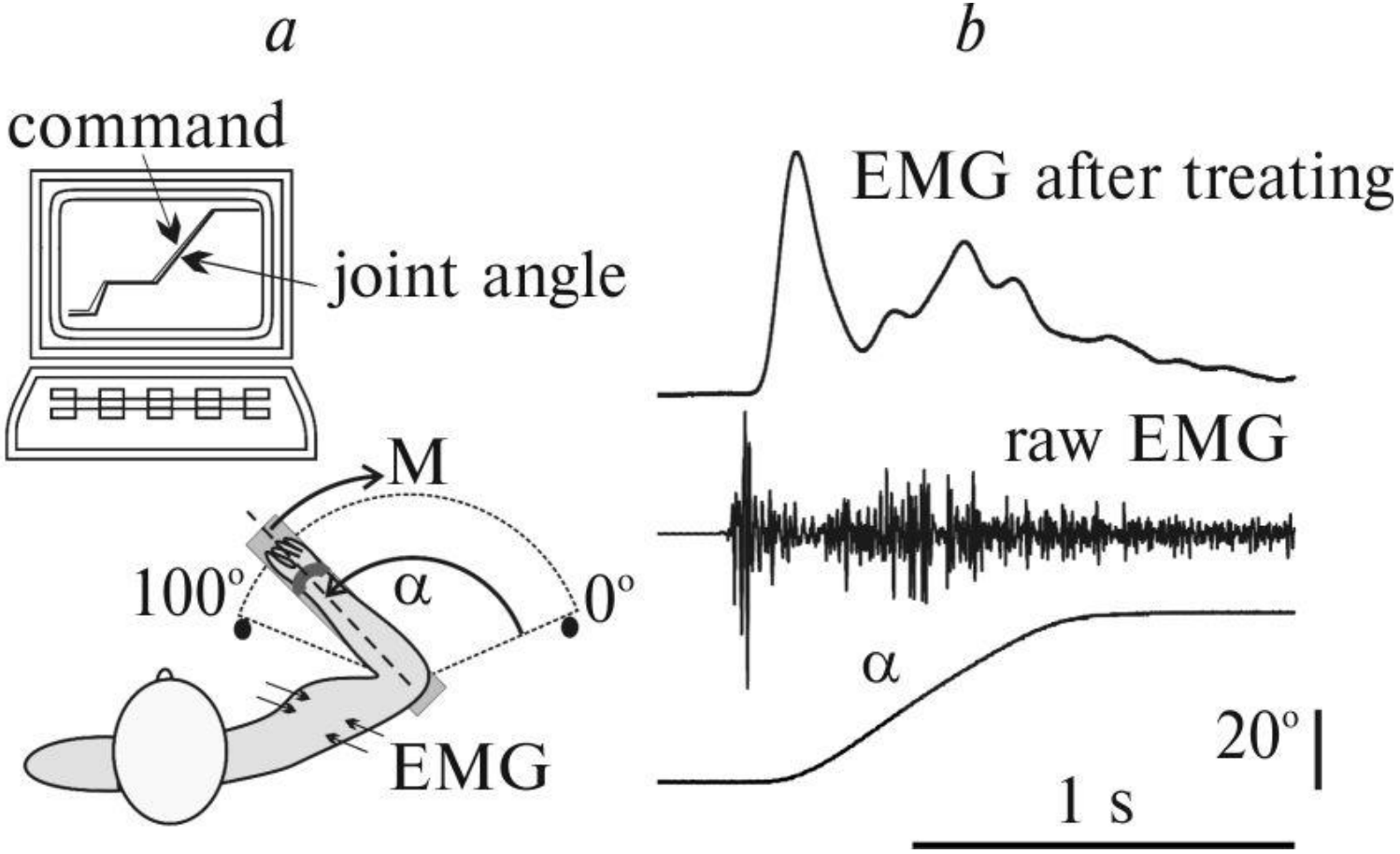
SINGLE- AND TWO-JOINT MOVEMENTS IN HUMANS

BASIC PRINCIPLES OF THE MOVEMENT ANALYSIS

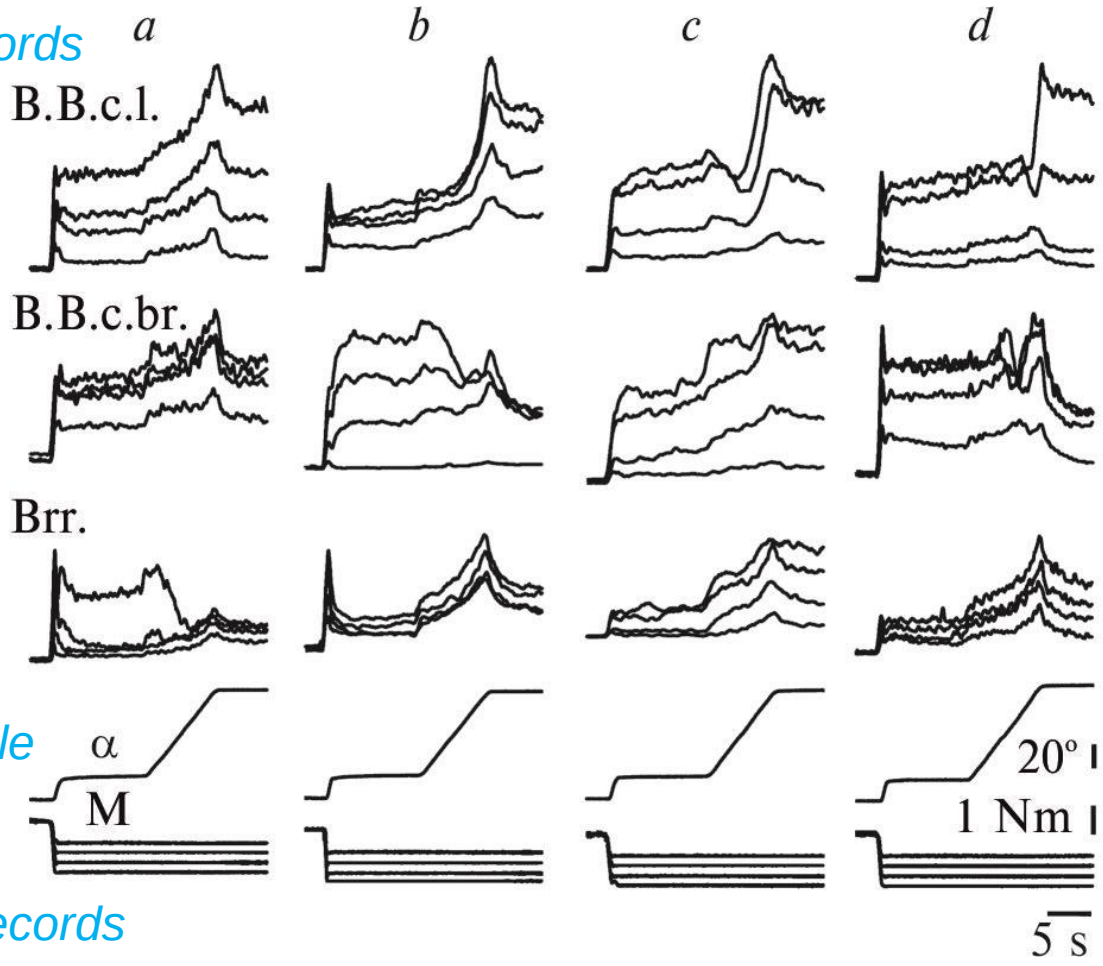


METHODS OF THE MOVEMENT ANALYSIS

EMGs are recorded by pairs of the surface electrodes with center to center distance 25 mm; the electrodes are fixed on the subject's skin over the muscles' bellies. Activity The recorded muscle activity is amplified by multichannel amplifier with using bandpass filter in the range 10 - 5000 Hz. The EMGs together with position signals is collected the data acquisition system; the EMGs and position signals are digitized at 10.0 and 2.0 kHz, respectively. EMG records are full-wave rectified and filtered (Batterworth filter, bandpass 50-500 Hz) in off-line regimen; this procedure introduced a phase lag in respect to the real changes of the EMG intensity near 130-150 ms. All tests are repeated 10 times for averaging the corresponding records. Before each experiment, the maximal voluntary contractions (MVCs) of all muscles are registered to normalize of the averaged EMG records in the percentage of MVC. When necessary, the averaged trajectories of movement were additionally underwent to the procedure of numerical differentiation for obtaining the velocity and acceleration of movement.

EMGs IN THE ELBOW FLEXORS DURING FLEXION MOVEMENTS

averaged EMG records



joint angle records

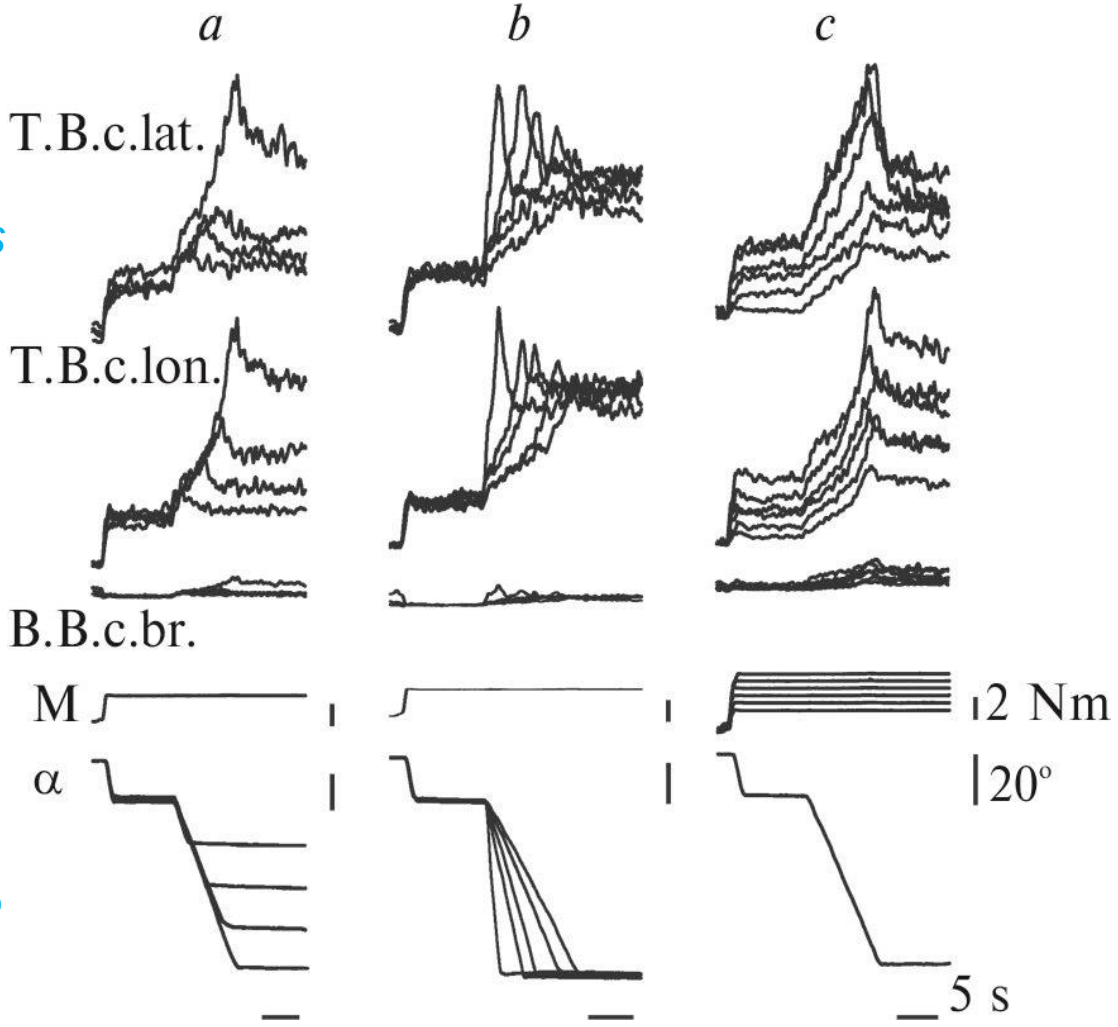
torque records

EMGs IN THE ELBOW EXTENSORS DURING EXTENSION MOVEMENTS

averaged EMG records

torque records

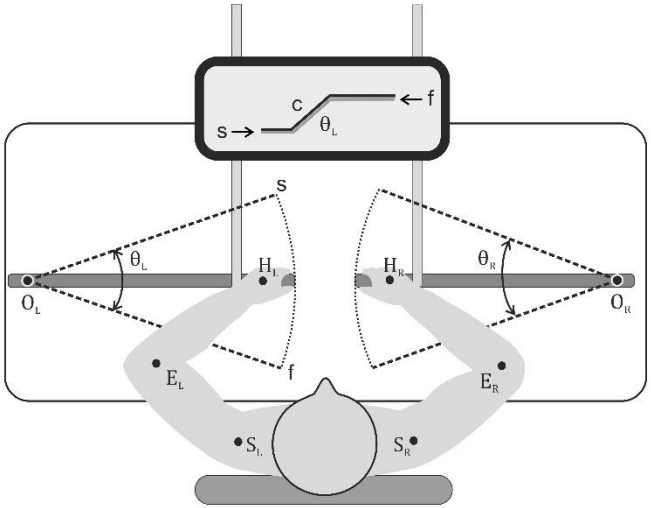
joint angle records



RESULTS OF ANALYSIS OF THE SINGLE-JOINT MOVEMENTS

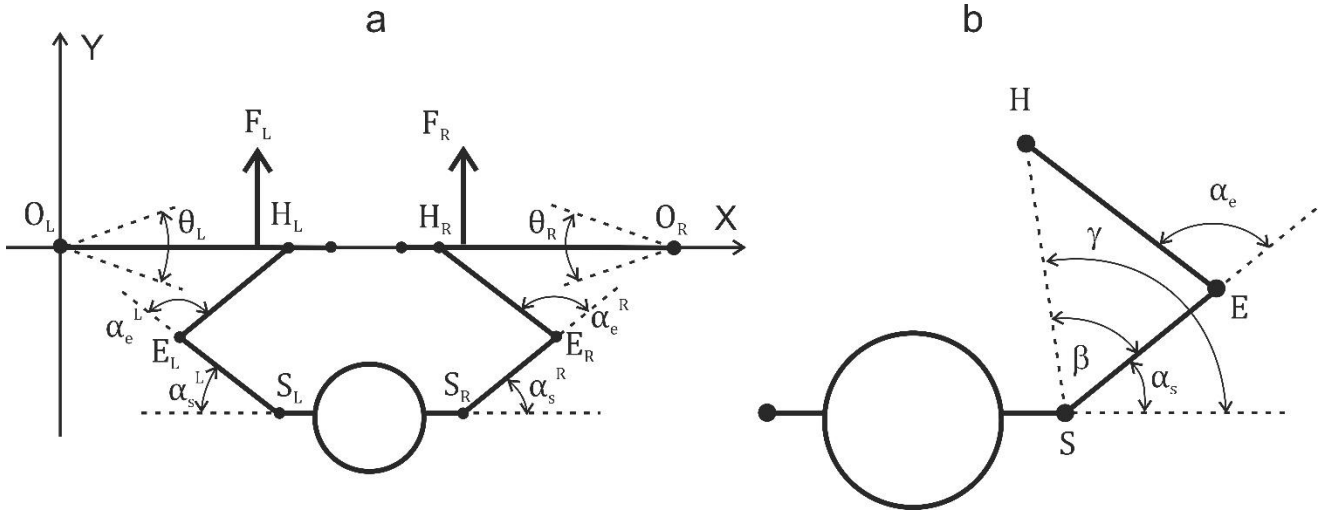
The simplest class of movements by contraction of agonists in the absence of the antagonist activation, a specific role should be attributed to the dynamic phase of the efferent activity, during which CNS must generate rather complex efferent commands to muscles. The presence of noticeable non-monotonous components in the EMGs of the elbow flexors is probably connected with their biomechanical arrangement within the joint. The non-monotonous components were not registered in the EMGs of the elbow extensors during fulfillment produced of similar movements in extension direction.

TWO-JOINT BIMANUAL MOVEMENTS

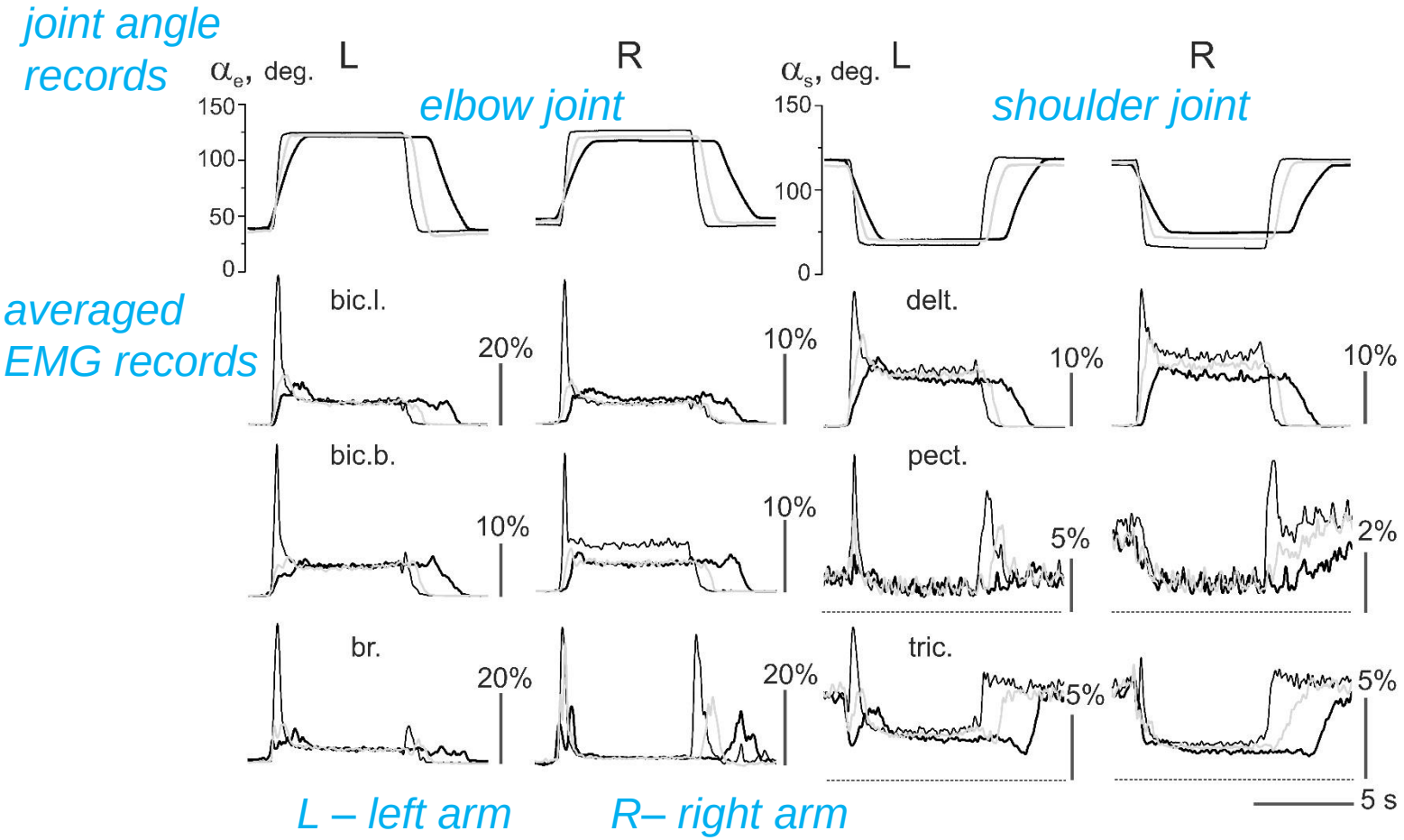


experimental setup

analysis



EMGs IN TWO-JOINT BIMANUAL MOVEMENTS

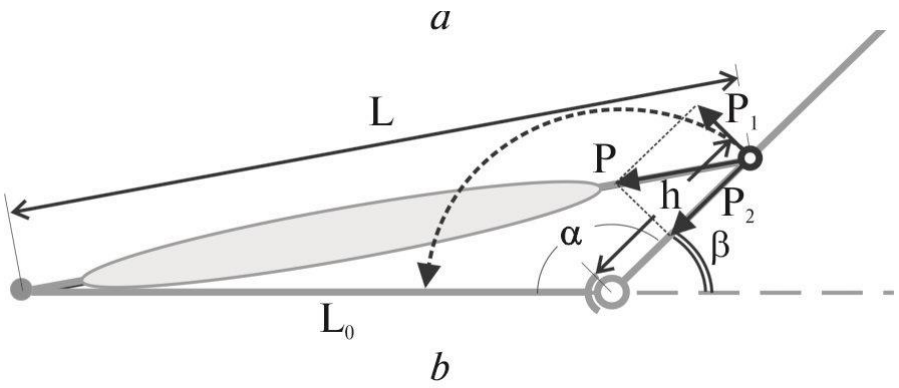


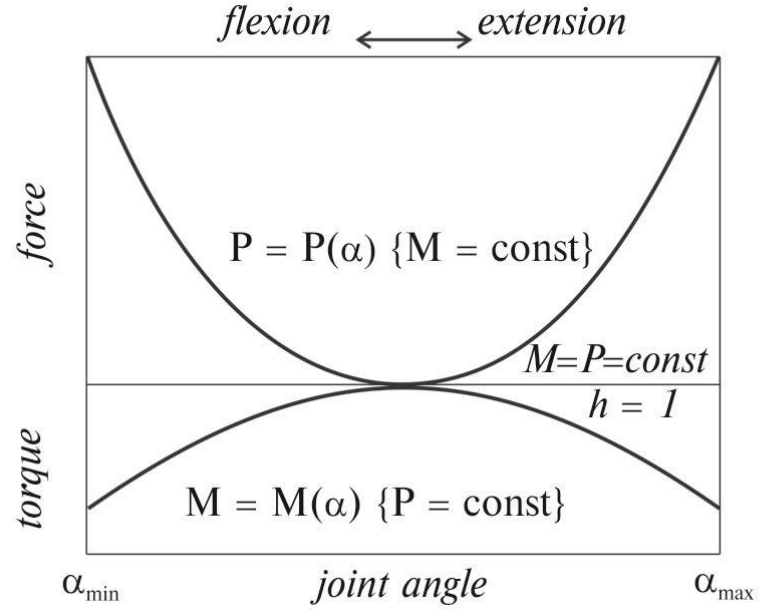
The averaged joint angle trajectories and averaged EMGs recorded from identical muscles at left (L) and right (R) subject's arms during test movements. Two rubber bands were used at each side for loading the test movements; Calibration of EMGs is given in % of MVC.

RESULTS OF ANALYSIS OF THE TWO- JOINT MOVEMENTS

During two-joint bimanual movements, the muscles under study can be divided into two synergic groups in accordance of their predominant actions: flexion of the elbow joint and extension of the shoulder one (1); extension of the elbow joint and extension of the shoulder one (2). The muscles of the first group generated noticeable velocity-dependent dynamic EMG components during the pull and push movements and supported a steady-state activity at the hold phase. The muscles of the second group co-contracted with the first group at the movement phases and lowered activity at the hold phase. In both muscle groups the dynamic components of EMGs strongly depend on velocity factor, while side and load factors as well as combinations of various factors acted only in the of the first group muscles. The extent of the EMG variability changed in various subjects that could signify that the same movements are governing by central commands with differing redistribution of activities between muscles; this redistribution may likely diminish the fatigue effects in repeated movement tasks.

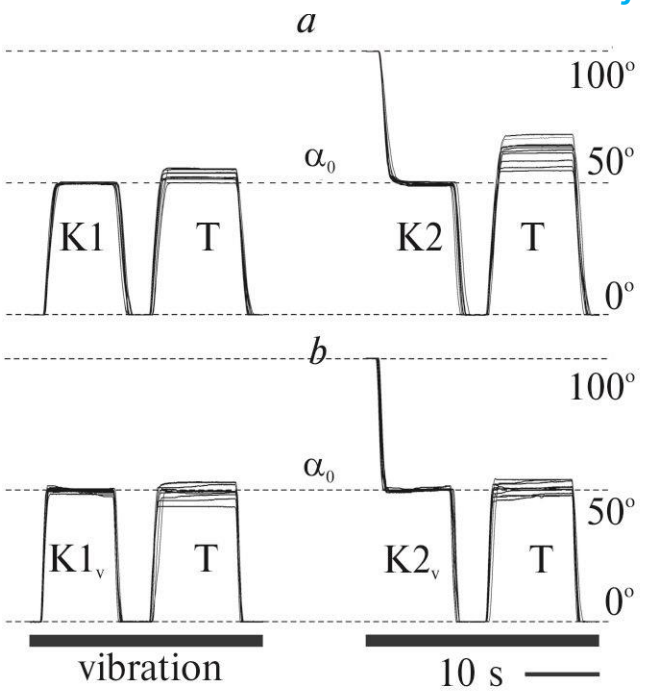
NONLINEAR EFFECTS CONNECTED WITH GEOMETRY OF THE MUSCLE ARRANGEMENT

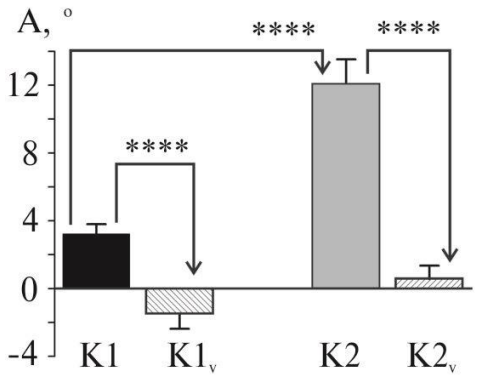


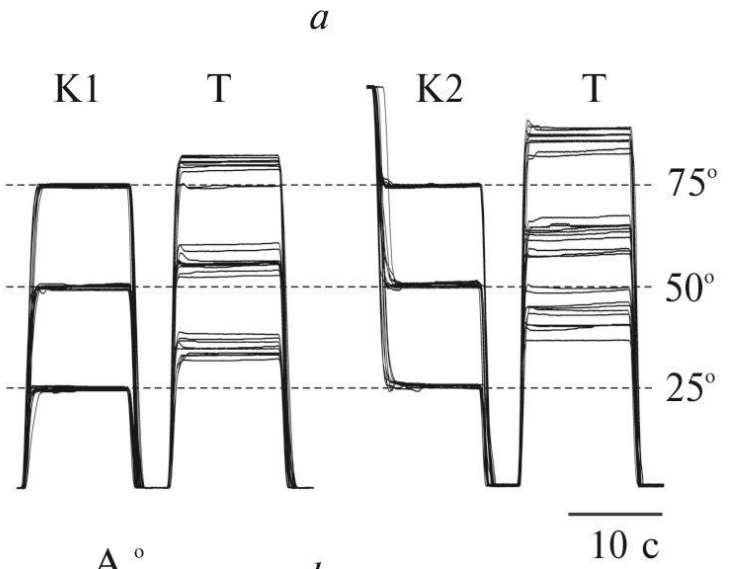


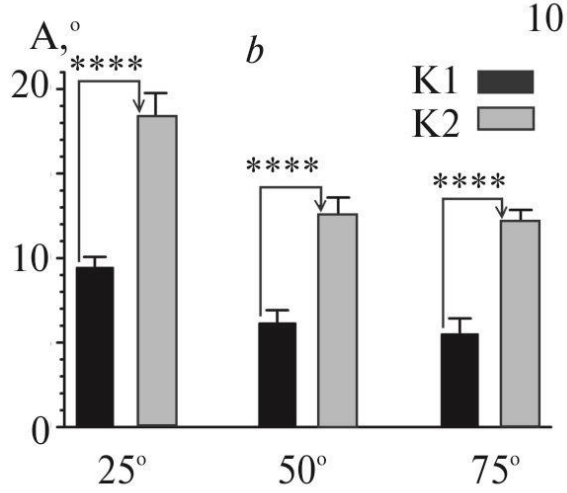
POSITION ERRORS DEPENDING ON THE MOVEMENT AFTER-EFFECTS

joint angle records









ANALYSIS OF THE POSITION ERRORS

Possible involvement of proprioceptive activity into the erroneous positioning can be considered as follows. When directions of the tested and conditioned movements coincide, a subject take a decision to stop a movement to the target, basing on a close similarity in patterns of the proprioceptive signals in these movements, the positioning errors are not significant. In oppositely directed movements to the target, the proprioceptive signals can be essentially different. The positioning errors were higher in both "flexion" and "extension" test movements when the direction of movement to the target had changed during transition from the conditioned to the tested movements.

REVIEW QUESTIONS

- Explain role of the dynamic phase of the efferent activity for execution of the single-joint transition movements.
- What is a reason for appearance of the non-monotonous components in the EMGs of the elbow flexors during flexion movements?
- Why the EMG patterns are different for flexor and extensor muscles during linear transition movements?
- Describe nonlinear effects connected with geometry of the muscle arrangement within a joint.
- Describe method of the EMG signal processing used for analysis of the movements in humans.