulator (stipro) with two independant way outputting a symmetric orthogonal pulse train lasting 0,3 ms at 80 Hz. So the two lattissimus dorsi could work together.The sessions lasted 12 minutes, the contraction time was five seconds and the rest one was 15 seconds. There were three sessions a week for three weeks.

Peak torque

A biodex type (Biodex Corprration, Shirley, NY, USA) isikinetic ergometer was used to mesure the maximum torque values developped over the arm flexion-extension movement at different velocities (-120, -60, 0, 60, 120, 240, 300, 360°/s). After one or two testings at selected speed, a rest of twenty seconds was observed between two repetitions. For the whole test tests, the effort must be maximal. For each speed, tests were doubled. Only the best performance was taken into account. Between each test four minutes rest permitted the subject to retriev in order to make another test in the best conditions. Before each test, an overheating with and without biodex was carried out.

Swimming tests

Each swimmer did three tests: hvo on 25 meters (the first one with a pull-buoy behveen thighs and belt fasten to feet, in order to avoid the leg participation, and the second one was carried out in full movement, that is to say whithout contraint. The 50 meters crawl was realized in full movement. Each test started in water. A fifteen free overheating was made before the beginning of the tests. A rest of ten minutes was respected between two tests in order to permit swimmers to retriev enough and can make a maximal effort

Analysis statistic

Pre and post-training mean values were compared within each group using the wilkoxon non-parametric statistical test. For each test any difference is significant if the probability threshold is at least equal to $p<0,05$ (noted: *).

RESULTS

Biodex tests

At the end of training, the results for electrostimulatedswimmers show an improvement (+43%) in peak torque eccentrically at velocitiy of 120°/s ($p<0,05$), isometrically (+15% and $p<0,05$) concentrically at fast velocities of 180 (+10%), 300 (+12%), 360 (+14%) with $p<0,05$ (fig. 1). While the control group shows no significant difference.

Swimming tests

A gain in swimming time for study subject is recorded for the 25 meters arms only (19 hundredth of a second with $p<0,05$), and for 50 meters full movement (38 hundredths with $p<0,05$) (fig. 2). There, the control group shows no significant difference.

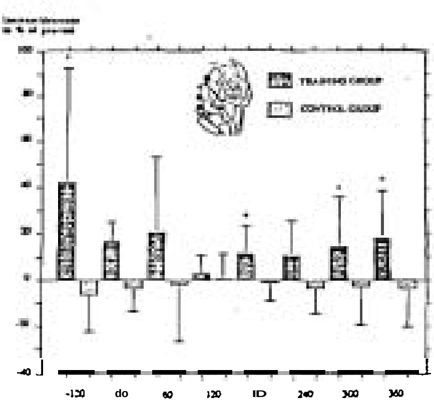

Figure 1. Increase or decrease of peak torque in control and training groups mesured by ergometer isocinetic (BIODEX) in % of the pre-test

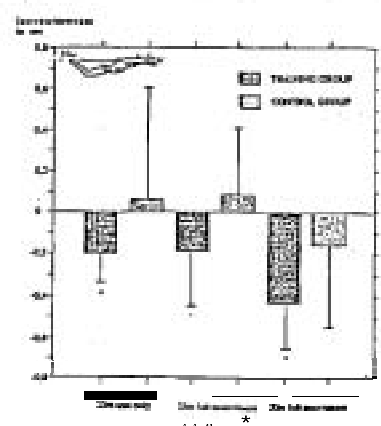

Figure 2. [illegible] and [illegible] of swimming's t— in control and training groups

DISCUSSION

The improvements recorded in eccentric for electrostimulated swimmers could be explained by preferential recruitment of fast fibres (Nardone, 1989). So an electrical stimulation cycle would entail a preferential recruitment of fast fibres.

The strength improvement depends on the contraction regimen used for training and testing tw (Sale and Mac Dougall, 1981). If training is carried out on a concentric regimen, improvements will be noticed. These ones would be due to apprenticeschip of specific coordinations of the movement (Rutherford and Jones, 1986). It can explain the important improvements found in isometric regimen. The strength improvement depends on the adopted attitude during training too (Rajcin, 1975; Thepaut-Mathieu and al, 1988; Kitai and Sale, 1989). This observation is carried out thanks to neurophysiological adaptations due to contraction repetition while training which can be easily shown duringthe test. The position which is nearly the same for tests on biodex and during electrostimulationsessions (angle arm-trunk is equal to 140°, 0" corresponding to the anatomic position) confirms the results found by these authors. So this strength improvement on isometric regimen can be due to a better recruitment of fibres as well type I fibres as type II and/or to a better coordination between agonist- antagonist. Improvements being specific to the training angle, we must train in the specific in order to keep a coordination of the wanted technical gesture.

The recorded results on biodex at fast velocities could be explained by Thorstensson (1977) who suggests that from 180°/s velocity, fibres composition of the muscles can be forecast. Moreover, the percentage of fast fibres in a muscle seems to be determinant for strength producing during fast concentric actions (Thorstensson and al, 1976; Froese and Houston, 1985). Electrostimulated swimmers who show higher improvements in peak torques. would profit by a bigger solicitation of type II fibres.

The adaptation shown in this part could be the consequence of a better activation of motor units (Thepaut-Mathieu, 1984) and/or preferential solicitation of muscular type IIb fibres (Enoka, 1988). This approah is supported by Cabric and al (1988) whose origins are favorable to reverse recruitment order of motor units. More recently, Duchateau and al (1990) checked the this hypothesis by using a method which allows to record the mechanical answer of an isolated motor unit. The result shows a higher strength improvement for the largest, the fastest and at a higher level motor units compared to smaller and slower ones. Several factors could be responsible for that:

- The first one is the diameter of motor axons. As a matter of fact, the excitation level of an axon is inverse ratio to its diameter (Solomonov, 1984). So large motoneuron have a lower excitability level. Also the large diameter axons are faster than small diameter ones on the contrary of voluntary contraction.

-The second one is the distance separing the electrostimulation electrod from axon. As a matter of fact, motor unit with a large diameter are the most often superficialy located in the muscle and so nearear the electrod (Lexel and al, 1983).

-The last one is the setting of cutaneous receivers that by the reflex way inhibits motorneuron of small motor units and excits big ones. Also they favour the recruitment of the biggest motorunits to the detriment of the smallest one (Garnet and Stephens, 1981; Burke and al, 1970).

The setting of these three factors clearly shows that the contraction under electrostimulation, of which the trend is the preferential recruitment of large motor units, would be liable to produce a reverse activation order compared to voluntary contraction one.

The important improvements recorded in swimming tests show that force gains measured by isokinetic ergometer are transfered to swimming gestual.

CONCLUSION

To sum up the essence of this work, it can be claimed that the significant results of the experiment point to the use of electrical stimulation for sports training if it is decided to increase explosive strength.

*Burke R.E., Jankowska E., Bruggencate **G.T** (1970) - A comparison of peripheral and rubrospinal synaptic input to slow and fast twitch motor units of triceps surae, ***journal of physiology***, 207: 709-732.
Cabric** M., Appell **H.J.**(1987) - Effect of electrical stimulation of high and low frequency on maximum isometric force and some morphological characteristics in men, ***Int. J. Sport Med 8: 256-260.
***Duchateau** J., Hainaut **K.**(1990) - Effects of immobilization on contractile properties, recruitment and firing rates of human motor units, *Journal of Physiology*, 422, 55-65.
Enoka** R.M (1988) Muscle strength and its development: new perspective, ***Sports Med.6: 146-168
***Froese** E.A., Houston M.E (1985) - Torqüe-velociy Characteristics and muscle fiber type in human vastus lateralis ***J.** Appl. Physiol.* 59: 309
***Gardner G.W** (1962) - Specifity of strength changes of the exercised and non exercised limb following isometric training, *Res.Quart.*, 34 (1) : 98: 101.
Garnett** R., Stephens J.A. (1981) - Changes in the recruitment threshold of motor units produced by cutaneous stimulation in man. **J. *of *Physiol.* 311: 463-473
Kitai** T.A., Sale D.G. (1989)- Specifity of joint angle in isometric training, ***European *Journal **of Applied** Physiology,* 58: 744-748
Lexell** J., **Henriksson-Larsén** K., **Sjöström** M. (1983) Distribution of different fibre types in human skeletal muscle: 2.A study of cross-sections of whole m. vastus. ***Acta Physiol. *Scand.* ***117: 115-122***
Nardone** A., **Romano C.,Shieppati** M. (1989) - Selective recruitment of high threshold human motor units during volontary isotonic lenghtening of active muscles, ***Journal of *Physiology*. 409: 451-471
Rajtcin** L (1974) - The effectivness of isometric and electro-stimulated training on muscle strength at different joint angles *Yesssis* ***Rev. 11: 35-39
*Sale D.G., **MacDougall** D. (1981)- Specificity in strength training: a review for the coach and athlete, *Canadian Journal **of Applied** Sport Science*, 6: ***87***- 92
* Rutherford, O.M.; Jones, D.A. (1986) - The role of learning and coordination in strength training. *European Journal **of** applied* **Physiology,** 55, 100-5.
Solomonov** M. (1984) External control of the neuromuscular system. ***IEEE Tram. Biomed. *Eng. BME31.*, 12: 752-763.
Thepaut** Mathieu **C.**(1984) - Modifications de la force musculaire et de l'activité des motoncurones au cburs d'un entrainement isométrique chez l'homme. ***Thése 3éme cycle, *Université **de Paris VI,*** 1vol., 87 p.
***Thepaut mathieu** C., Van Hoecke **J.**, **Maton** B - (1988) Myoelectrical and mechanical changes linked to length specifity during isometric training. ***J.** Appl. Physiol.,* 64: 1500-1505
***Thorstensson** A., **Grimby** G., Karlsson J. (1976) - Force-velocity relations and fiber composition in human knee extensor muscles. ***J.** Appl. Physiol.* 40: 12-16
***Thorstensson** A., Larsson L., Tesch P., Karlsson **J.**(1977) - Muscle strength and fibre composition in athletes and sedentary men. Med. ***Sci.** Sports* 9: 26-30