VIBRATORY STIMULATION TRAINING: A NEW APPROACH FOR DEVELOPING STRENGTH AND FLEXIBILITY IN ATHLETES

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INTRODUCTION

Exercises for strength abilities and flexibility are a main component of the training process in most sport disciplines. They determine both the general and specific bases for skillful performance. Moreover, the types of exercises, the methods and the instruments used for strength training are the most popular areas of innovation in sport training. Elite sport strength training

has been the focus of special attention in the past in the following directions:

- isometric exercises (Hettinger, 1964)
- isokinetic exercises (Counsilman, et al., 1972)
- electrostimulatory contractions (Koc, 1971)
- the use of anabolic steroids as ergogenic stimulators (see Silber, 1992 for a review)

All these directions, with the exception of the last one, contributed to the progress of training methods. Another situation is observed in the area of flexibility training. The repertoire of stretching exercises was supplemented in the last four or five decades with the introduction of PNF (proprioceptive nervous facilitation) techniques only.

It is certain that contemporary athletic training requires methodological and technological innovations which may improve the physiological and biomechanical aspects of athletic training.

The vibratory stimulation (VS) method may be considered as a combination of these two aspects. Early investigations on VS were conducted by Hugharth and Eklund (1966) and Matthews (1966) from a neurophysiological point of view. The effects of VS stem from the fact that the muscle is stimulated during active contractions. The practical application of this method has also been used on physiotherapeutic grounds (Bishop, 1974). Only recently, VS was investigated regarding motor fitness training (Nazarov & Spivak, 1987; Issurin et al., 1988). While VS could potentially be applied to a large area of fitness exercises,

the implementation of this approach has been limited until now. This is probably due to a lack of knowledge and experience, and a lack of appropriate devices.

The purpose of this work is to present some positive results using the VS method to develop strength and flexibility in athletes. Namely, the study was aimed at testing the VS training and defining the effect of the VS program compared to conventional methods.

METHOD

Subjects

Twenty-eight male physical education students (aged 19-25 years) were employed for this experiment.

Apparatus

The vibratory stimulation apparatus was designed to perform various isometric and dynamic exercises for maximal and explosive strength, stretching and restoration. The device consisted of electromotor connecting with eccentric cable transmission and ending means (bar, ring, handle or straps) to be used for pulling, pushing or pressure. Any loading device can be connected with the cable transmission for providing the resistance of movement. The electromotor by reduction rotates an axis with a wheel. The center of the wheel's rotation is displaced eccentrically. A stiff cable girdles the wheel and is connected with a load via the pulleys. Attached to the far end of the cable is a handle or ring, which can be used to perform either strength or stretching exercises with superimposed vibration

Experimental Design

The subjects were randomly assigned into three experimental groups which trained three times a week during three weeks according to the following prescription:

Groups A and B trained on a sitting bench pull exericse with both arms while the load was gradually increased from 80% to 100% of one repetition at maximum (1RM). After that they performed two-leg split stretching exercises in three modes, namely: static, ballistic, and stretching along with trunk flexion. Each workout was comprised of six sets of sitting bench pull and six sets of two-leg stretching with 2-3.5 min. rest between sets. The workouts' content differed in the application

The VS strength training resulted in a substantial increase of isotonic 1RM value for sitting bench pull. An average gain was 49.8% while the conventional strength training resulted in a 16.1% increase. The "placebo" subjects showed no gain in 1RM. The RM-ANOVA showed significant main effects for "treatment" and "pre-post" factors. Their interaction was also significant (p<.001).

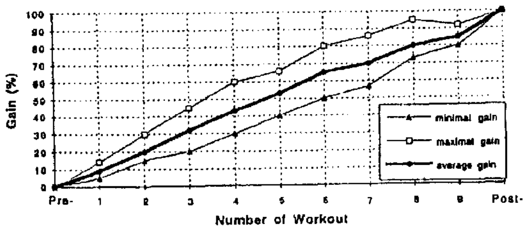
The isokinetic peak force and peak power values resulted in a significant pre-post effect. However, the differences between the pre and post results were approximately the same in the three treated groups.

The VS flexibility treatment resulted in a mean increase of 8.7% in the legs split compared to the 2.4% mean average increase of the conventional group and the 1.2% of the "placebo" group. The RM ANOVA applied to split gain revealed a significant pre-post effect, and also a treatment X pre-post interaction (p<.001).

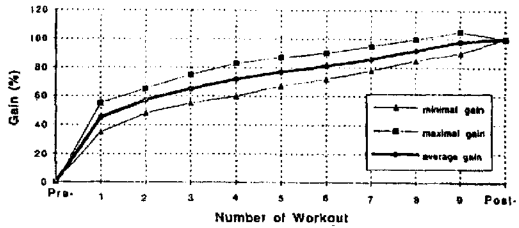
Similar results were obtained for the trunk flexion component. The VS flexibility group showed a mean gain of 43.6%, compared to 19.2% and 5.8% of the conventional stretching and "placebo" training groups, respectively. Significant pre-post effect and a treatment X pre-post interaction (p<.003) were revealed by RM ANOVA.

The physical fitness gains in each of the studied groups are demonstrated in Figures 1 and 2.

Gain in maximal force during the sitting bench pull exercise by 'number of workouts'.



Flexibility gain in a legs split by 'number of workouts'.



The VS strength training resulted in a linear increase of maximal isotonic force throughout the whole period of practice. During practice the VS stretching exercises elicited the maximal gain following the first workout (average of 45% of the total increase). The gain after each further session was minimal.

DISCUSSION

The results of this study revealed that: a) the VS exercises resulted in an increase of maximal strength and/or flexibility, more than in conventional training procedures, and b) the gain-rate in strength differs from the gain rate in flexibility during VS stimulation.

According to Hagbarth and Eklund (1966) VS results in excitation of primary afferent endings of motor spindles. This excitation evokes a reflexive increase of muscle contraction. Hence, voluntary muscle contraction can be strengthened by means of VS.

The main target for VS in the stretching exercises are the Colgi tendon organs. They are sensitive to active tension and evoke an inhibition of contraction, followed by relaxation of the muscle. We exploited this relaxation during stretching with VS.

Also, vibratory wave propagation caues recruitment of receptors which, in turn, activate previously inactive motor neurons and activate additional motor units into contraction (Bishop, 1974). Unlike the local stimulation, our method of superimposed vibration activates many muscles and stimulates additional motor units. A visible effect that was marked during workouts, was an immediate improvement of maximal force exertion under VS conditions.

It is a common belief that short-term muscles vibration, like vibratory massage, enhances local blood circulation (Wakim, 1985). It is also well known that maximal muscle contraction causes squeezing of capillars. The vibration of contracting muscles prevents such squeezing. Moreover, the rhythmical occillations of intramuscular pressure elicit an effect of mechanical pump. The consequences of such a blood flow increase could be an activation of all metabolic processes within muscles. Consequently, this occurrence can facilitate both VS strength and VS stretching exercises.

During VS, blood flow increases and a friction between vibrating tissues elicit substantial heating (Oliveri et al., 1989). Moreover, an increase in muscle temperature decreases the viscose resistance of muscles and vascular bed (De Vries, 1983). This effect during stretching exercises benefit from this by-product of vibration, particularly because the warm-up itself enhances flexibility as well.

The phenomenon of pain alleviation by VS has been known for a long time, although its mechanism is not clear (Lundeberg et al., 1984). Pain reduction during performance of stretching exercises was, in our opinion, the major factor contributing to the positive effect found after VS training.

The constant and almost linear increase of maximal strength (Figure 1) purports a wide possibility of muscle adaptation to VS training. However, this adaptation was rather specific. Another type of adaptation relates to VS flexibility training (Figure 2). The rapid gain of flexibility after initial workouts assumes an utilization of available reserves of elasticity within the muscles and tendons. However, further progress requires morphological evolution of tendons, ligaments and joints. Such an evolution takes a prolonged period of time.

It is concluded that VS strength and flexiblity exercises have a sufficient advantage over the conventional mode. Thus, this new approach to training can be recommended for adoption in practice.

REFERENCES

Bishop, B. (1974). Neurophysiology of motor responses evoked by vibratory stimulation. Physical Therapy, 54 . 1273-1282.

Counsilman, J. (1972). Isokinetics: A new approach to strength development. Athletic Journal, 52, 7.

DeVries, H.A. (1983). Physiology of exercises for physical education and sports . Dubuque, IA: W.C. Brown.

Hagbarth, K.E., & Eklund, G. (1966). Motor effects of vibratory stimuli in man. In R. Granit (Ed.), Muscular afferents and motor control . Nobel Symposium. Almquist & Wiksell, Stockholm, 177-186.

Hettinger, T. (1964). Isometrisches muskeltraining . Stuttgart: ¡Georg Thieme Verlag.

Issurin, V.B., Kuna, S.V., Temnov, P.N. (1988). Effectiveness of vibratory stimulation with different regimes in exercises for maximal strength and strength endurance. The state of the problem of athletes preparation in the water sports. Scientific Issue of the Leningrad Research Institute of Physical Culture , Leningrad, 154-158.

Koc, J. (1971). Muscle strength training by means of electrostimulation ¡method. Theory and Pract. Phys. Cult. (Moscow), 3 , 64-67.

Lundeberg, T., Nordemar, R., Ottosson, D. (1984). Pain allevation by vibratory stimulation. Pain, 20 , 25-44.

Matthews, P.B.C. (1966). The reflex excitation of the soleus muscle of the decelebrate cat caused by vibration applied to its tendon. Journal of Physiology, 184 , 450-472.

Nazarov, V.T., & Spivak, G. (1987). Development of athlete's strength abilities by means of biomechanical stimulation method. Theory and Practice of Physical Culture (Moscow), 12 , 37-39.

Oliveri, D.J., Lynn, K., Hong, C.Z. (1989). Increased skin temperature after vibratory stimulation. American Journal of Phys. Med. Rehabilitation , 68 , 81-85.

Silber, M. (1992). Anabolic androgenic steroids in Soviet sport. Concord, CA: Atletika.

Wakim, K.G. (1985). Physiologic effects of massage. In J. Basmajan (Ed.), Manipulation, traction and massage . Baltimore: Williams and Wilkins.