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Strength increases from the motor program: comparison of training with maximal voluntary and imagined muscle contractions

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1. This study addressed potential neural mechanisms of the strength increase that occur before muscle hypertrophy. In particular we examined whether such strength increases may result from training-induced changes in voluntary motor programs. We compared the maximal voluntary force production after a training program of repetitive maximal isometric muscle contractions with force output after a training program that did not involve repetitive activation of muscle; that is, after mental training.
2. Subjects trained their left hypothenar muscles for 4 wk, five sessions per week. One group produced repeated maximal isometric contractions of the abductor muscles of the fifth digit's metacarpophalangeal joint. A second group imagined producing these same, effortful isometric contractions. A third group did not train their fifth digit. Maximal abduction force, flexion/extension force and electrically evoked twitch force (abduction) of the fifth digit were measured along with maximal integrated electromyograms (EMG) of the hypothenar muscles from both hands before and aftertraining.
3. Average abduction force of the left fifth digit increased 22% for the Imagining group and 30% for the Contraction group. The mean increase for the Control group was 3.7%.
4. The maximal abduction force of the right (untrained) fifth digit increased significantly in both the Imagining and Contraction groups after training (10 and 14%, respectively), but not in the Control group (2.3%). These results are consistent with previous studies of training effects on contralateral limbs.
5. The abduction twitch force evoked by supramaximal electrical stimulations of the ulna nerve was unchanged in all three groups after training, consistent with an absence of muscle hypertrophy. The maximal force of the left great toe extensors for individual subjects remained unchanged after training, which argues against strength increases due to general increases in effort level. 6. Increases in abduction and flexion forces of the fifth digit were poorly correlated in subjects of both training groups. The fifth **finger** abduction force and the hypothenar integrated EMG increases were not well correlated in these subjects either. Together these results indicate that training-induced changes of synergist and antagonist muscle activation patterns may have contributed to force increases in some of the subjects.
7. Strength increases can be achieved without repeated muscle activation. These force gains appear to result from practice effects on central motor programming/planning. The results of these experiments add to existing evidence for the neural origin of strength increases that occur before muscle hypertrophy.