TORQUE-JOINT ANGLE RELATIONSHIP FOR VASTUS LATERALIS MUSCLE

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INTRODUCTION

Joint-torque is the result of the action of muscle force and its lever to the joint. With the change of the angle in the joint there is a change in muscle length which affects the size of maximal force that the muscle can develop, there is also a change in the muscle's lever. Beside the muscle length change, the degree of muscle activation which can change with the joint-angle, can also influence the muscle's ability to develop maximal force (Thomas et al., 1987).

It rarely happens that only one muscle is responsible for a certain body movement. Generally one or more muscles or muscle groups participate, acting as a functional entity. In the knee, the major extensor muscle is the quadriceps femoris, consisting of four muscles which distally join into the patellar tendon, while proximally each has its own rooting. It is possible to expect that the individual muscle heads of the quadriceps femoris contribute their share to the torque in the knee in individual angles in different proportions. The same fenomenom of muscle compartmentalization was studied by Tjoe et al. (1991) in cat gastrocnemius.

The goal of the research was to study the changes of isometric torque in the knee at different angles and different activations of the quadriceps femoris muscle and to point to the differences in the relationship torque-angle in the knee in the vastus lateralis muscle in regard with the quadriceps femoris muscle as a whole.

METHODS

Six students of the Faculty of Sport in Ljubljana volunteered for the experiment giving informed consent.

Average age of subjects is 23.5 ñ 5.3, weight 68.8 ii 2.6 and height 174.8 ñ 4.6.

Each student performed knee extension in four different angles in the knee (45, 60, 75, 90 degrees) and with three different methods of activating the quadriceps femoris muscles:

- maximal voluntary isometric extension in the knee (MVC)
- supramaximal isometric twitch (TW) of the flattened quadriceps femoris muscle and
- submaximal isometric train of impulses of electrical stimulation (TR) of the relaxed vastus lateralis muscle.,

Students performed these contractions in each individual angle twice by the pyramid rule (from 45 degrees to 90 and back).

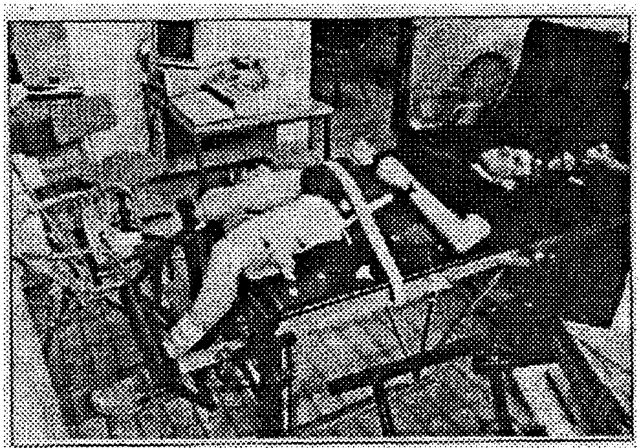

Figure 1. Position of subject before measurement.

During measurement, the subjects lay on his **back** so that his shank hung over the table's edge. The knee axis was always in the axis of the lever, on which a crossbar was fixed being pressed by the subject and which enabled measurement of force in different knee angles, which is clearly seen in Figure **1**. By fixing the hips with a band to the table, hip movement on the table and twisting of the pelvis was prevented.

Size of force pressuring on the lever had been measured by home-made sensor. The sensor was fixed to the crossbar which had a constant lever in respect to the knee axis in all angles, or positions. The force was measured with a frequency of 200 I-Iz. On the basis of the measured force and given lever torque had been measured.

Electrical stimulation. Twitch. On individual heads of the quadriceps femoris muscle **(vastus** lateralis, **vastus medialis** and rectus femoris) a pair of electrodes was fixed, the anode to the distal part of the muscle, the cathode in the area of the motoric plates of the muscle. all muscles were simultaneously stimulated by equal stimulation parameters in all knee angles, positions: duration of impulse 0.3 ms and supramaximal amplitude. Only the **vastus** lateralis muscle was stimulated by a train of impulses. The length of the train was 0.8 s, the frequency 100 Hz, length of impulses 0.3 ms, the amplitude was twice the amplitude of the motoric threshold at individual impulse of length 0.3 ms. Electrodes size 5x5 cm (AXELGAARD, FALLBROOK, CA) and **four-**channel home-made electrical stimulator were used.

Data processing. Among the results of maximal values of torque in individual **knee** angles in individual modes of muscle activation (MVC, TW, TR), the one with a bigger maximal torque was used. Then a normalisation of individual variables was carried out on the results of the knee angle of 45 degrees, so that the presented values are relative.

RESULTS

Normalised results are presented in Figure 2. From the figure it is evident that the torque curves of maximal voluntary activation and twitch activation have similar courses, while the torque curve in activation by a train of electrical impulses is different. Torque values at activation, reached by maximal voluntary activation as well as by twitch activation, with an increase of the knee angle to above 45 degrees, are increasing while torque values at activation by a train of electrical impulses at first grow, above the knee angle of 60 degrees they begin to fall and at knee angle of 90 degrees reach only 60 % of the starting value. Results of all the subjects are in quality very similar to each other.

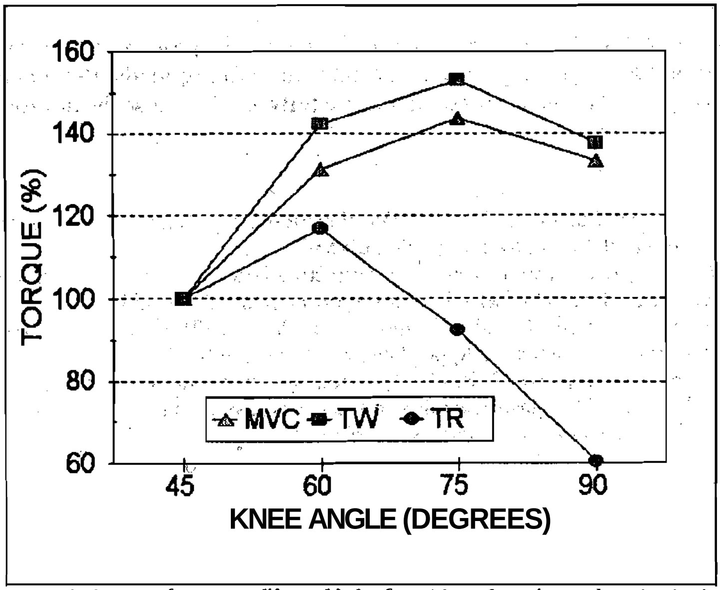

Figure 1 *Changes* of torque at diferent kinds of quadriceps femoris muscle activation in regard to the angle in the knee.

DISCUSSION

During maximal voluntary activation of the quadriceps femoris muscle all the motor units, mostly activated by tetanic frequency. ought to be in accordance with the Henneman size principle (Henneman et al., 1965). The quadriceps femoris muscle in completely activated by supramaximal twitches, when simultaneously all motor units should be activated at the same moment. Theoretically this method should enable the assessment of various torque changes as the result of the changes in the knee angle, as it ensures, in all angles, positions, maximal muscle activation. In voluntary activation a discrepancy could occur between maximal activation at various angles due to different inclusion of motor units, or rather, due to activation frequency. For the vastus lateralis muscle the train of electrical impulses was chosen because it is possible to ensure greater muscle strength with smaller currents, while for twitch contractions, relatively more powerful electrical currents are needed which could also simultaneously activate adjoining muscles. Because of this it was possible to use small amplitude in trains and by this achieve greater localisation of the electrical stimulation influence.

From the course of the curves where the quadriceps femoris muscle had been completely activated (MVC and TW) it can be seen that the normalised torque values are quite similar. The fact that individual muscles can deviate from the general trend can be seen from the course of the curve of the vastus lateralis muscle. We can conclude that the mechanical contributions of the vastus lateralis muscle in different knee angles, are different in regard to the complete quadriceps femoris muscle. A similar situation was found in stimulation of the triceps brachii muscle in arm extension (Strasset al.. 1991).

For elucidation of obtained results it would be necessary to perform additional analyses, especially from the viewpoint of knee-geometry and the actual size of activation of individual muscle heads of the quadriceps femoris in different knee angles.

CONCLUSION

If the method proved valid, it would be sound to include it in professional work in sport and rehabilitation due to its simplicity. Especially in defining loads, that depend on angles in the knee-joint. The method could successfully be used also in motion of other joints.

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