MECHANICAL MUSCLE PROPERTIES AFTER TWO TYPES OF PLYOMETRIC TRAINING

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INTRODUCTION

Strength training effects may be highly specific. It has been documented that changes in strength are not only specific to the joint angle (Kitai & Sale 1989), but also to the type (Sale 1987) and to the velocity of contraction (Bell & Jacobs 1992). However, these suggestions are not always supported. Different studies conclude that the speed of exercise (Housh & Housh 1993) and the contraction type (Petersen 1991) do not appear to have specific training effects.

These conflicting results may be interpreted based on differences in training intensity, training duration, training mode and subject groups.

Beside this, most studies are limited to use strength measures to evaluate training effects. Question arises whether these simple strength measures are able to reflect the complex system of muscle adaptation to strength training.

This study is designed to evaluate the use of a muscle model in investigating training programs.

METHODOLOGY

Thirty male university students participated in the study. They were divided in 3 groups : one control group (N=10) and two training groups (N=2*10).

An active programmable dynamometer (Promett) was used for training and testing the right elbowflexors. With this system isometric, concentric and eccentric contractions can be performed at different speeds and at different amplitudes. The subjects were seated in a chair. The back of the chair was turned over 30". The shoulder was stabilised and the elbow was supported to become a horizontal position of the upperarm. Subjects grap a handle which was mounted on the lever arm of the system. The distance between the handle and the axis was measured to adjust the alignment of the elbow axis to the system axis.

The study was spread over a period of 8 weeks. The first week all subjects performed a pretest that consisted of 18 maximal contractions (isometric, concentric and eccentric). EMG of three elbowflexors (m. biceps brachii, m. brachioradialis, m. brachialis) was recorded and quantified using the differentiation technique described by Van Leemputte and Willems (1987).

The subjects, except those of the control group, excercised their elbow flexors three times a week, during six weeks. Each session they performed 4 sets of 8 maximal effort plyometric contractions. These plyometric movements consisted of two successive contractions (concentric + eccentric) over an amplitude of 120" at a velocity of 60°/s. The only difference between both training programs was the fact that the sequence of those contractions was reversed namely concentric-eccentric for the CE-group and eccentric-concentric for the EC-group. All training sessions were supervised by the same investigator and consistent encouragement was provided to ensure that each repetition was performed at a maximal effort.

After the training period all subjects performed a posttest which consisted of the same measurements as the pretest.

Based on this pre-and posttest a mechanical muscle model was quantified.

The muscle model of Van Leemputte (1985) is selected because of its accuracy and relative simplicity. The input of the model is the degree of activity of the muscle, derived from EMG, and the muscle length in function of time. The output of the model is the torque at the elbow. The model is evaluated for elbow flexion in a wide variation of contraction types (static, concentric, eccentric and plyometric), at different velocities and amplitudes. Between estimated torque, as output of the model and measured torque an average error of 7 % existed. The model has 8 coëfficients which are thaught to represent basic muscle mechanical properties. There are four coëfficients (a,b,c,d) which stand for the S-shaped Force-Length relationship (Huxley & Simmons 1971). Two coëfficients (e, for concentric movements and g for eccentric movements) stand for the hyperbolic Force-Velocity relationship (Hill 1970) Finally there are two coëfficient representing the influence of a concentric (f) and eccentric (h) contraction history (Cavagna 1977; Edman 1975).

By comparing the coëfficients determined before and after training, an attempt was made to speculate further on the underlying mechanism which may be responsable for the strength increase.

The specific purpose of this study is to examine whether these 8 coëfficients can be influenced by training and if the specifity of both training forms. namely the influence of the contraction history, can be recognized in the coefficient that represent this property.

RESULTS AND DISCUSSION

Analysis of the results using strength measures

During the training sessions, the average torque of the concentric and the eccentric part of the plyometric movements were calculated for each subject. Comparing the results of training session 1 with those of session 14 of both training groups, the concentric dynamic torque increased with more then 20% for all subjects, whereas the eccentric dynamic torquegain was more then 30%. These increases were significant ($P<0.02$) for both traininggroups.

At the different angles no significant differences were found between static moments, measured before and after training.

Comparing both training groups showed that no significant differences in training effects of both training programs were found. Both training groups made similar dynamic torquegains.

Analysis of the results using a muscle model

-Isometric Torque-

A non-determination of 7.4% in the pretest and 6.8 % in the posttest. was found by estimating the moments using the model. Respectively 5.4% and 4.7% of this non-determination was caused by the inaccurate EMG-registration and quantification. For the estimated static moments, both training groups improved only at an angle of 170° ($P<0.05$).

-Torque Velocity-

Dynamic torque is highly influenced- by the Torque-velocity relationship. The coëfficients e and g of the model represent the individual sensitivity of the subject to this relationship. Both coëfficients were determined before and after training.

The numerical value of these coëfficients are difficult to interpret. The coefficients were used to calculate theoretical moments as a function of velocity only (figure 1).

The CE-group made for both contractiontypes significantly greater dynamic torque gains then the EC-group (concentric $P<0.01$ and eccentric $P<0.05$).

The Torque Velocity relationship of the control group showed no significant differences in the posttest.

-Influence of the contraction history- ,

From literature we know that the force that can be generated by a muscle at a certain moment depends upon the muscle behaviour previous to this moment. This previous behaviour is called contraction history. If a muscle shortening occurs in activated condition, there is a concentric contraction history. The extent to which muscleforce could be influenced by this factor is expressed to the f-coëfficient. According to literature (Edman 1975) this contraction history leads to a force reduction. An active muscle-lengthening is called an eccentric contraction history, and leads to a force-increase. Individual sensitivity of each subject is represented by coëfficient g of the model.

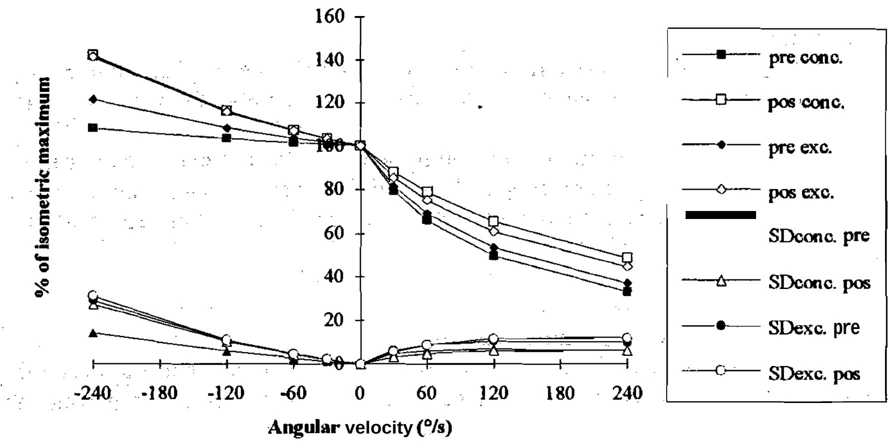

Figure 1 Force-velocity relationship (expressed in % of isometric force =100%) with SD before and after training estimated with the coëfficients e and g of both training-groups. Pre = before training, pos = after training, conc. = conc.-exc. group, exc. = exc.-conc. group.

In a similar manner as to the Torque Velocity relationship, theoretical dynamic torques were estimated, as a function of the contraction history only.

The EC-group reduced significantly ($P<0.05$) the negative influence of a concentric contractionhistory. Whereas before training dynamic forces reduced with almost 22% due to a concentric contraction history, this was only 12% after training.

For the CE-group and the CO-group the coëfficient representing this factor was not changed in the posttest.

No group showed significant changes for the eccentric contraction history pre- and post training.

CONCLUSIONS

The strength measures were unable to give a specific description of the muscle adaptation to the training program.

The isokinetic movements evaluated in this study showed no significant difference between both training groups. This is not in contradiction with the discussed results, but can be understood as a consequence of the combined influence of the studied factors on the performance. Using a mechanical muscle model, the influence of force determining factors on muscle contrtaction can be studied isolated. Whereas the CE-training is more effective on the factor velocity, the EC-training has a more positive influence on the factor contraction history. The result is a similar gain, but the cause of this gain is completely different, namely an ameliorated force-velocity relationship versus a reduced influence of the concentric contraction history.

Specific changes in force development after training can be studied using a muscle model. These findings are a useful contribution in determining specific effects of training.

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