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# EARLY ADAPTATION OF M. QUADRICEPS FEMORIS VOLUNTARY ACTIVATION DURING REPEATED ASSESSMENT OF MAXIMUM VOLUNTARY ISOMETRIC STRENGTH

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## SUMMARY

This study is carried out to investigate early adaptational effects of repeated maximum voluntary isometric contractions (MVCs). Therefore a treatment and a control group performed m. quadriceps femoris MVCs on four different days in order to determine isometric strength and voluntary activation. Additional maximum eccentric contractions served to assess eccentric strength, which is associated with inhibition and/or the ability to voluntarily activate a muscle.

From the first to the last session, first preliminary data showed an increase in isometric strength as well as in voluntary activation (VA). While VA of the treatment QF increased by 4.14%, VA of the control QF increased by 3.0%. Accordingly early adaptations to repeated MVCs appear to be due to learning and/or neural plasticity. In contrast, eccentric strength showed non-systematic behavior and failed to markedly exceed isometric strength during all the four sessions. Although absent eccentric force enhancement has been reported earlier, such force enhancement has also been shown to increase with training since the latter is thought to reduce stretch induced inhibition. However, to strengthen these first preliminary results additional data has to be collected.

## INTRODUCTION

MVCs serve as a measurement to assess maximum strength as well as to investigate neuromuscular biomechanics. However, literature showed that during MCVs voluntary activation of m. quadriceps femoris (QF) as determined by interpolated twitch technique (ITT) [1] only reaches 85% to 95% [2-4]. Therefore the first question arising is, if MVCs are a suitable tool to assess muscular strength. Second, when investigating neuromuscular biomechanics by MVCs some studies did several preceding familiarization sessions, while others did not. Due to this, results might be confounded and difficult to interpret as evidence regarding putative muscular properties. Thus, the aim of the current study was to investigate the effect of repeated measurements of MVCs on voluntary activation, isometric and eccentric strength of QF.

## METHODS

During a 2 week period subjects attended the lab on four different occasions separated by at least two days. While the right QF was tested in all the four sessions, the left QF was tested in session one and four only and served as a measure of contralateral transfer. Further the left QF of a control group was tested in sessions one and four in order to distinguish between contralateral transfer and learning and/or adaptation caused by the first session.

For the assessment of maximum isometric strength and voluntary activation, subjects had to perform maximum voluntary isometric knee extensions at 60° knee flexion angle. Voluntary activation was determined using ITT according to van Leeuwen *et al.* [2] by applying a submaximal superimposed twitch during MVCs. Intensity for stimulation was adjusted to result in 50% of the potentiated resting twitch obtained for maximal stimulation. Electrical stimulation over the muscle belly was delivered as a doublet current pulse (100 Hz) of 200 µs duration by a constant-current stimulator (DS7AH, Digitimer Ltd, UK). Current passed from a proximal electrode (7.5 x 13 cm, ValuTrode, Axelgaard, Denmark) placed slightly lateral over the QF to a distal electrode of the same size positioned over the QF muscle belly just above the patella. Maximum eccentric strength was also obtained at 60° knee flexion angle during a maximum voluntary lengthening contraction from 45° to 75° knee flexion at an angular velocity of $60°s^{-1}$. To ensure a high level of voluntary activation the dynamometer-driven lengthening only started when subjects reached 95% of their maximum isometric strength. Both, isometric and eccentric strength were measured by an isokinetic dynamometer (IsoMed2000, D&R Ferstl GmbH, Germany).

After a brief warm-up, subjects were placed on the dynamometer's seat with their right or left shank strapped to the dynamometer's lever arm. Knee joint axis and the rotation axis of the dynamometer were aligned carefully and subjects were secured by safety belts and shoulder pads to prevent unwanted movement during the contractions. Then, potentiated twitches with increasing stimulation intensity were obtained until the torque response leveled off. Subsequently, stimulation current was reduced to produce a torque response of 50% of the maximum potentiated twitch. Following that, subjects performed two MVCs at 45° knee flexion to determine 95% of their angle specific maximum torque, which was set as a trigger to start the lengthening contractions. The test contractions included three isometric and three eccentric MVCs. During and two seconds after each isometric MVCs, superimposed doublets and potentiated resting twitches were delivered to the muscle. There was no stimulation during the eccentric MVCs. Test contractions were performed in a randomized order and a rest of at least 3 min was enforced between contractions.

Maximum isometric torque was taken at the onset of stimulation and corrected for passive torque produced by the weight of shank and foot. Superimposed twitches were calculated as the difference between peak torque during the twitch and maximum isometric torque and resting twitches were calculated as the difference between peak torque during the resting twitch and passive torque. Voluntary activation is then given as (1-(superimposed twitch/resting twitch))*100. Maximum eccentric torque was analyzed as the angle specific torque during lengthening when the lever arm passed 60° knee flexion.

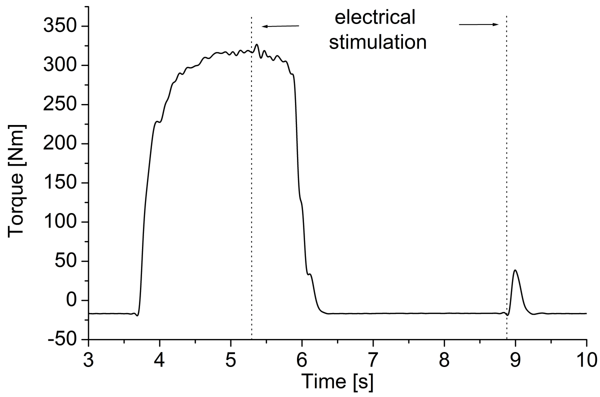


**Figure 1**: Exemplar torque-time-trace with superimposed and resting twitches evoked by submaximal doublets.

**RESULTS AND DISCUSSION**

Since this is an ongoing study the results presented are based on preliminary data of the treatment group only (n = 3). From the first to the last session isometric strength of the right QF slightly increased from 294±23 Nm to 305±68 Nm, while voluntary activation (VA) increased from 76.1±6.2 % to 80.2±3.6 %. However, the preliminary data showed some variability with individual correlations between isometric strength and VA ranging between r = 0.5 and r = 0.95. From the first to the last session MVC strength of the left control QF increased from 262±17 Nm to 297±30 Nm, whereas VA increased from 69.1±2.4 % to 72.1±9.0%. Eccentric strength of the right and left QF hardly exceeded isometric strength, and showed non-systematic inter-session changes between 1.01±0.09 and 1.08±0.16 of the corresponding maximum isometric torque.

Due to the early stage of the ongoing experiments and the limited number of subjects, the preliminary results have to be interpreted with caution. Despite the expected observation of an increase in isometric strength and in VA of the test QF, differences in VA between sessions one and four have been relatively small (4.14%). Also in comparison to former studies on VA of QF, the level of VA as found for our first subjects was somewhat lower than reported earlier (range 71.2% - 93.4%). According to the test protocol, this might partly be due to the submaximal stimulation via the muscle belly instead of supramaximal nerve stimulation. The 3% increase in VA of the left control QF points towards early adaptations in neural function caused by repeated performance of MVCs.

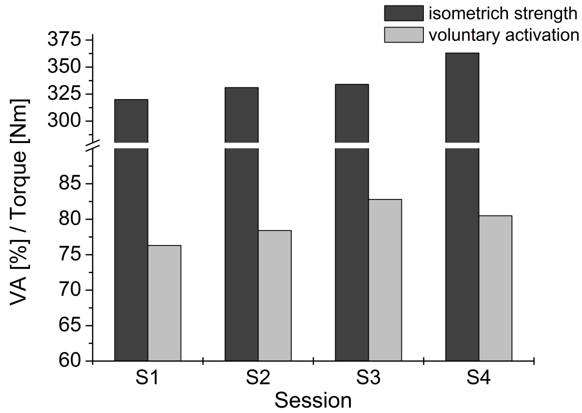


**Figure 2**: Exemplar data (n = 1) showing right QF isometric strength and voluntary activation from sessions one to four.

In contrast to our expectations, eccentric strength neither exceeded maximum isometric strength nor did the ratio eccentric/isometric strength increase from sessions one to four. Although absent eccentric force potentiation of QF is associated with neural inhibition and has been reported earlier, there is also data showing eccentric forces of QF exceeding isometric MVCs by approximately 20-30%. Since this was especially true when eccentric contractions started from high preloads as done in the current study, this is somewhat surprising. Previous studies have further shown that training may lead to downregulation of inhibitory pathways. However, our tentative results did not reflect such an adaptation.

**CONCLUSIONS**

This study is designed to investigate the effects of repeated performance of MVCs on voluntary activation and eccentric strength of QF. First results showed an increase in isometric strength and VA, which however was relatively small. Eccentric strength hardly exceeded isometric MVCs not either after four test sessions. According to the changes observed for the control QF, the early adaptation described above might be due to neural plasticity. However, more data has to be collected.

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