Neural drive to the diaphragm in cervical spinal cord injury

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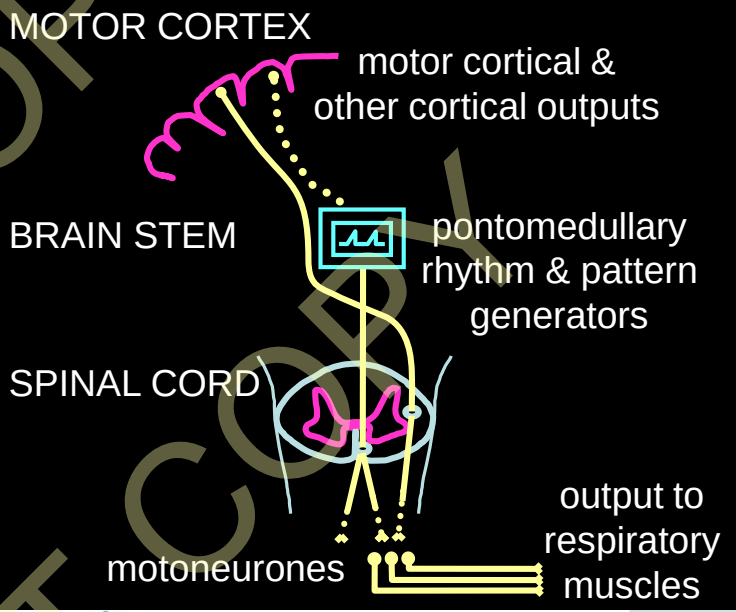
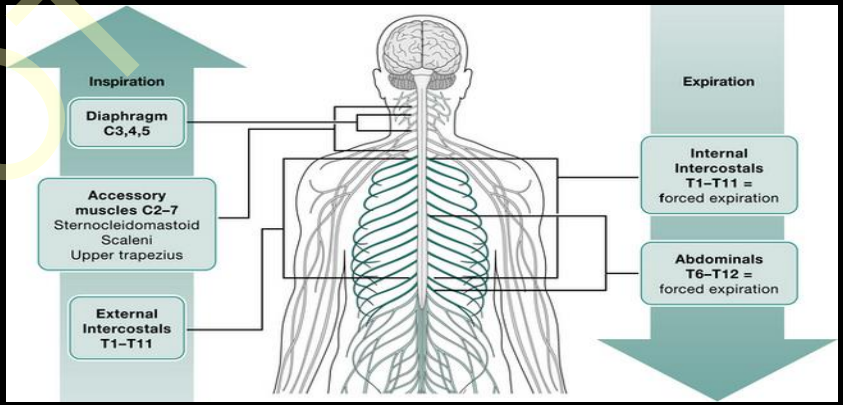
Background

- Neural control of breathing
- Spinal innervation of the respiratory muscles
  - Diaphragm (C3-C5)
- Cervical spinal cord injury
  - Partial paralysis of diaphragm
  - Reduced inspiratory capacity
  - Increased neural drive following unilateral cervical spinal cord contusion in rodents (Rana *et al.,* 2016)





Aims & Hypotheses

- **Determine if there are changes in discharge properties of diaphragm motor units in people with tetraplegia**
  - Increase in motor unit output
- **Determine if there are neurogenic changes in diaphragm motor units in people with tetraplegia**
  - Larger motor unit potentials

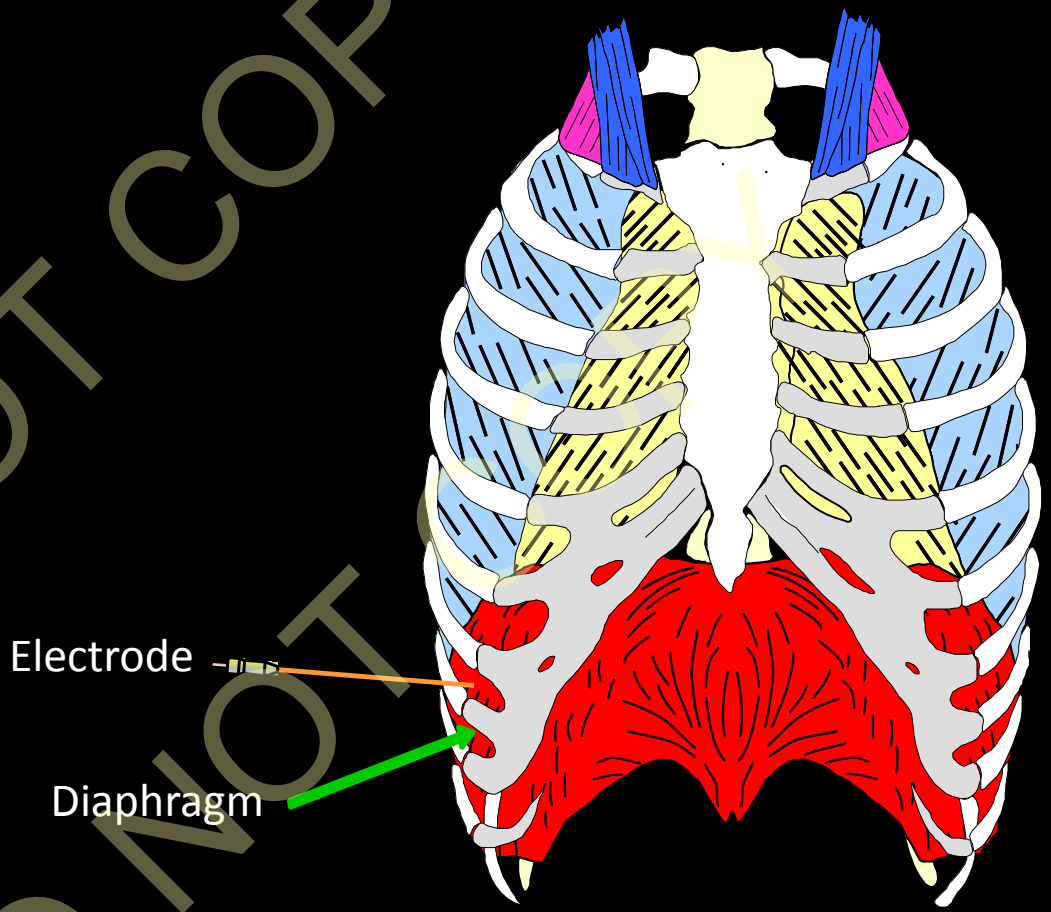
Methods

Participants:

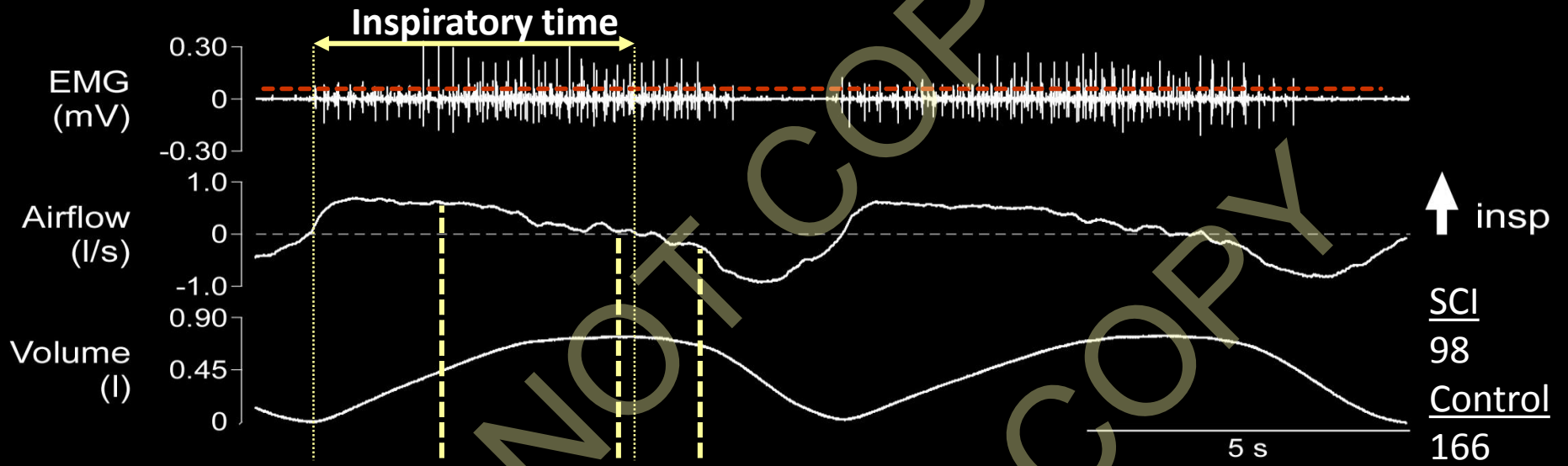
- Tetraplegia
  - n = 6
  - Aged 59 ± 10 years (mean ± SD)
  - BMI 25 ± 2 kg/m^2
  - C3-C6, AIS A-C, chronic
  - MIP: 46 ± 15 cmH_2O
- Able-bodied controls
  - n = 6
  - Aged 59 ± 14 years
  - BMI 26 ± 2 kg/m^2
  - MIP: 104 ± 34 cmH_2O

Recording:

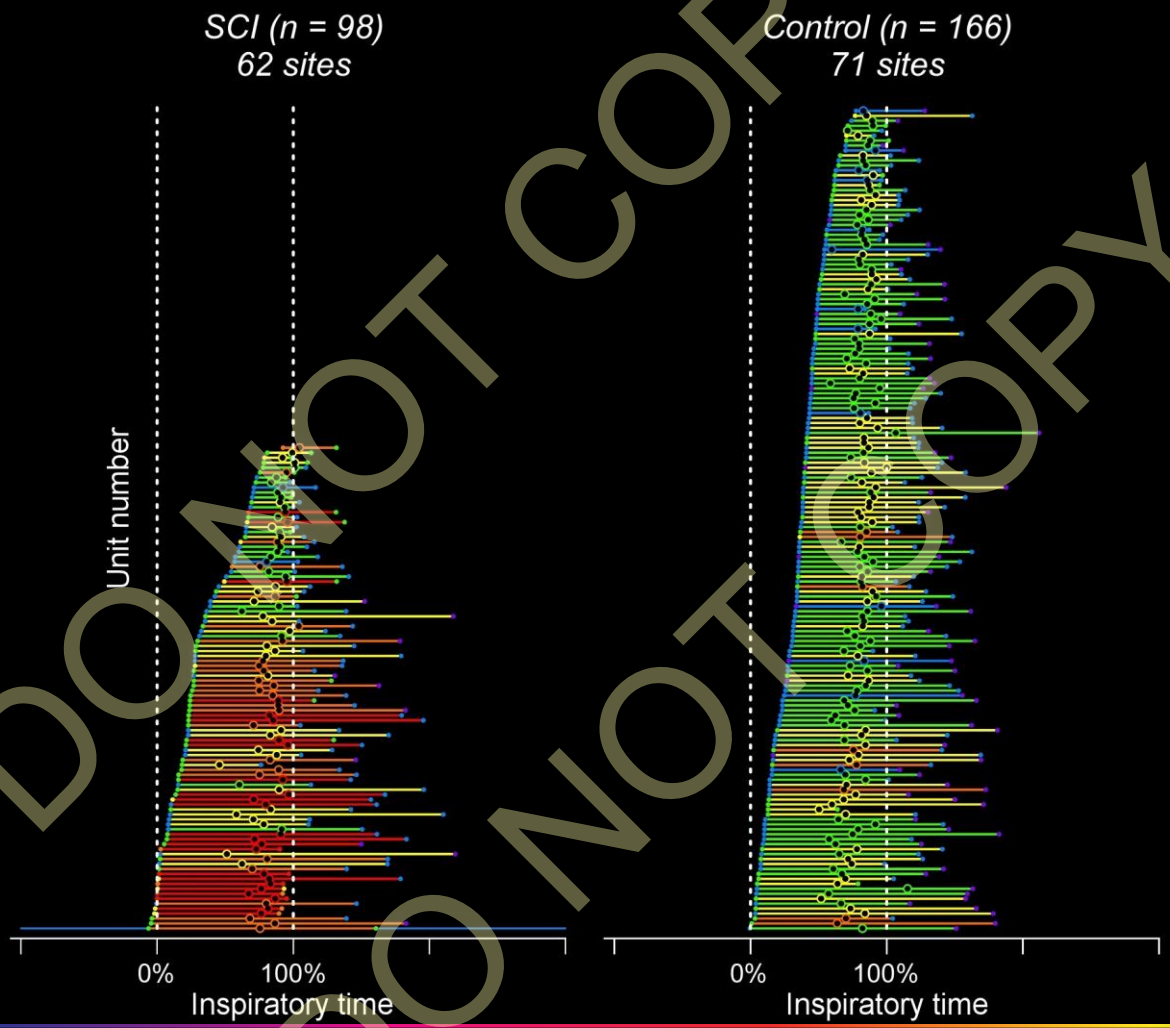
- Seated and during quiet breathing
- Ultrasound imaging
- Intramuscular EMG electrode



Motor unit extraction from a participant with tetraplegia



Time & Frequency Plots



Motor Unit Frequencies & Times

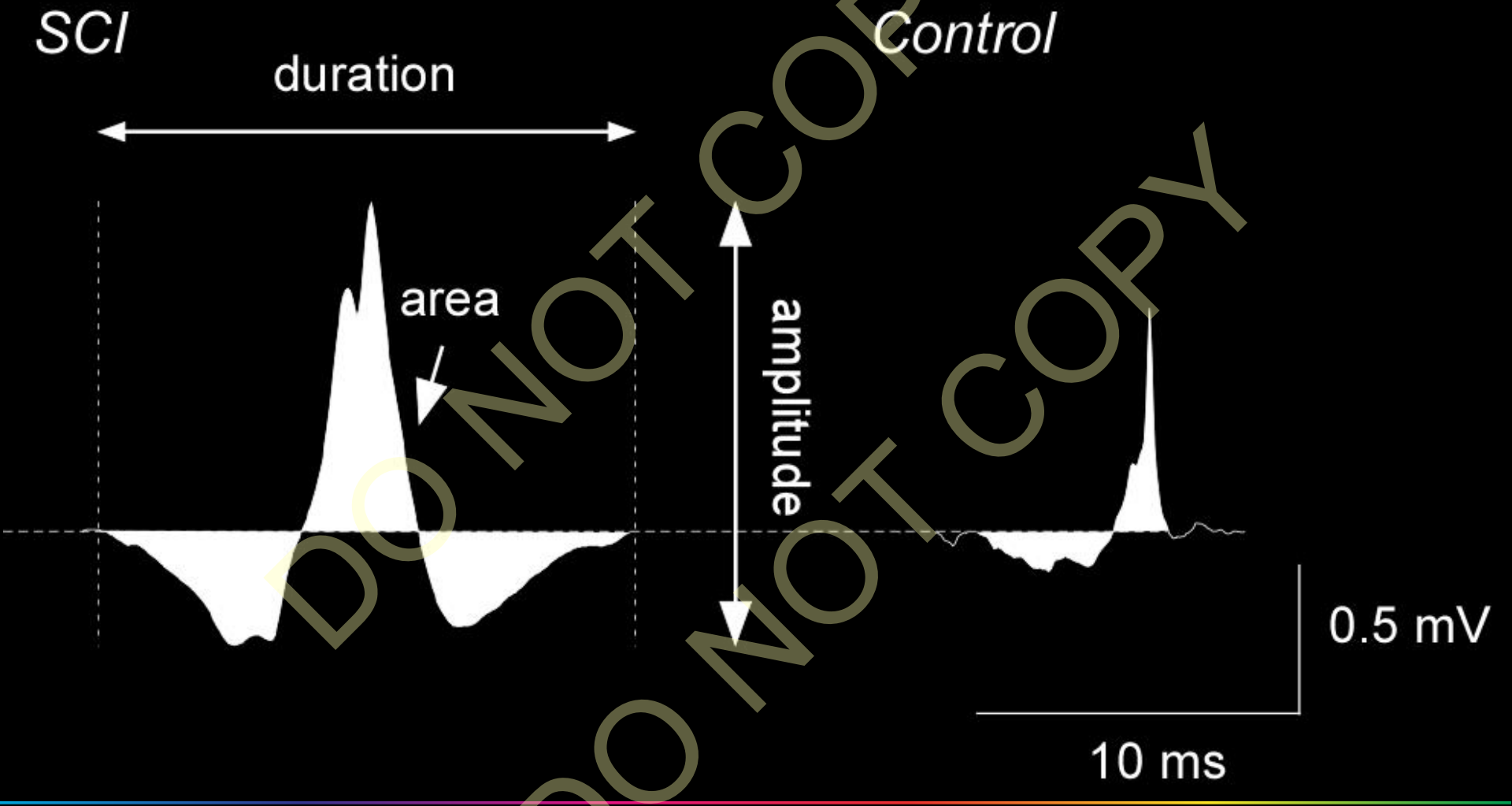
	Tetraplegia	Able-bodied control	*P*-value
Onset discharge frequency (Hz)	10.9 ± 3.3*	8.7 ± 1.8	0.017
Peak discharge frequency (Hz)	17.2 ± 5.0*	12.4 ± 2.2	< 0.001
Offset discharge frequency (Hz)	9.0 ± 3.8*	6.7 ± 1.6	0.040
Tidal volume (l)	0.64 ± 0.12	0.70 ± 0.19	0.081
Inspiratory time (s)	1.65 ± 0.30	1.71 ± 0.39	0.172
Mean flow (l/s)	0.39 ± 0.05	0.41 ± 0.10	0.322

Mean ± SD

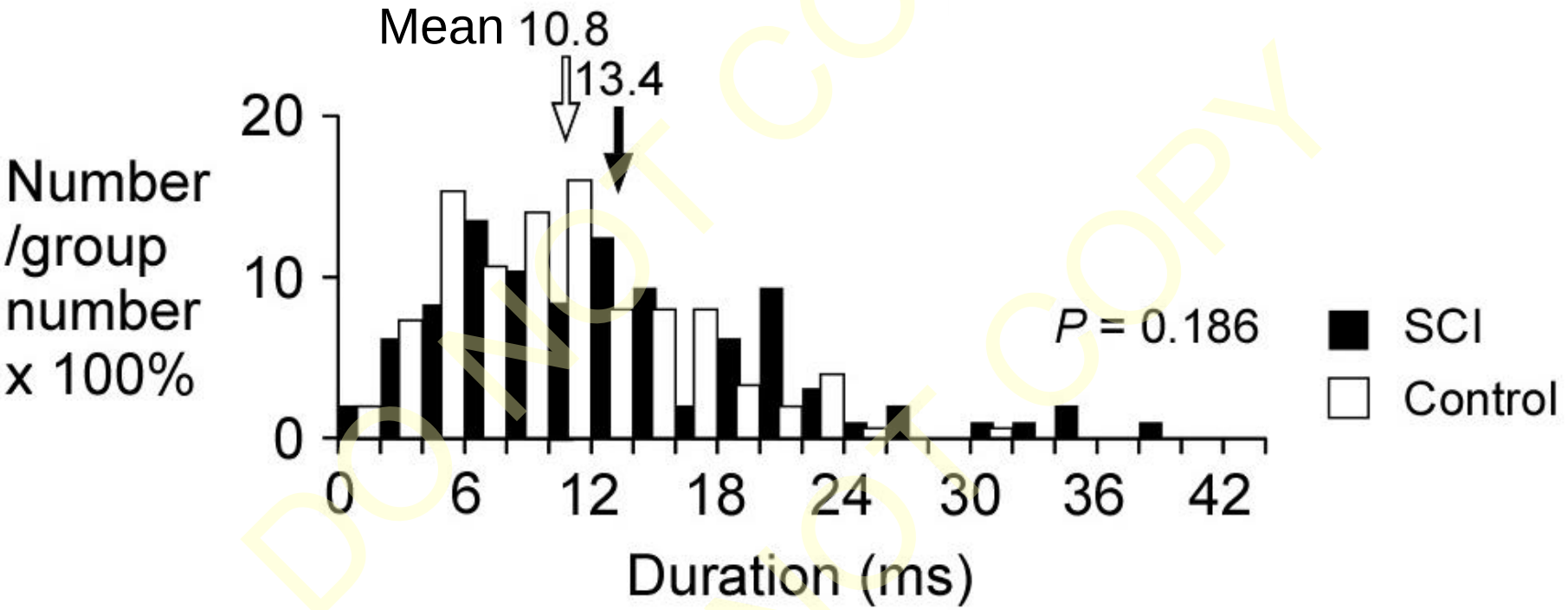
Increase in discharge frequency suggests an

increase in neural drive to the diaphragm during quiet breathing in tetraplegia

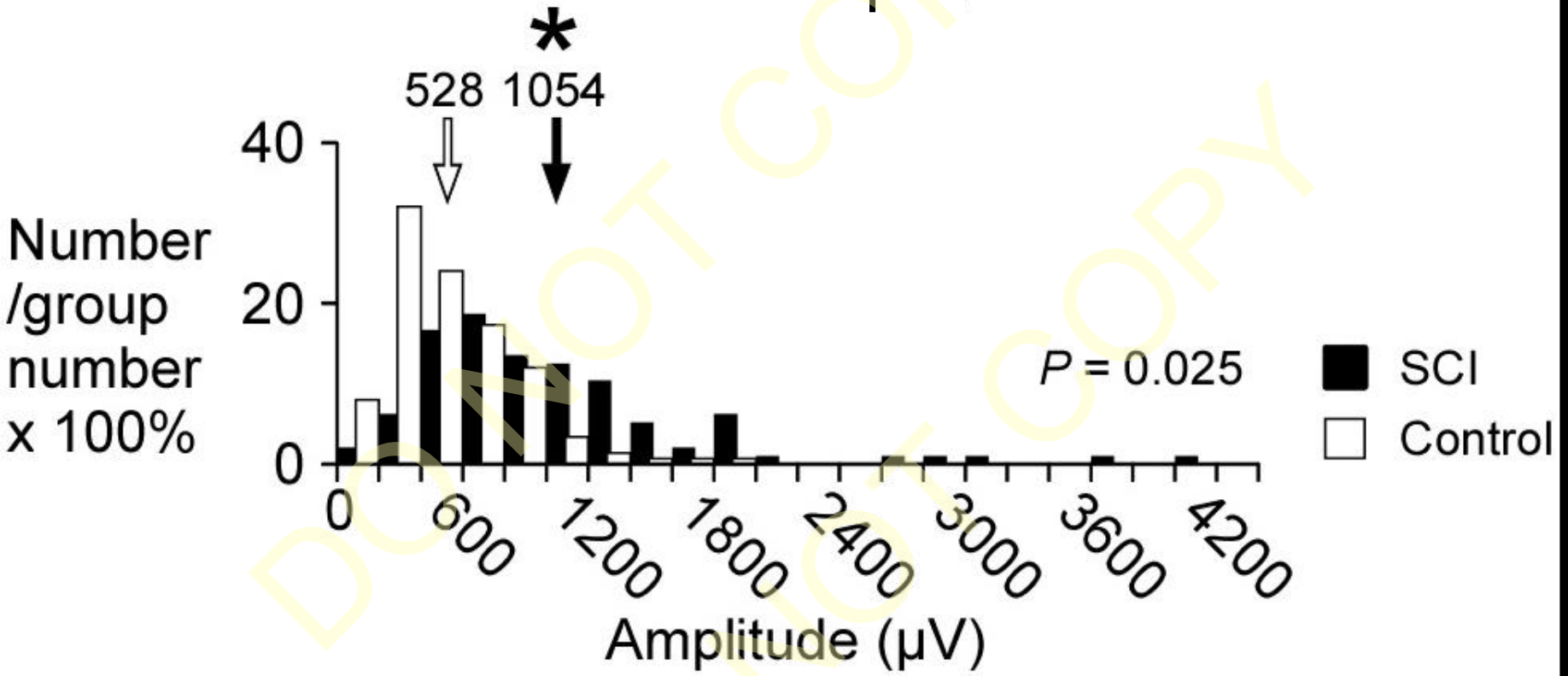
Motor Unit Potential Morphology



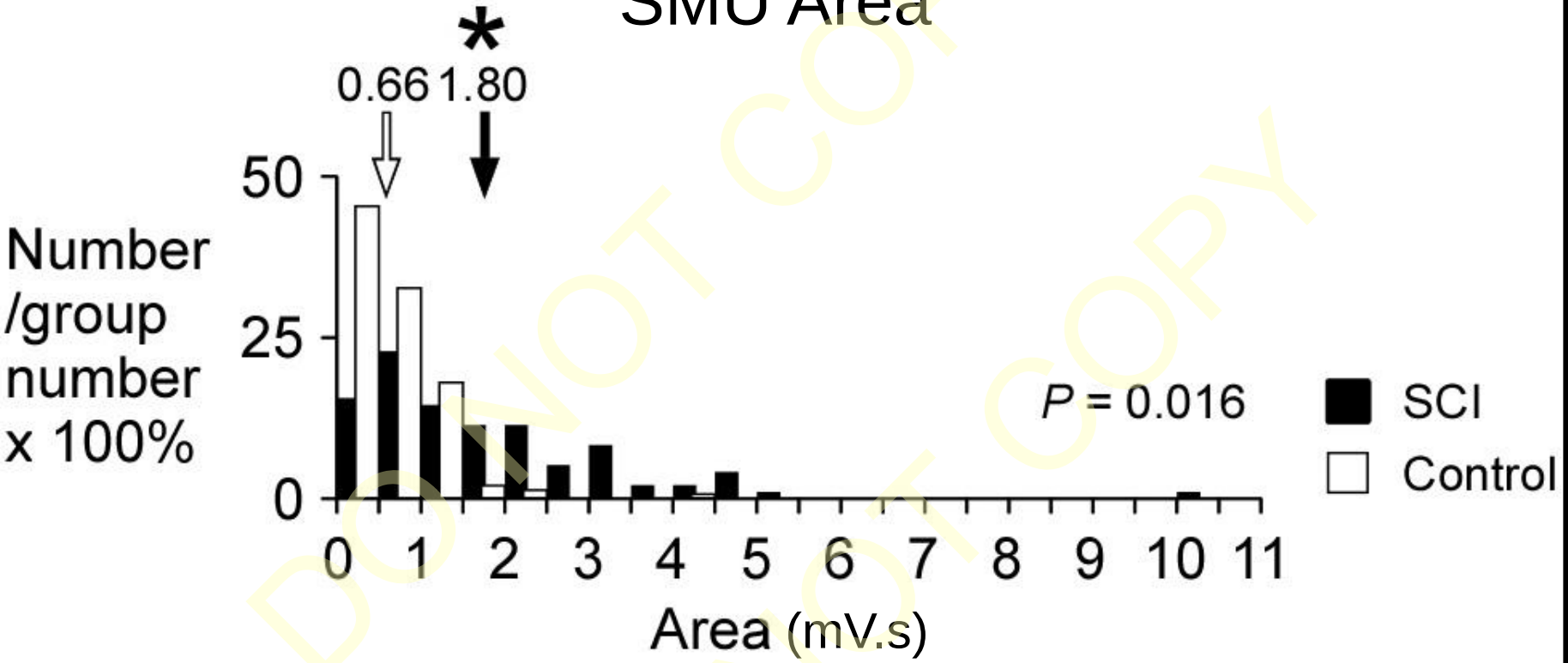
SMU Duration



SMU Amplitude



SMU Area



Diaphragm motor unit potentials are larger in tetraplegia

Summary

In tetraplegia:

- Diaphragm **motor unit discharge frequencies** are higher during quiet breathing

- Diaphragm **motor unit potentials** are larger

Physiological Mechanisms

Increase in discharge frequency of diaphragm motor units

- Following cervical spinal cord injury, diaphragm muscle strength is reduced
- Diaphragm motor unit discharge frequency increases as an adaptation to maintain ventilation

Increase in size of diaphragm motor unit potentials

- Damaged phrenic motoneurones denervate their diaphragm muscle fibres
- Remaining phrenic motoneurones innervate denervated muscle fibres
- Innervating a larger number of muscle fibres results in a larger motor unit action potential

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