THE INFLUENCE OF STATIC STRETCHING ON THE VISCOELASTIC PROPERTIES OF M. TRICEPS SURAE

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INTRODUCTION

The technique of passive muscle stretching is widespread in sports, general fitness and physiotherapy. Prevention of strain injuries (Garret 1990), relief of muscle soreness (High 1989) and improvement of flexibility (Etnyre 1988) are prime motives of this practice. However, there still is lack of basic research to provide a solid scientific background to prove these clinical beliefs.

Investigations concerning the effects of muscle stretching on alpha motoneuron excitability (Thigpen 1985; Guissard 1988; High 1989) emphasise a possible neuro-physiological mechanism in this matter. Inhibition before, during and through muscle stretching has been the rational of more complex proprioceptive neuromuscular facilitation techniques.

On the other hand, one should not forget the viscoelastic nature of responses to tensile loading common to biological soft tissues in general (tendons, ligaments, arteries, organs, etc.). (Crisp J; Fung Y 1972).

Taylor (1990) recently demonstrated the viscoelastic behaviour of whole muscle-tendon units to tensile stress on m. Extensor Digitorum Longus en m. Tibialis Anterior of rabbits. He concluded that many principles of viscoelastic behaviour in tendon and other connective tissue (including stress relaxation, creep and permanent set behaviour, hysteresis, dependency on time and precondition, a.o.) still hold true for whole muscles.

This study aims to describe the mechanical behaviour of human m. Triceps Surae to tensile loading and was designed to provide some indications regarding the effects of different modalities of static stretching on this behaviour.

METHODOLOGY

Twenty males and eleven females, aged 22 to 28, participated in this study. They all had a history free of major ankle injuries. Male testees were randomly assigned into two subgroups with respect to the duration of the static stretch (30 s vs 10 s). Females all performed short maintained stretches.

Each subject completed two sessions of seven passive stretches administered by the leverarm of a computer controlled, motor driven dynamometer (PROMETT-system).

The subjects were fastened in an adjustable chair rigidly connected to the dynamometer, the right leg extended and sustained, the left leg maximally bent in the hip to stabilise the pelvis. Furtheron, wooden plates were inserted between the back of the chair and the pelvis to avoid any hip displacement while exerting force on the foot. After aligning the ankle axis with the axis of the dynamometer, the lever was manipulated to determine the critical torque (Mcrit) and angle associated with a stretch just short of causing pain.

During the subsequent loading and unloading cycles of m. triceps surae, the leverarm of the system has been kept constant (10°/s). Due to an interactive loop the stretching amplitude was determined depending on the force exerted on the lever. This allowed a gradual increasing stretching amplitude as a result of creep and lengthening in repetitive stretches and provided an early stop of the manoeuvre when active muscle force was exerted.

By programming the end of the elongation cycle at 90% and 100 % of the critical torque in the two sessions a variation in the stretching intensity was induced.

The first and last passive stretch of each session consisted of an isokinetic movement up to the Mcrit (Stretch). After a short hold (200 ms) in this extreme position (Hold) the same isokinetic movement, but in opposite direction, was employed to relax the muscle (Relax). Between these two 'control measurements' five identic static stretches were performed.

Torque and angular position were sampled through all tests. Raw moment data were filtered digitally, corrected for gravitational influences and expressed as a function of the angular displacement. Stretching amplitude was defined as the range of motion starting from a 1% increase of the torque till the attainment of the programmed torque. Relax amplitude was defined as the displacement back to the 1% torque level. The storage and recovery of energy in successive stretch-relax cycles was obtained by integrating the load as a function of the angular displacement. Hysteresis was defined as the proportion of the recovered energy to the stored energy. Additionally, two and three degree least square fits to the data were determined and stiffness was defined as the first derivative of these fits.

Finally, the data were expressed relative to their maximum to allow interindividual comparisons.

RESULTS

Differences among first and last control measurements in the two sessions revealed significant (1%) differences in the stretching amplitude and the final positions to reach the critical programmed torque. The angle at the beginning of each stretch, which was determined to be the 1% torque increase, was found to be constant over the subsequent stretching cycles.

Stretch amplitude improved by 3.6° (+/-9°) when calculated over the whole group and for all conditions, and by 7° (+/-5°) in groups exercising at 100% of the critical torque. Males did not enhance their stretch amplitude by performing stretches at 90% of the critical torque.

Females had significant (1%) smaller stretch amplitudes compared to males over all tests, but no differences were found regarding the angle at the beginning of each stretch. Critical torques were significant lower among females (5%).

Subgroups regarding the duration of the hold phases (10s or 30s) only showed significant differences among parameters calculated out of the hold and relax phases. Long maintained stretches (30 s) did not affect subsequent stretch cycles.

Energy stored and recovered at 50%,75%,90% and 100% of the stretching amplitude showed no differences in the successive stretching cycles. Correlations among these values all are high (+.90). Consequently, hysteresis was very stable and not affected by static stretching. In control measurements hysteresis fluctuated about 0.61 (+/- 0.13) in males and 0.71 (+/- 0.37) in females.

Correlations of this data with data concerning the length of the shank and the circumference of the calf all were low and non significant.

DISCUSSION

Among the many parameters calculated out of the subsequent stretch-hold-and relax curves only few differences showed statistical significance. These findings stress the very stable response of m. triceps surae to tensile loading.

However, we do believe that the improved stretch amplitude in successive stretches can be attributed to an acute lengthening of the muscle. The constant starting angle over all stretching cycles largely exclude major repositioning effects in this matter. Acute lengthening of muscles in repetitive stretching was also reported by Taylor (1990) in more direct measures of rabbit muscles. He found a 3.46% (+1.08%) increase of the initial length after ten stretches to a fixed load.

Gender differences with respect to the stretching amplitude and the improvement of this amplitude through subsequent loading cycles in this study are to be explained by a less intensive loading among females. Critical torques differed significantly among males and females. Female subjects obviously had not the same confidence in the loading device as males and they probably never reached their real critical torques during the experiment. Consequently, the 100% and 90% intensity criteria were less effective to females as they were to males.

Longer hold phases did not affect stretch and elongation process, which is a finding in agreement with Borms (1987), who compared the effect of 10 s,20 s and 30 s maintained stretches.

CONCLUSIONS

The highly nonlinear shape of the load-stretch diagrams, the difference in stress response to loading and unloading (hysteresis), the decrease of tension when holding a fixed stretched length (stress relaxation) and the enlarged stretch amplitude in subsequent stretching cycles (indicating creep and lengthening) demonstrate viscoelastic properties in the response of m. triceps surae to tensile loading.

The shape of the stretch curves, the final stretch amplitude as well as the improvement of this amplitude over a session of 7 static stretches was more affected by to intensity of the stretch as it was by the duration of the hold phases.

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