

Motor unit discharge properties of respiratory muscles during quiet breathing

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The diaphragm is considered the principal muscle of inspiration. However, many other muscles have an inspiratory action with different mechanical linkages to the rib cage. In this study we compared the discharge properties of single motor units in a range of “obligatory” human inspiratory muscles to quantify the distribution of inspiratory neural drive to each of the inspiratory motoneurone pools during quiet tidal breathing.

Studies were performed on 5 healthy volunteer subjects who sat comfortably in an upright chair while breathing through a mouth piece. We recorded single motor unit activity from five separate inspiratory muscles; diaphragm, scalenes, parasternal intercostals, dorsal external intercostals (third space) and dorsal external intercostals (fifth space), during normal quiet breathing (e.g. Gandevia *et al.*, 1999; De Troyer *et al.*, 2003). Electromyography recordings were made from 10 sites within each muscle using monopolar needle electrodes. Each of the muscles were studied on separate occasions. Before each measurement, the thicknesses of the musculature at the sites of intramuscular electrode insertion were assessed using ultrasonography (e.g. De Troyer *et al.*, 1997). Data were sampled and analysed through a commercially available spike-analysis system. Measurements were made of the onset and peak discharge properties of single motor units, and inspiratory flow and were averaged over three breaths.

In total, we recorded from 260 single motor units. The data (mean \pm SEM) are summarised in the Table below.

Muscles	Diaphragm	Scalenes	Parasternal intercostal	Dorsal external intercostal (3 rd Space)	Dorsal external intercostal (5 th Space)
No. of units	40	57	63	66	34
Onset time (ms)*	377 \pm 62	421 \pm 73	666 \pm 50	637 \pm 61	1119 \pm 129
Onset time %**	21.7 \pm 3.3	21.0 \pm 3.4	31.6 \pm 2.4	30.4 \pm 2.2	41.7 \pm 3.8
Onset frequency (Hz)	8.0 \pm 0.3	5.9 \pm 0.2	7.0 \pm 0.6	7.9 \pm 0.6	5.9 \pm 0.2
Frequency peak (Hz)	12.6 \pm 0.5	9.1 \pm 0.3	11.8 \pm 0.3	12.4 \pm 0.4	10.2 \pm 0.4

* defined as the time after onset of inspiratory flow.

** defined as onset time relative to total inspiratory time.

The results suggest that there is relatively early recruitment of the diaphragm and scalene muscles. The diaphragm and dorsal external intercostal muscles (third space) had the highest initial ($P<0.05$) and peak firing frequencies ($P<0.01$). The data describe for the first time the discharge properties of inspiratory motoneurons from a range of human inspiratory muscles during quiet breathing. It is likely that there is a non-uniform output from the different inspiratory motoneurone pools during quiet tidal breathing.

De Troyer, A., Leeper, J.B., McKenzie, D. K. & Gandevia, S.C. (1997) *American Journal of Respiratory Critical Care Medicine*, **155**, 1335-1340.

De Troyer, A., Gorman, R. B. & Gandevia, S. C. (2003) *Journal of Physiology*, **546**, 943-954.

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