Indian J Physiol Pharmacol 2006; 50 (3) : 319–321

LETTER TO THE EDITOR

A STUDY OF FATIGUING ISOMETRIC CONTRACTIONS OF THE HUMAN FIRST DORSAL INTEROSSEOUS MUSCLE

Sir,

(Received on March 14, 2006)

Surface electromyogram (EMG) from muscles undergoing sustained isometric voluntary contractions has been well studied. Power spectral analysis of the myoelectric signals so obtained, characteristically shows a time dependant shift of the mean power frequency to lower frequencies, as the contraction proceeds (1). Such a compression of the EMG power spectrum to lower frequencies has been considered as an index of localized muscle fatigue (2) and has been attributed mainly to a decrease in the muscle fibre conduction velocity (3). This study was done to quantify the changes in the EMG of the first dorsal interosseous (FDI) muscle during fatiguing contractions in a small group of the Indian population.

Eight subjects (5 males and 3 females) aged 18 to 27 years participated in the study following a written informed consent. All were right handed, healthy volunteers with no known history of neuromuscular disease. Subjects were not selected based on their physical condition or level of exercise of the hand as with piano training. All the subjects were made familiar with the experimental procedure, and had practice sessions before actual recordings. The temperature of the room was between 27–32°C during all test sessions.

Static isometric contraction of the FDI of the dominant hand was performed to exhaustion, by abducting the index finger against a force transducer (Grass Instruments Ltd.), kept firmly fixed on a board, at 50% of the maximal voluntary contraction (MVC). Muscle force was amplified and acquired on a personal computer (PC). The signal was also displayed on the moving chart paper of a physiograph by means of a pen recorder. The MVC was taken as the largest of the peak forces produced by three brief (3 second duration), maximal contractions of the FDI muscle, at intervals of 1 minute. The contraction at 50% MVC was done 20–30 min after recording the MVC. Visual feedback was given to the subjects to maintain force at 50% MVC by means of a predetermined line (calculated from the MVC) drawn on the moving chart paper of the physiograph and the sustained contraction was maintained by them without any verbal encouragement. The contraction was terminated when the subject felt that the force could no longer be maintained at the required level. The duration of contraction was noted from the recordings.

The surface EMG picked up by 2 circular silver disc electrodes (1 cm diameter) placed 2 cm apart on the FDI, was amplified, digitized, displayed and stored on the PC. The raw EMG was bandpass filtered between 20 Hz and 500 Hz. A custom software was used to compute the *Mean frequency* of the EMG by spectral analysis using an 8 second moving window of the EMG. The mean frequency values at the first 8 sec (T_0) of contraction, at 1 min of contraction ($T_{1\,min}$), at mid-point of contraction (T_{mid}) and at end of contraction (T_{end}) were noted. Percentage changes of mean frequency of EMG from the value at time T_0 were calculated and fed into an SPSS package for repeated measures analysis of variance followed by post hoc Bonferroni test. Probability values of $P<0.05$ were considered statistically significant. Percent changes were used, rather than absolute values, when pooling data from all subjects, as the latter depend on a number of factors like electrode orientation and spacing.

Table I presents the main results of all parameters measured in all subjects. Mean force developed during contraction of FDI at 50% MVC was 8 ± 0.61 (mean ± SEM) Newton and the average duration of contraction to fatigue was 5.08 ± 0.755 (mean ± SEM) min. The power spectrum of the EMG showed a general shift of the mean power frequency to lower frequencies as contraction progressed, which became significantly lower at time T_{end} from that at time T_0 (Fig. 1).

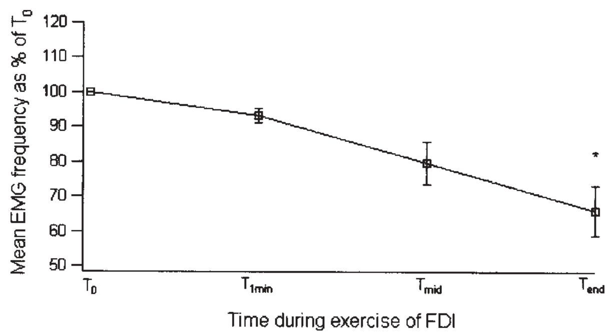

Fig. 1 : T_0, initial 8 sec of contraction; $T_{1\,min}$, at 1 min of contraction; T_{mid}, at mid point of contraction; T_{end}, at end of contraction. Data points are mean±SEM, (n=8).
*Significantly different from T_0, $P<0.05$.

The FDI muscle is constituted by low threshold and high threshold motor units which are reported to be fatigue resistant and fatigue susceptible respectively (4). Nearly all the motor units of the FDI are known to be activated at 50% MVC (5). The shift in the power spectrum of EMG to lower frequencies is believed to be due to fatigue selectively of the fast twitch, type II muscle fibres (6). The results of our study done in an Indian population corroborate the findings of previous studies done in the western population. We found a significant shift in the mean power frequency of the EMG of the FDI muscle to lower frequencies, at the point of fatigue, during static

TABLE I : Force in Newton (N) at 50% maximal voluntary contraction (MVC), duration of contraction, spectral parameters in hertz (Hz) and percent shift in mean frequency at T_{end}, for all subjects.

Subject	*50% MVC N*	*Duration Min*	*Spectral parameters (Hz)*				*% shift at T_{end}*
			T_0	*$T_{1\,min}$*	*T_{mid}*	*T_{end}*	
DJ	9.8	3.7	114.4	108	101.8	79.1	30.9
BP	5.39	3.9	148.5	135.9	112.1	74.7	49.7
BJD	7.35	6	67.8	60.6	46.6	39.8	41.3
SDB	7.96	5.2	182.4	157.8	130.9	69.8	61.7
SR	10.4	4.7	129.0	125.0	116.2	108.4	16
KD	9.19	3.7	101.3	100.8	96.4	83.1	18.0
BKC	7.35	3.5	108.9	110.2	106.7	105.6	3
RC	6.43	9.9	127.8	108.4	59.8	63.2	50.5

T_0, $T_{1\,min}$, T_{mid} and T_{end} are the mean frequencies within the initial 8 sec of contraction, at 1 min of contraction, at mid-point and at end of contraction respectively.

isometric contractions of the FDI muscle.

A limitation of the study was that it was not possible to document that each subject had reached the same degree of muscle fatigue at cessation of muscle contraction. In one of the subjects (BKC) the shift in the mean power frequency to lower level at T_{end} was comparatively less. This could be attributable to the presence of only minimal localised fatigue of the subject's FDI muscle at termination of contraction which may be explained by the fact that factors like motivation are difficult to control. A repeated recording done in the same subject gave a mean frequency value of 76.5 Hz at T_0 which increased to a value of 106 Hz at $T_{1\,min}$ and subsequently fell to a value of 97.4 Hz at T_{mid} and 76.7 Hz at T_{end}. We are unable to explain this unusual observation of a lower value of mean power frequency at the beginning of contraction. The recorded EMG did not have any noise and the probability of involvement of EMG picked up from other muscles was ruled out by further experiments.

Similar studies done to electrically and mechanically characterise the contractions of the FDI muscle in different groups of people, whose hand muscles have been trained differently as a result of their occupation, would be interesting. It could throw light on the nature of the training effects produced by the occupation and its influence on the fibre type distribution in the FDI muscle. Greater compression of the mean power frequency has been reported in individuals with a higher proportion of type II muscle fibres (7). Would the duration of contraction to exhaustion be longer and the compression of mean frequency of EMG be lesser, in painters, typists and embroidery workers than in manual labourers ? Answers to these questions could find application in ergonomics and work physiology.

ACKNOWLEDGEMENTS

The guidance given by Dr. J. Prakasa Rao and the Department of Bioengineering, CMC, Vellore are gratefully acknowledged.

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