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Recommendations for Somatosensory Evoked Potentials

Peter Walsh / Bryonny Carr / Jeffery Holman

IFCN published recommendations

Recommendations for the Practice of Clinical Neurophysiology:
Guidelines of the International Federation of Clinical Physiology (EEG Suppl. 52)
Editors: G. Deuschl and A. Eisen

Published by Elsevier Science B.V.

Chapter 2.4

Somatosensory evoked potentials

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ELSEVIER

Clinical Neurophysiology 119 (2008) 1705–1719

www.elsevier.com/locate/clinph

Invited review

Recommendations for the clinical use of somatosensory-evoked potentials

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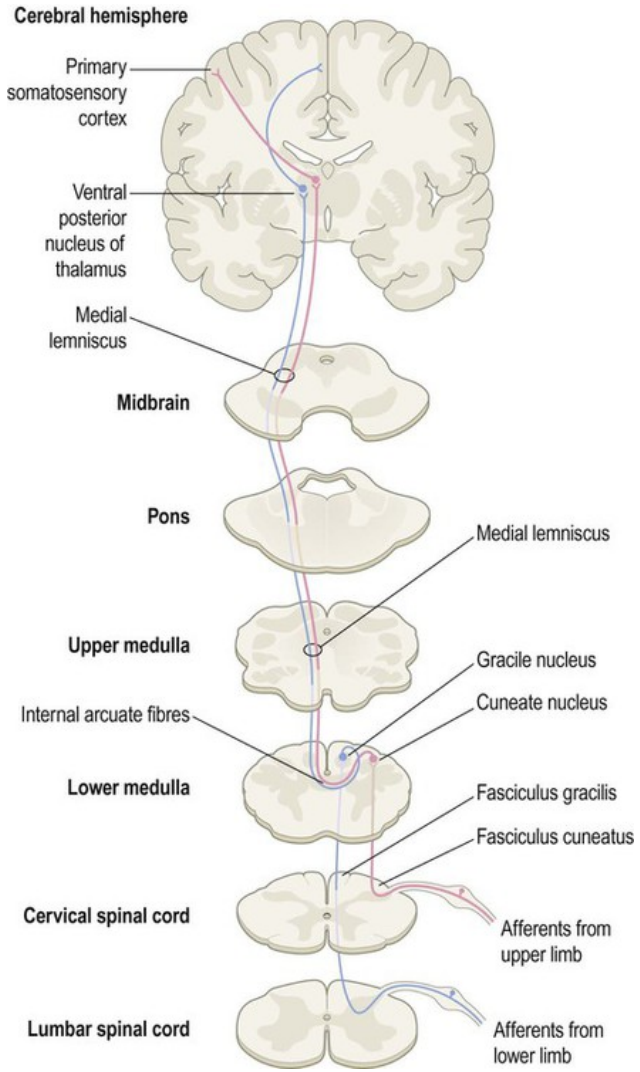
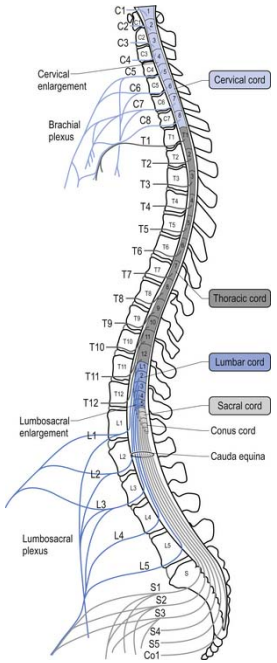
The dorsal lemniscal somatosensory pathway





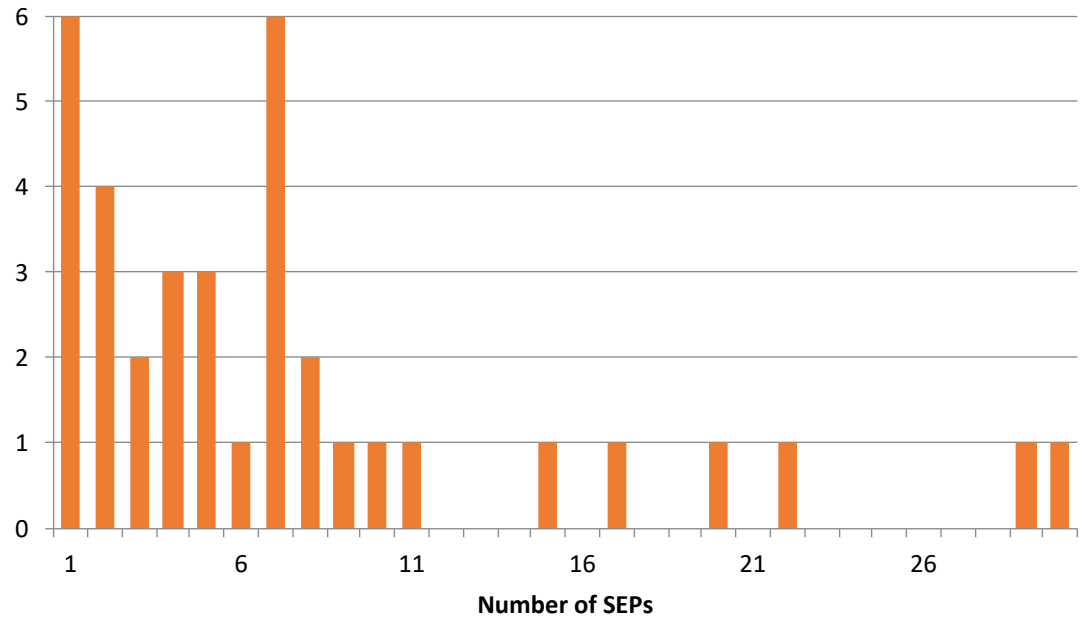
Clinical uses of SEPs

- Peripheral nervous system
  - Peripheral neuropathy
  - Focal neuropathy
  - Plexopathy
- Ventral rootlets and roots
  - Lumbro-sacral root disease
  - Cervical root disease
  - Radiculopathy
  - Lumbar stenosis
- Spinal Cord
  - Spinal cord trauma
  - Cervical spondylosis
  - Myelopathy
  - Syringomyelia
  - Spinal tumours
  - Tethered cord
- Brain and brainstem
  - Multiple sclerosis
  - Myoclonus
  - Coma

No of SEPs by centre

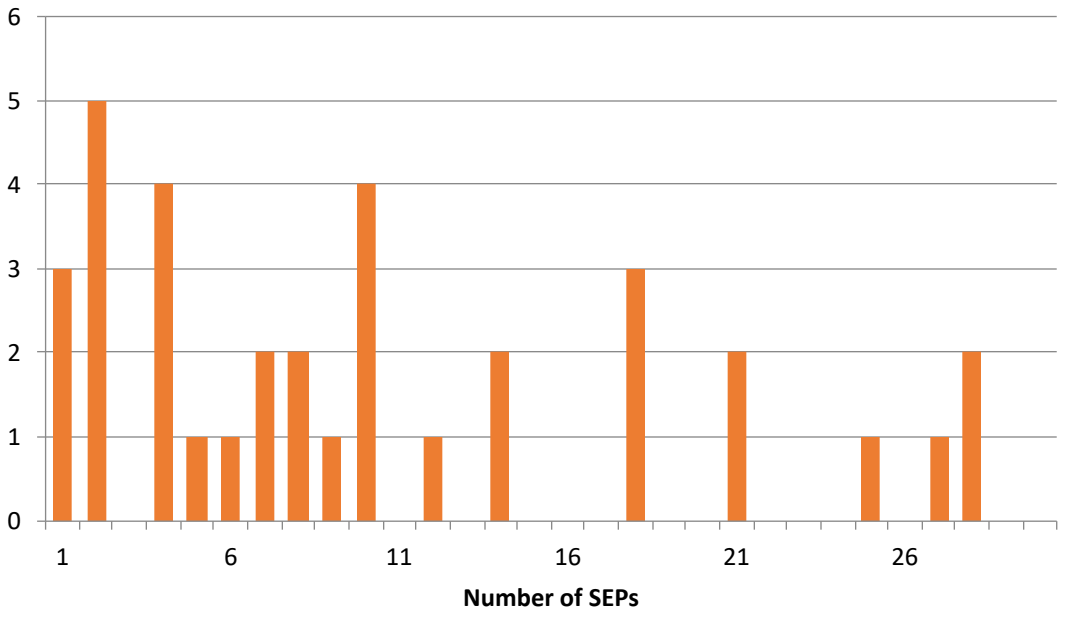
Upper Limb

37 centres / 275 patients



Lower Limb

35 centres / 372 patients

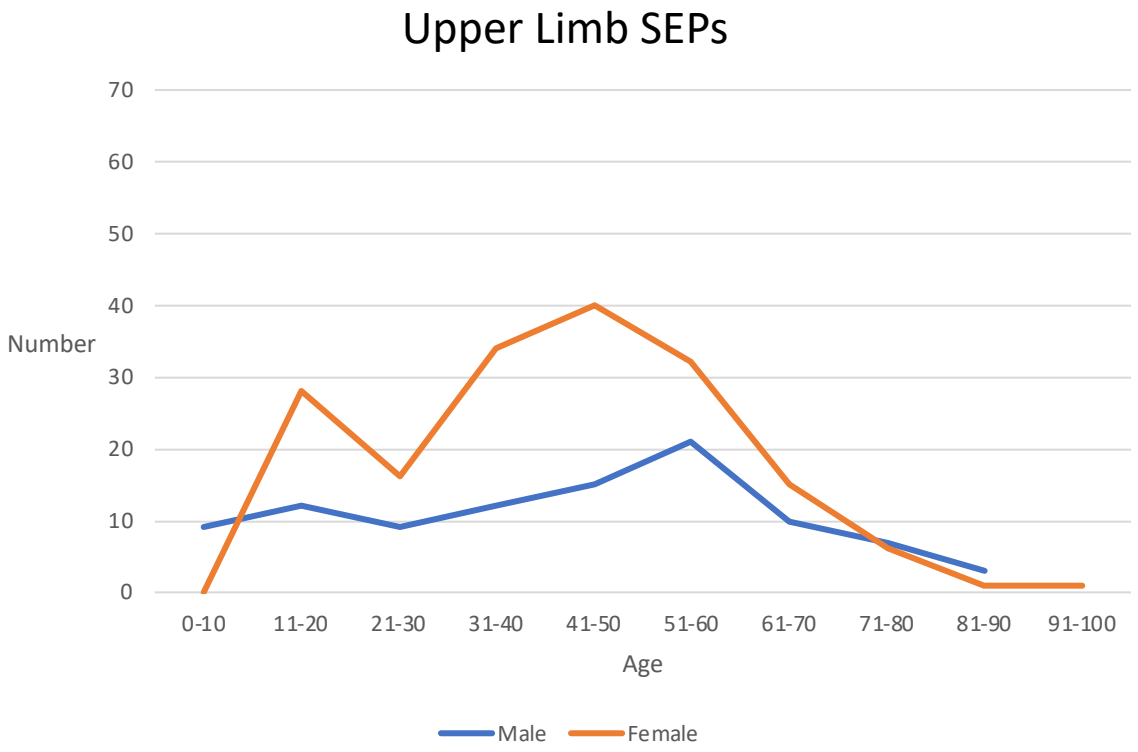


Age of patients

Female = 175, Male = 99 (1.7:1)

Female $x = 41.6 \pm 17.6$

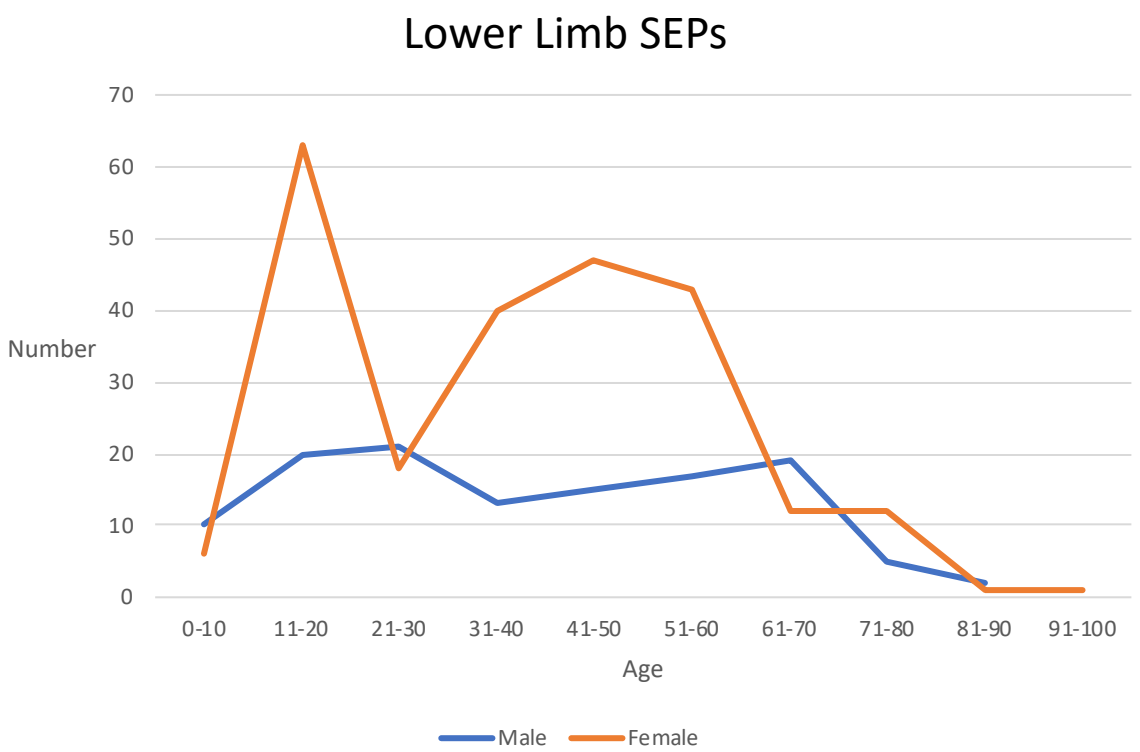
Male $x = 43.1 \pm 21.2$



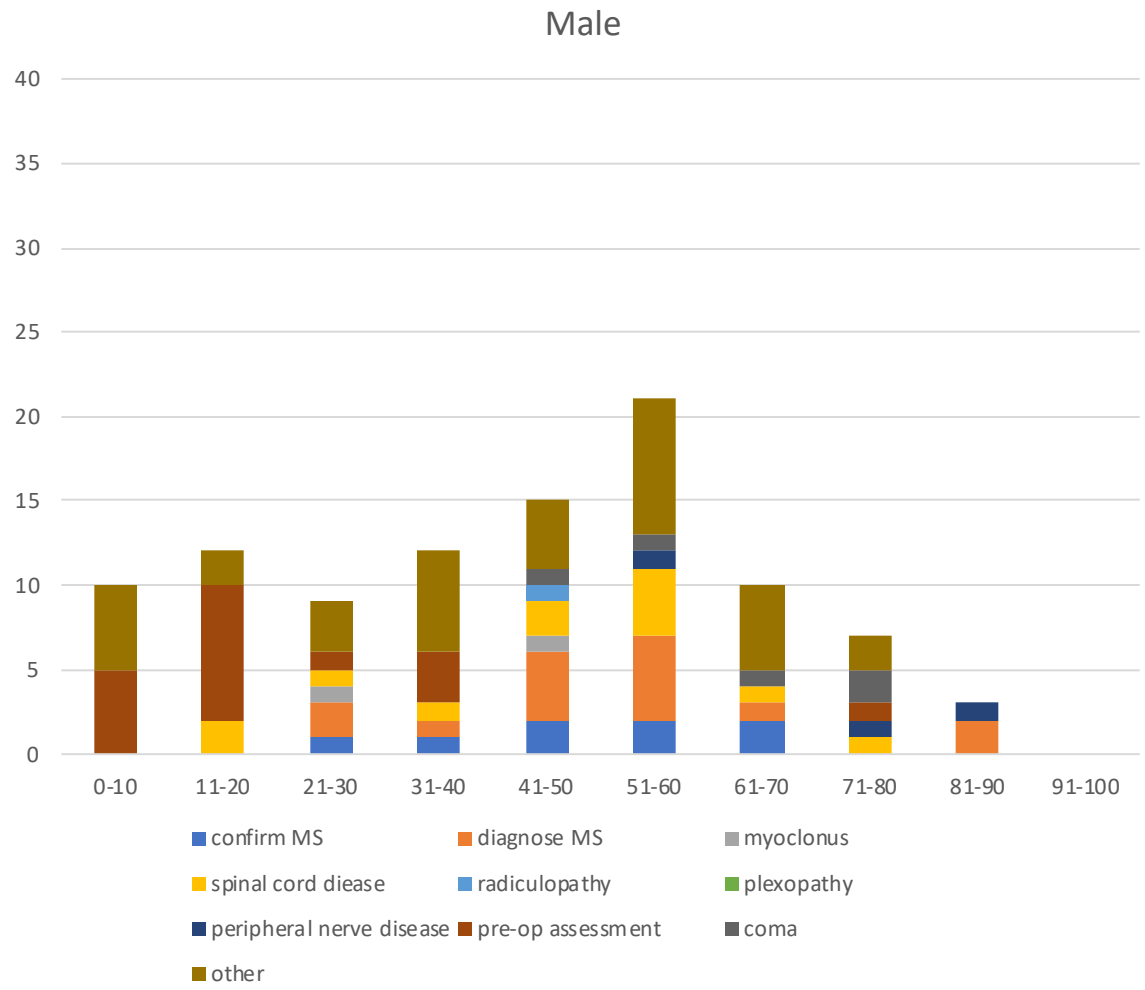
Female = 243, Male = 123 (1.9:1)

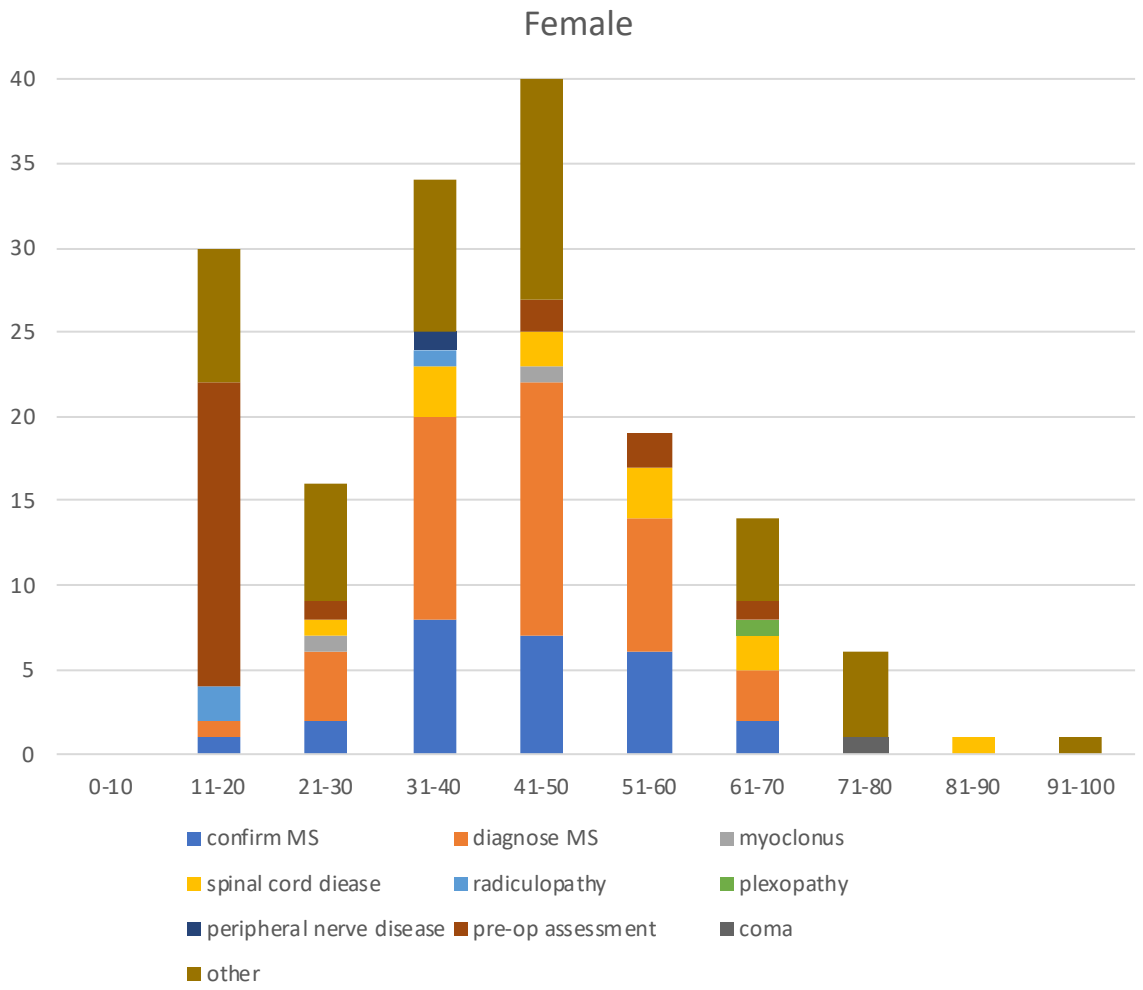
Female $x = 37.88 \pm 19.4$

Male $x = 39.4 \pm 20.8$



Reason for referral





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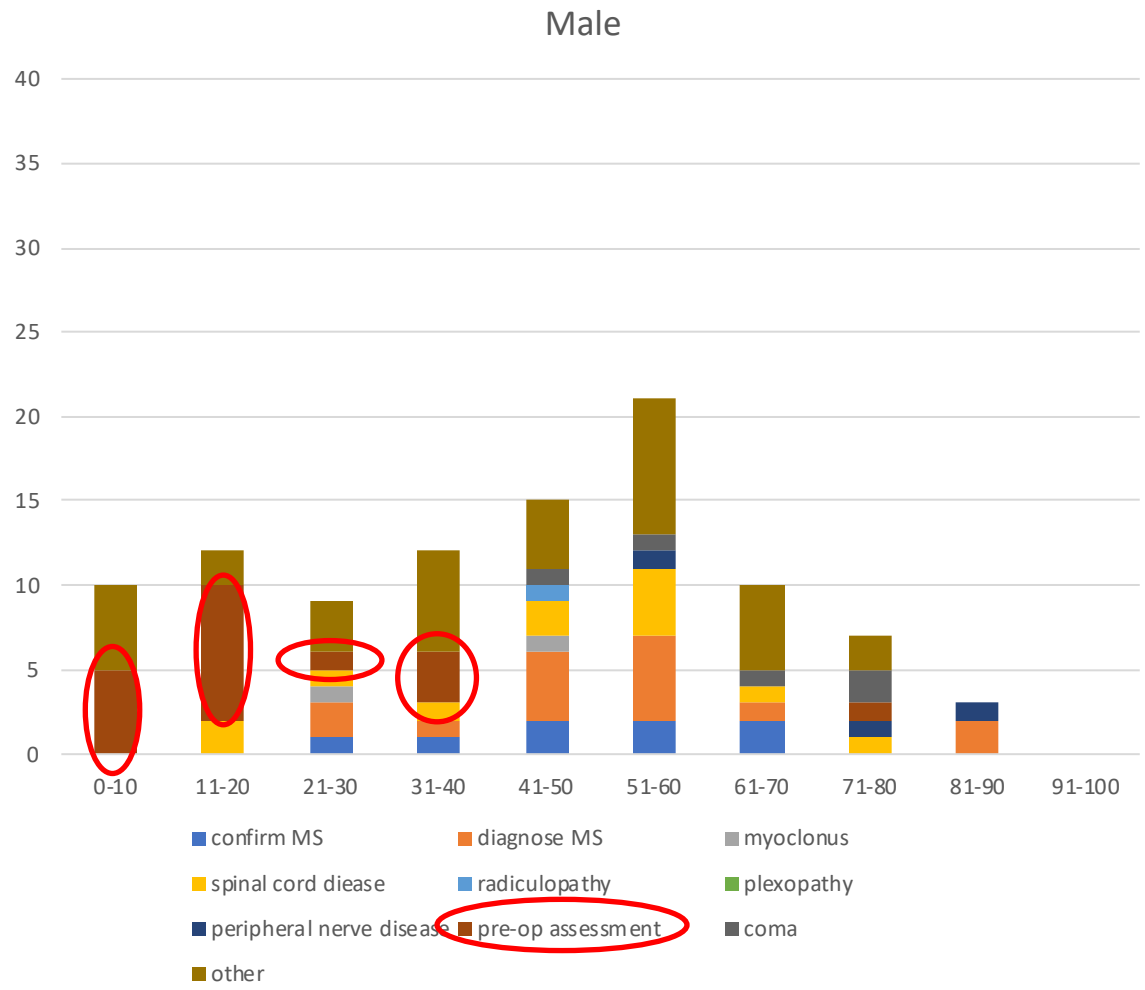
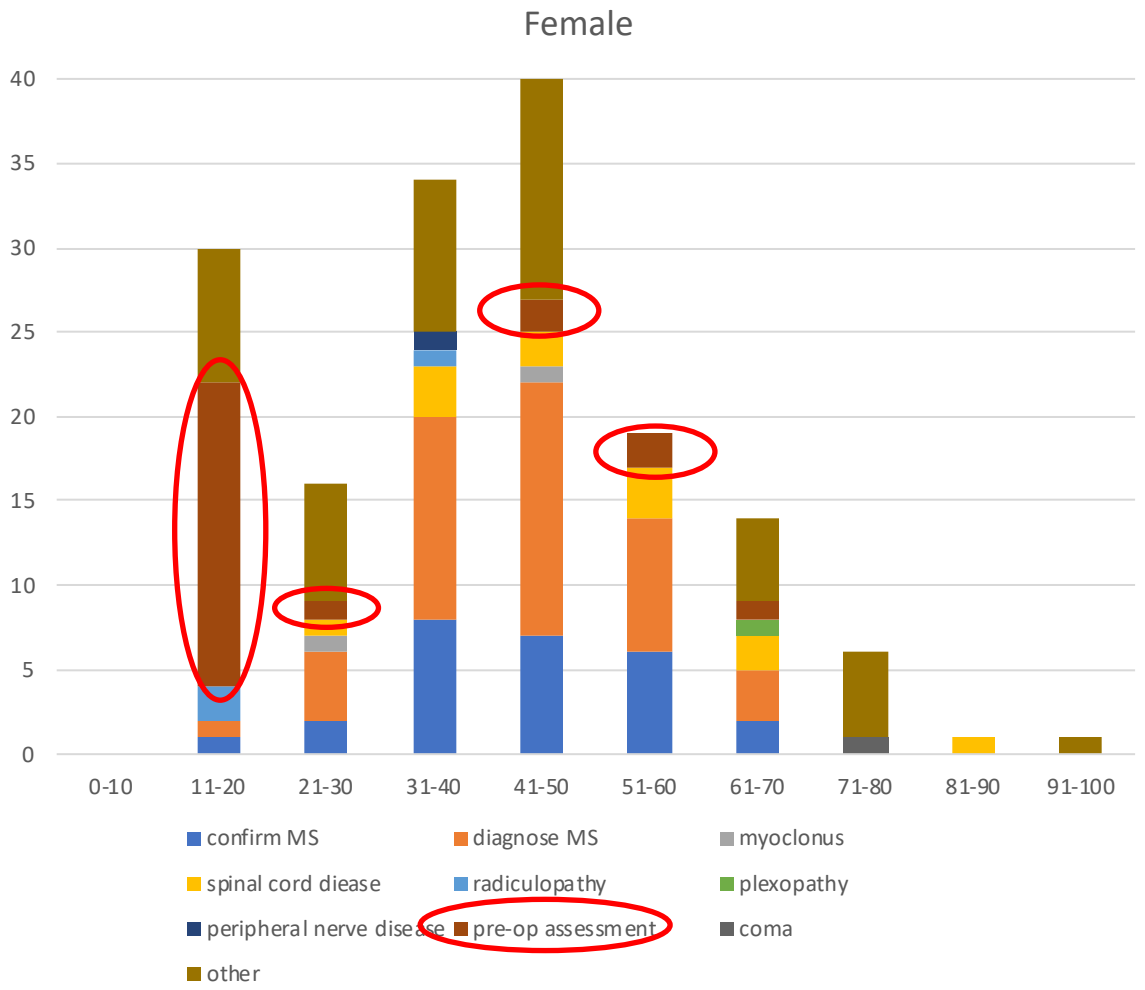
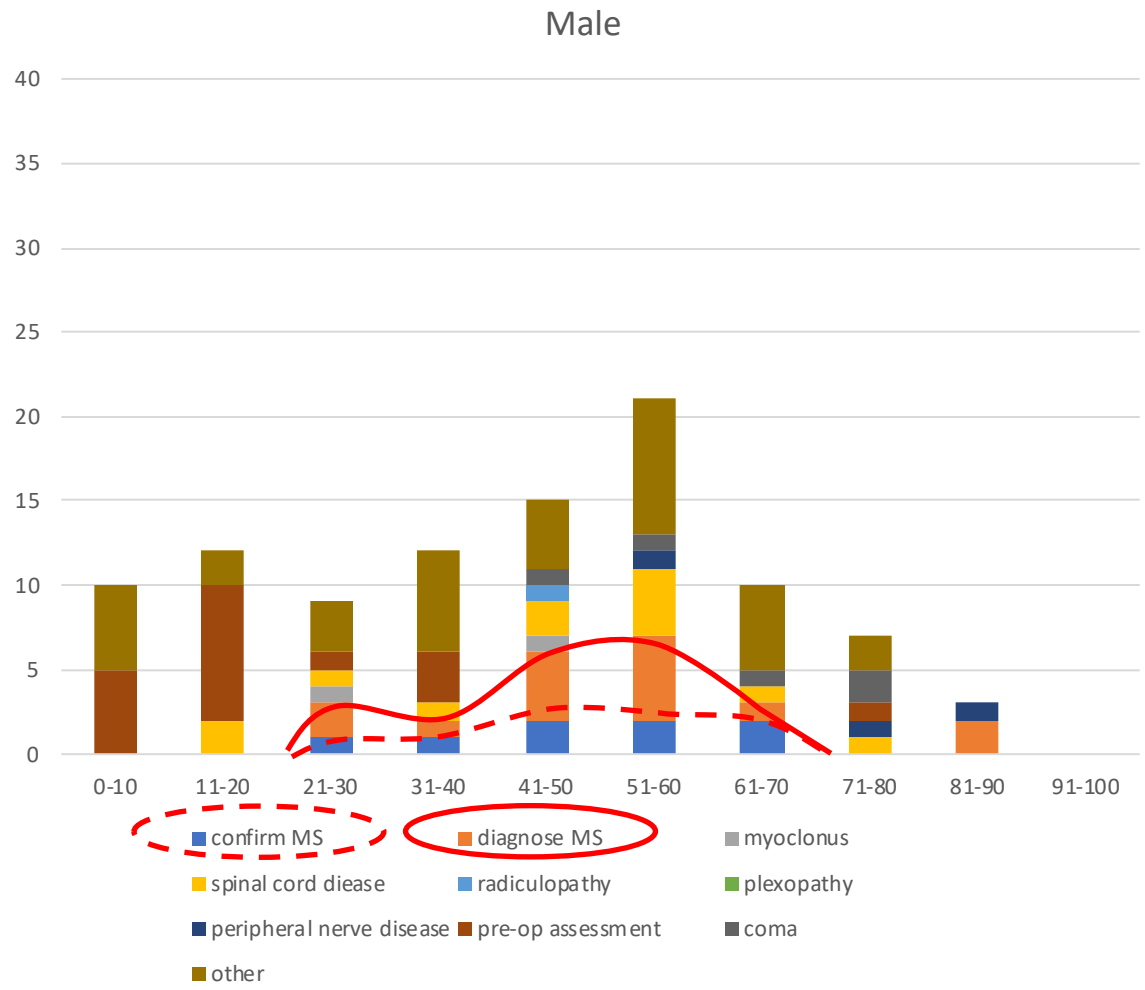
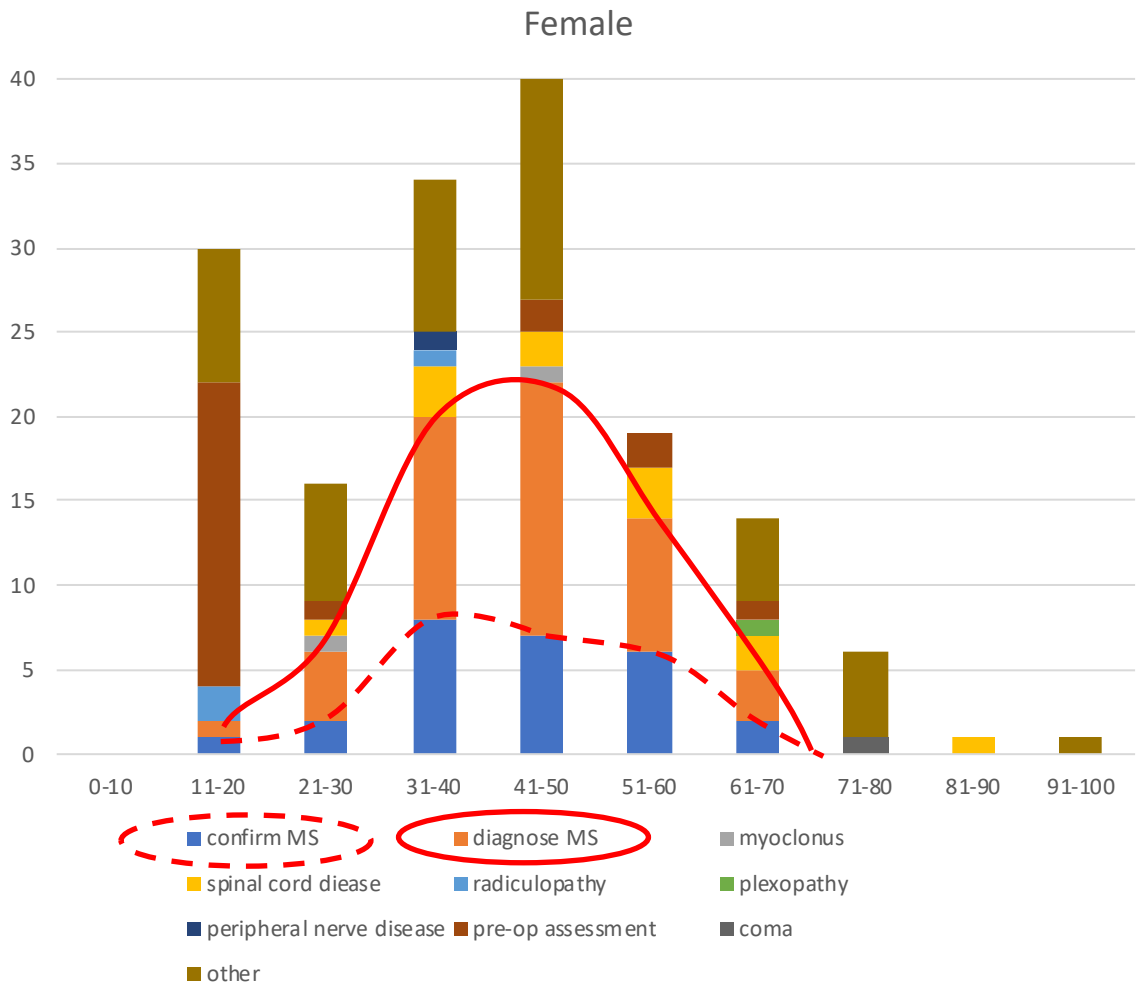


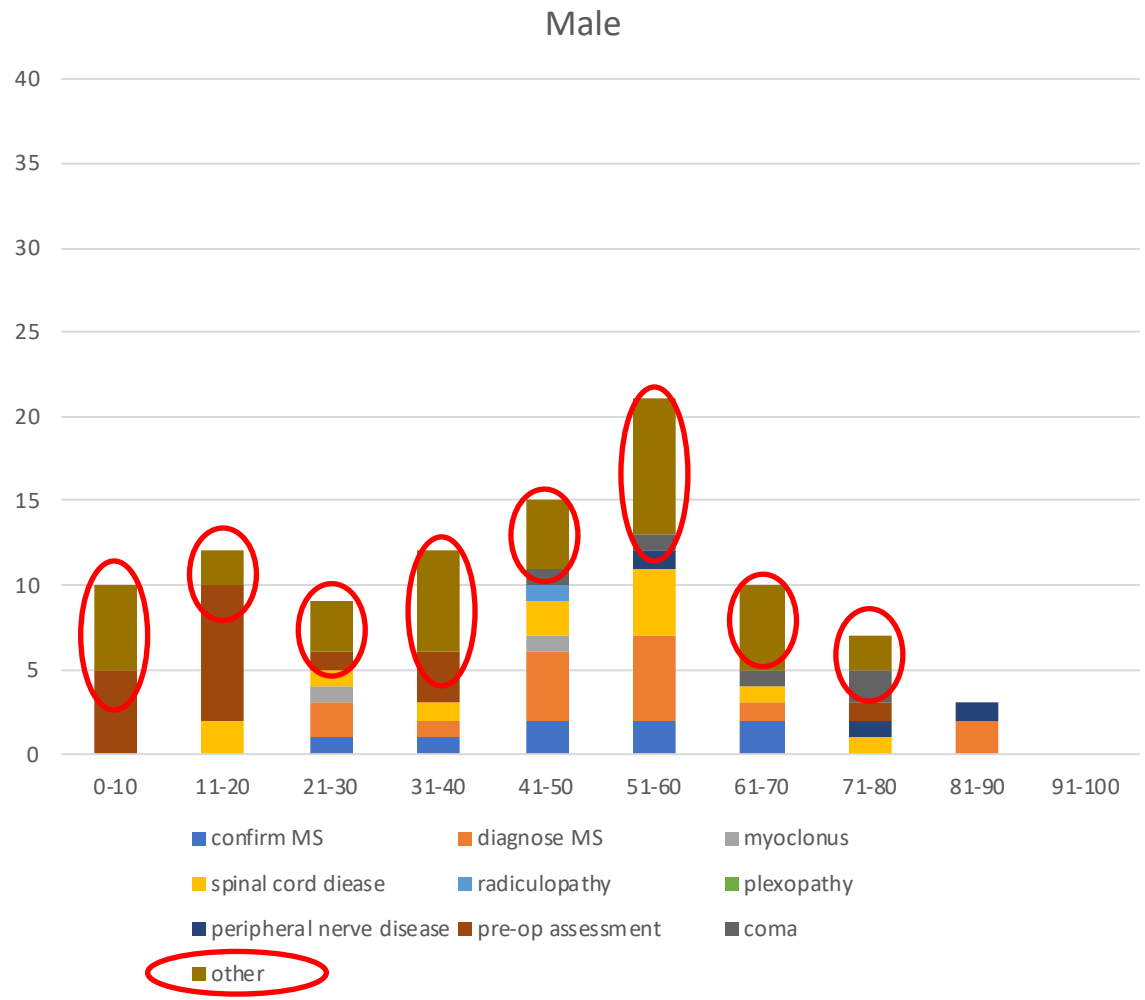


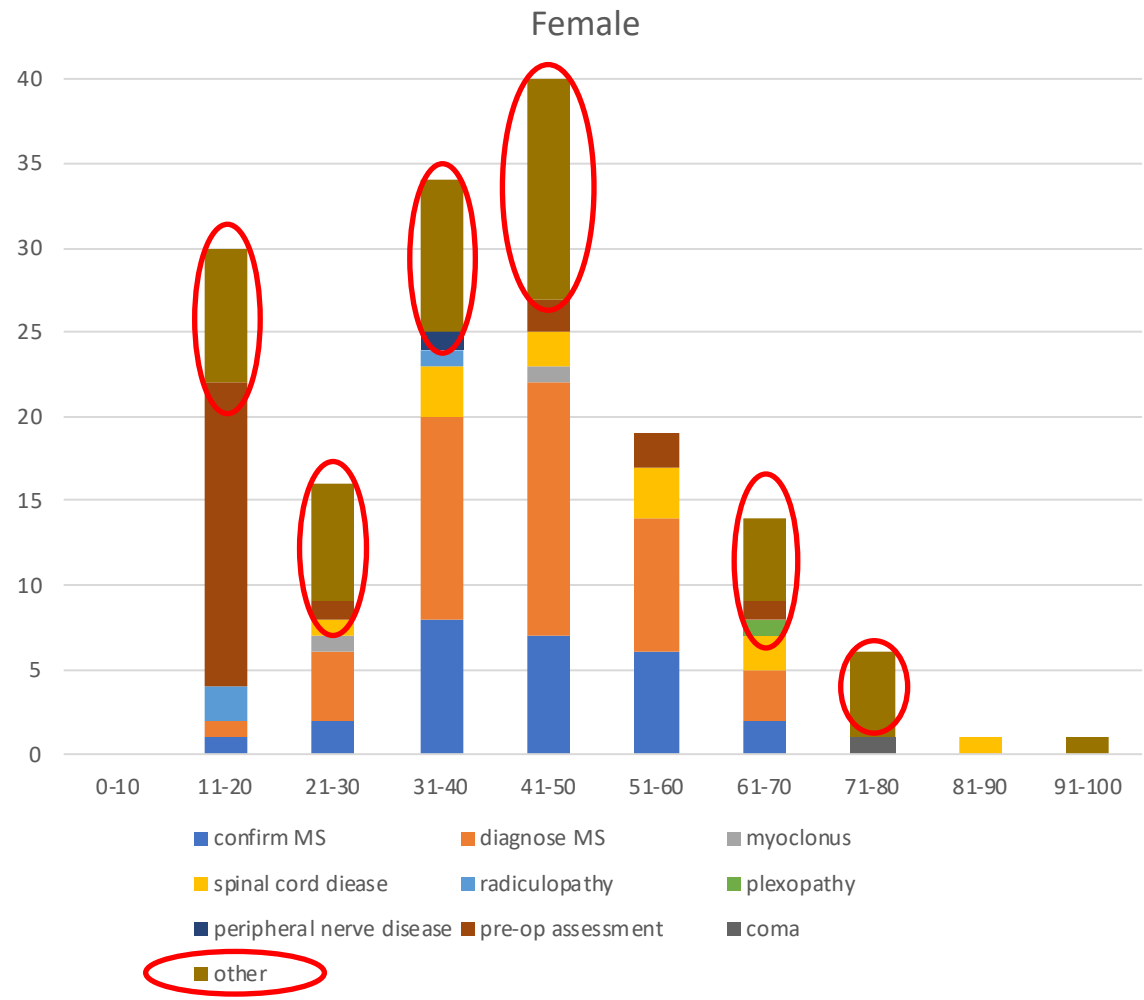
Reason for referral





Reason for referral

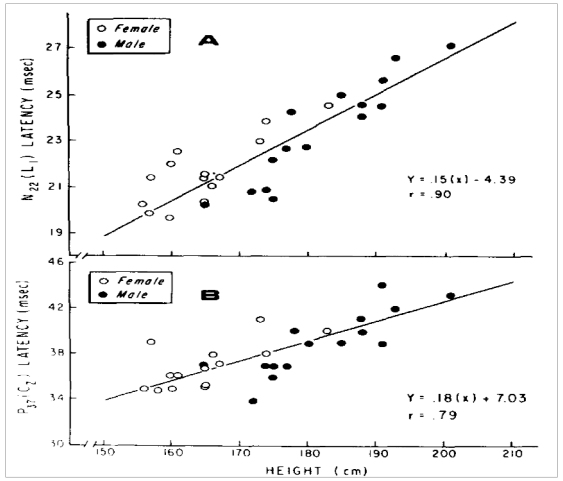


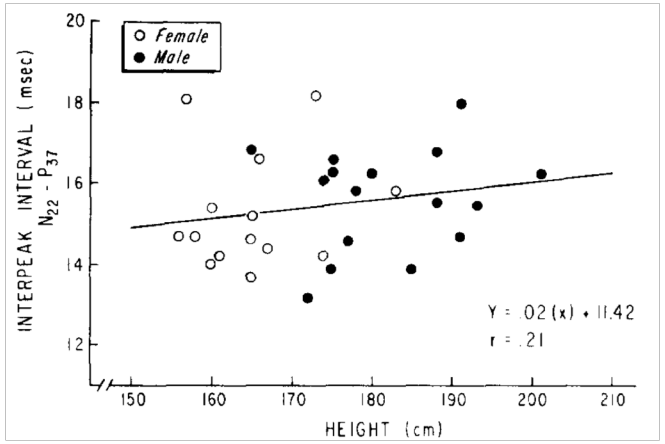


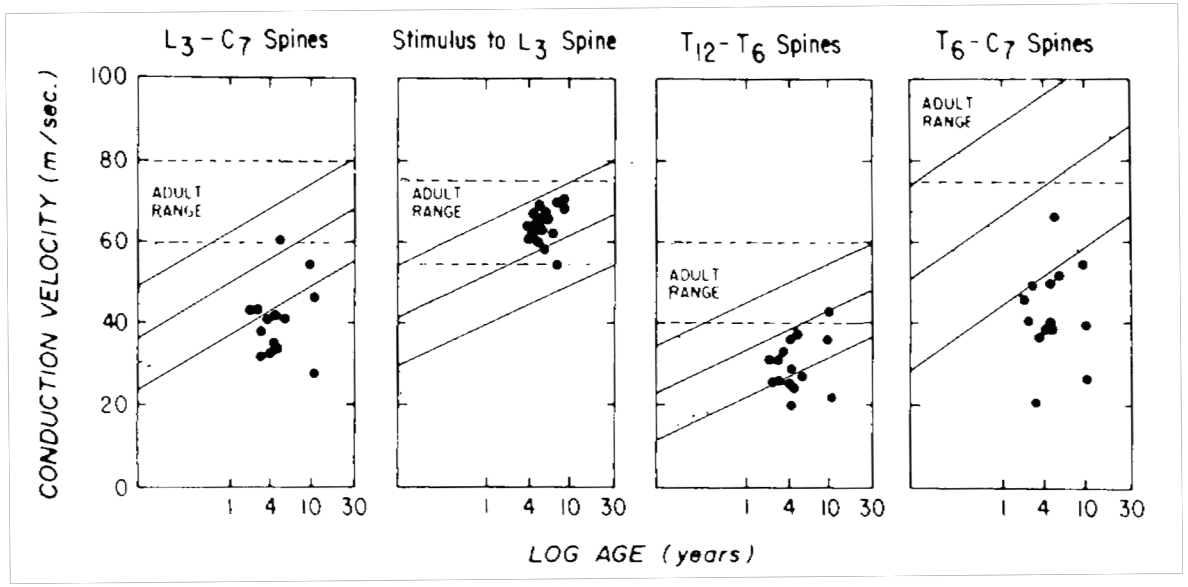
Standard 1

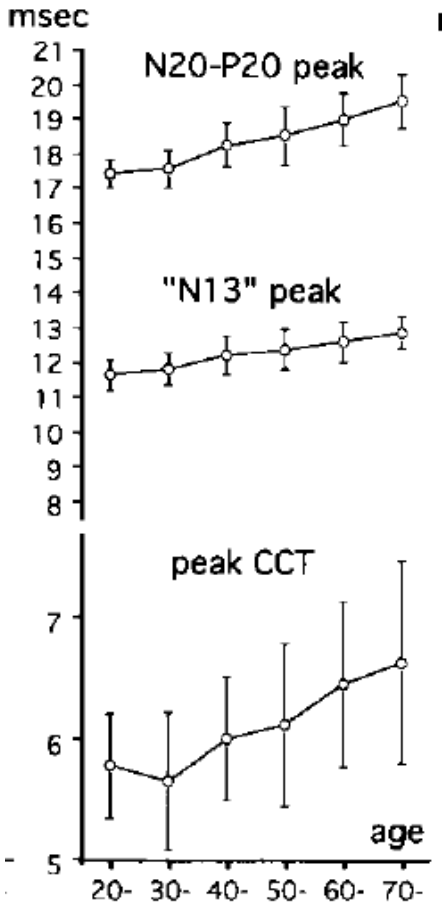
Before starting testing the patient is identified and the clinical information from the referral verified.

Influence of height, age and sex on SEPs



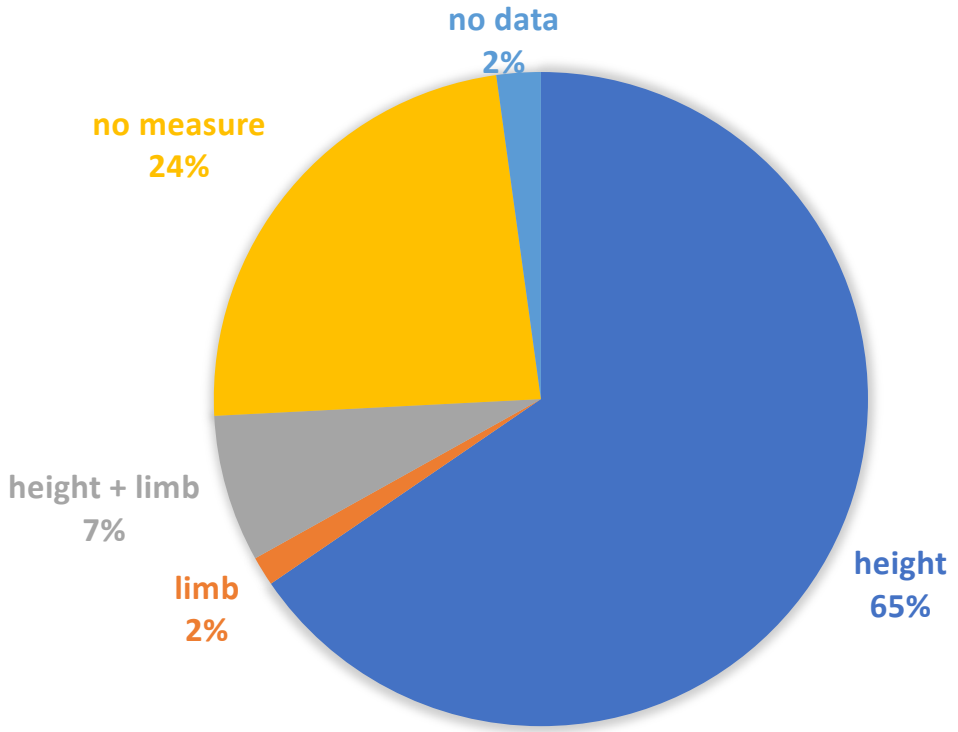






Patient data collected

	Upper Limb SEPs	Lower Limb SEPs
Height	180	274
Limb	4	
Height **and** Limb	20	
No height/limb	65 (24%)	85 (24%)
No data	6	13



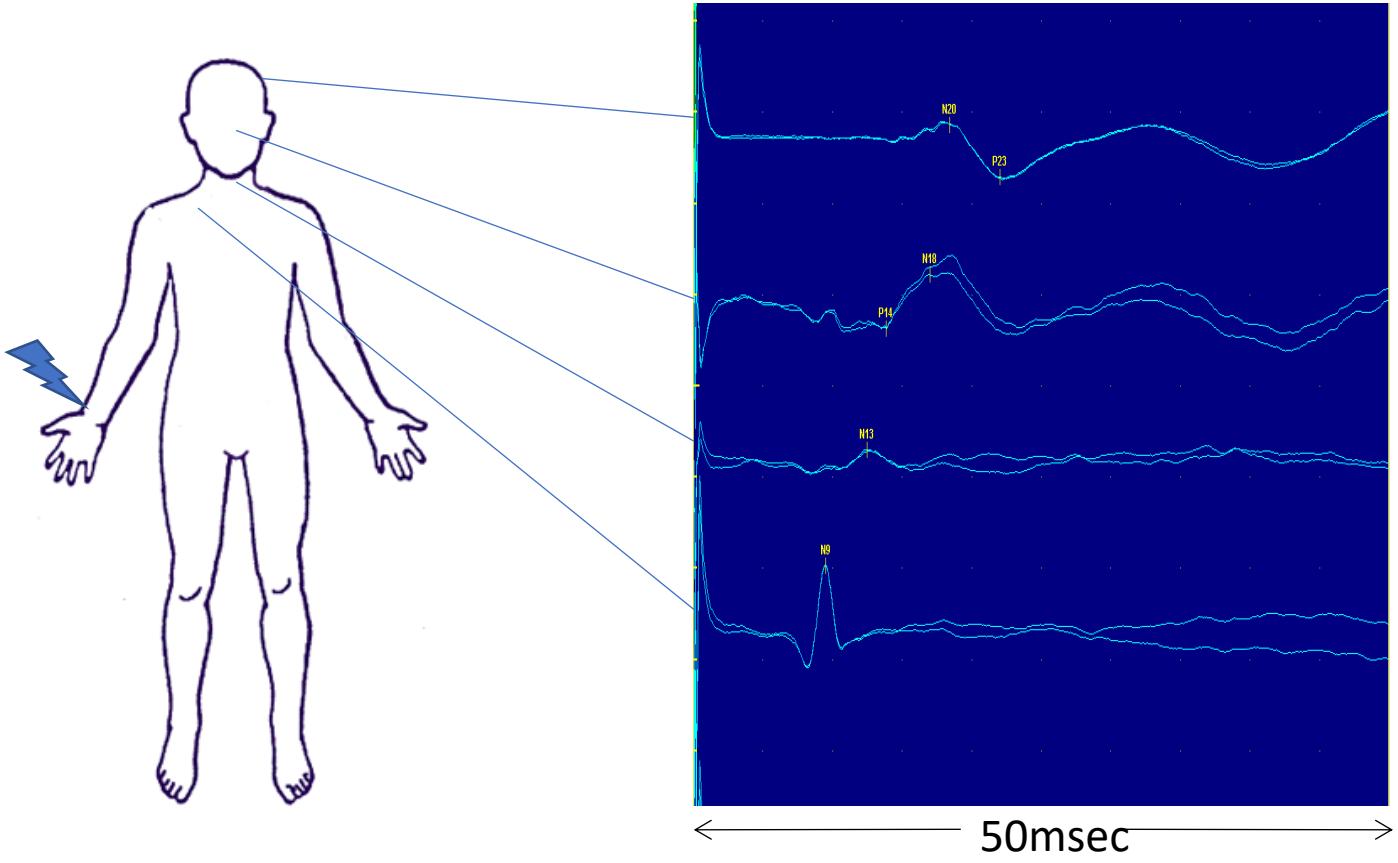
Standard 2

The absolute latencies of SEPs are directly influenced by the patients age, sex, height, limb length and temperature.

The patient should be kept warm during the testing procedure and interpretation should consider height (and/or limb) and age/sex adjusted normal values.

Standard 3 – Upper limb SEPs

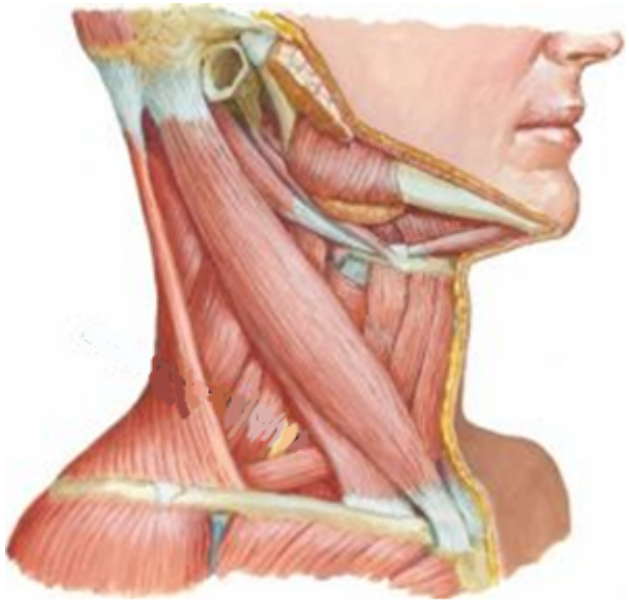
It is suggested that a *minimum* of 4 channels are recorded as a standard after independent bilateral stimulation, so that absolute conduction to the plexus, cervical cord and cortex can be assessed, along with the inter-latency differences and inter-side differences of the plexus-cord conduction time and the cord-cortex conduction time to be calculated.



Erbs point potential

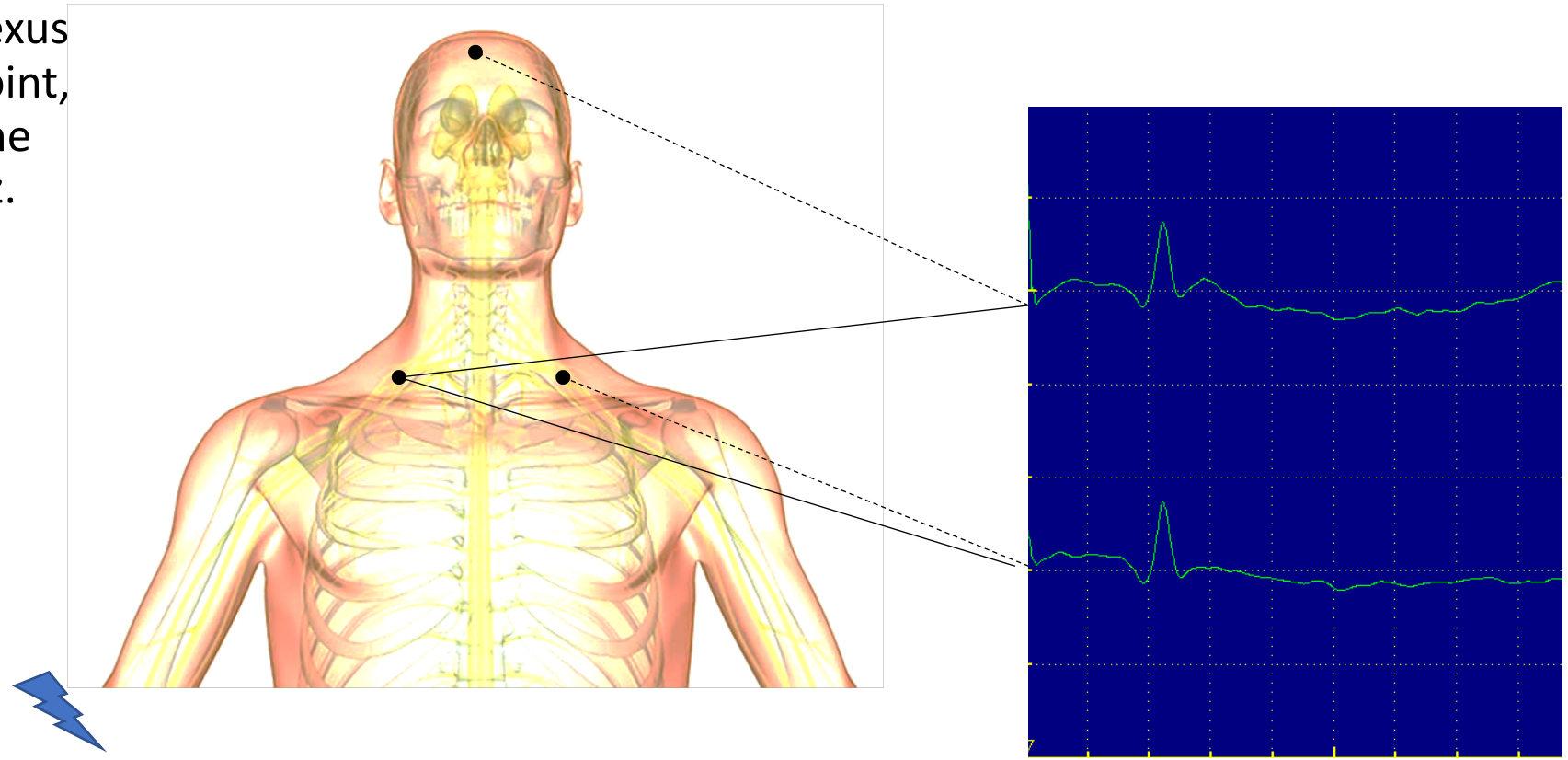
	Reference	
	Fz	EPc
EPi	192 (77%)	58 (23%)
incomplete	25	

Erb's point is located within the angle formed by the posterior border of the clavicular head of the sternocleidomastoid muscle and the clavicle, 2-3 cm above the clavicle.



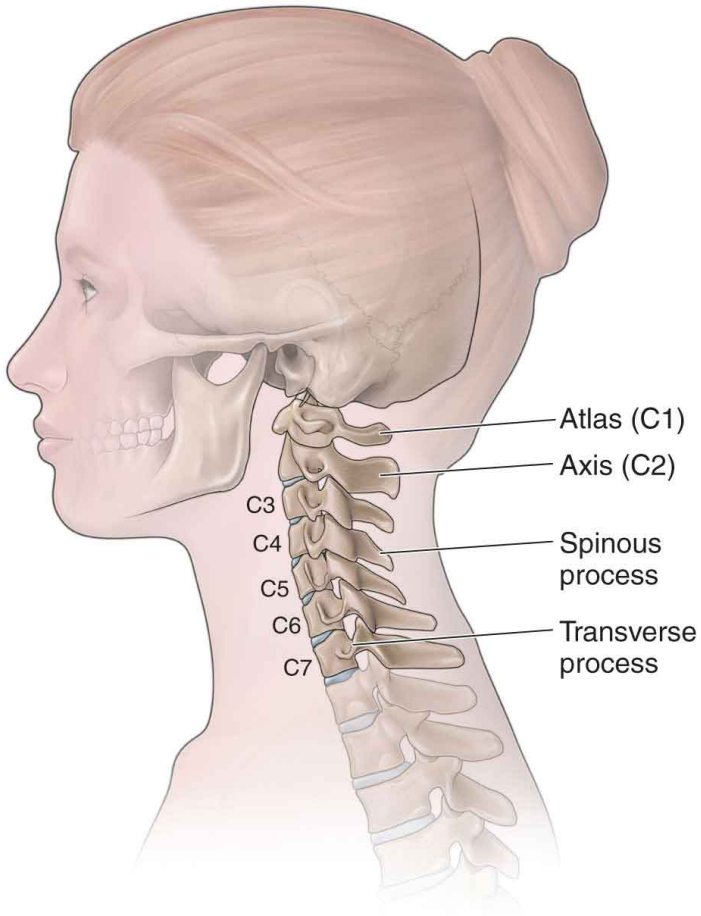
Erbs point potential

Guideline – The propagated plexus volley is recorded from Erb's point, with the reference placed on the contralateral Erbs point or at Fz.

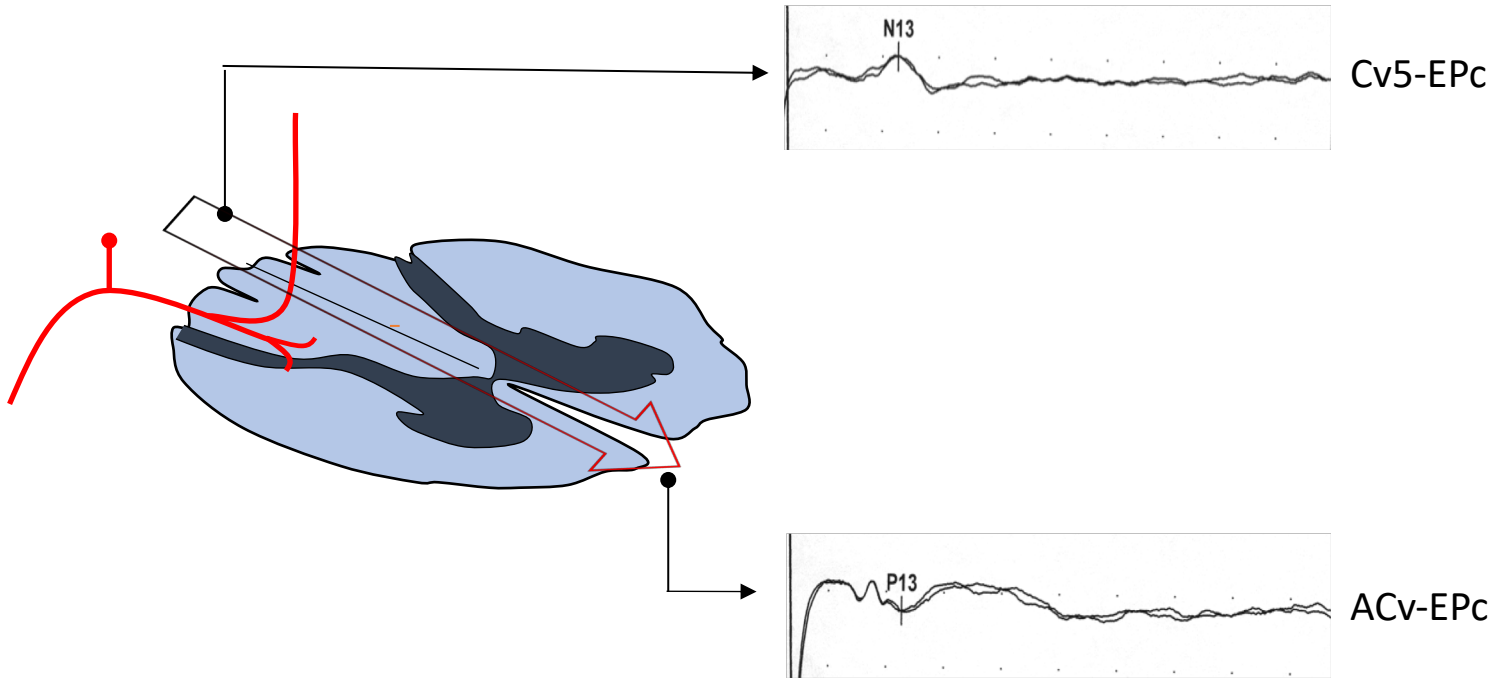


Recording the ‘cervical’ potential

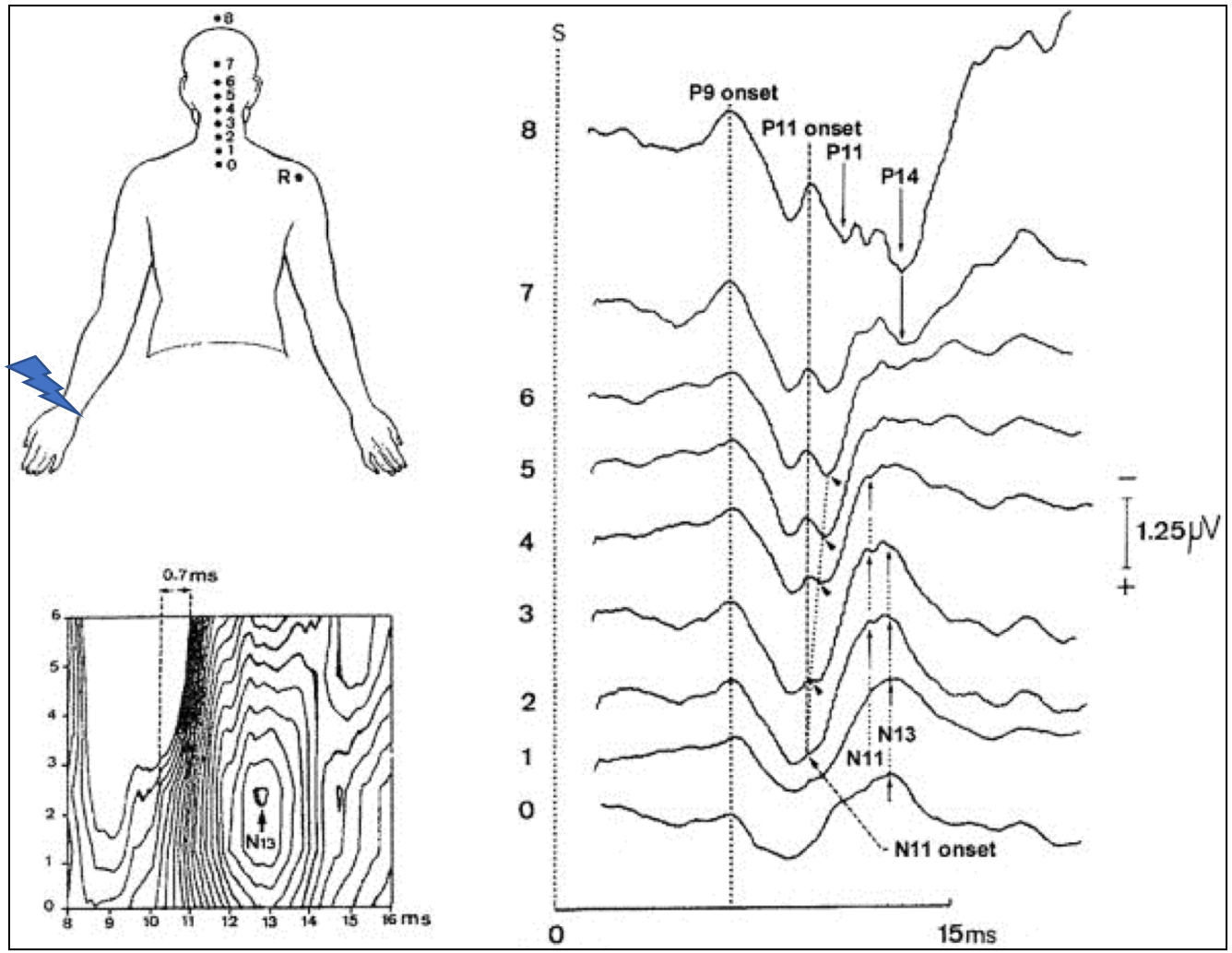
		Reference				
		Fz		Ant Cerv		EPc
Active	C2	4				
	C2/C5	11	**16%**	29	**12%**	
	C2/C6	23				
	C5			17	**7%**	
	C5					7
	C6	3				
	C6/7	25	**60%**		**5%**	
	C7	112		9		
incomplete		35				



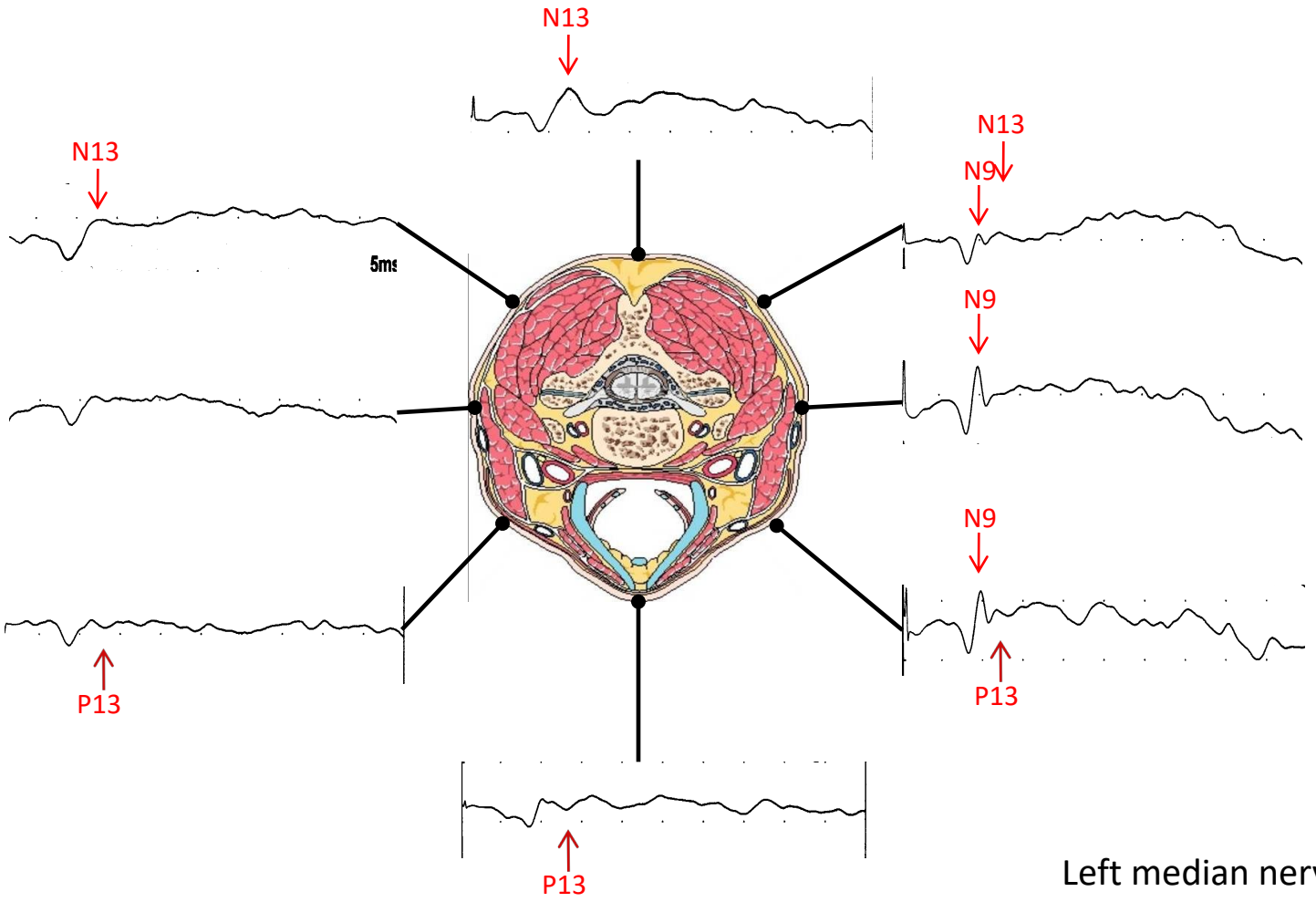
The cervical potential is a ‘stationary horizontal dipole’



Cervical potential distribution



Cervical potential distribution

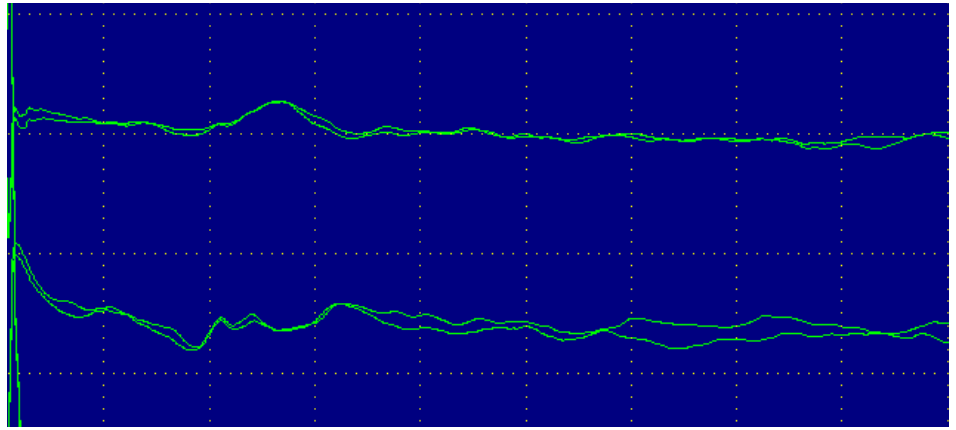


Left median nerve stimulation

Inadequacy of the Fz reference

Cv5 – EPc

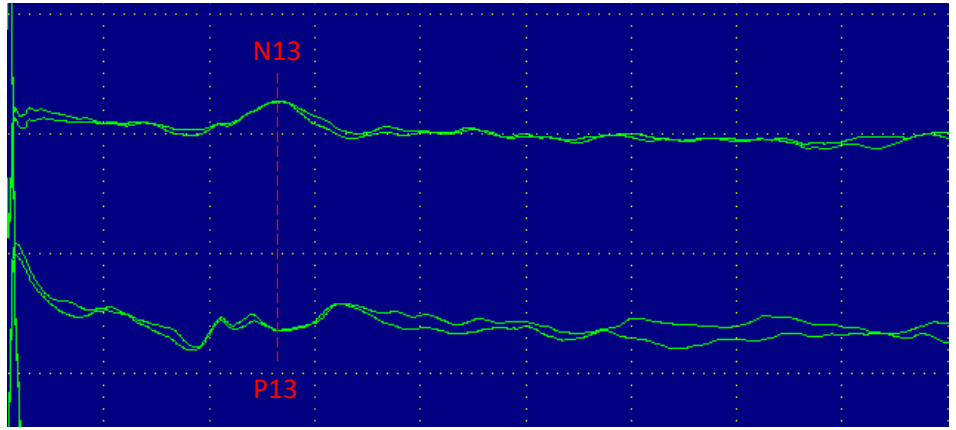
ACv - EPc



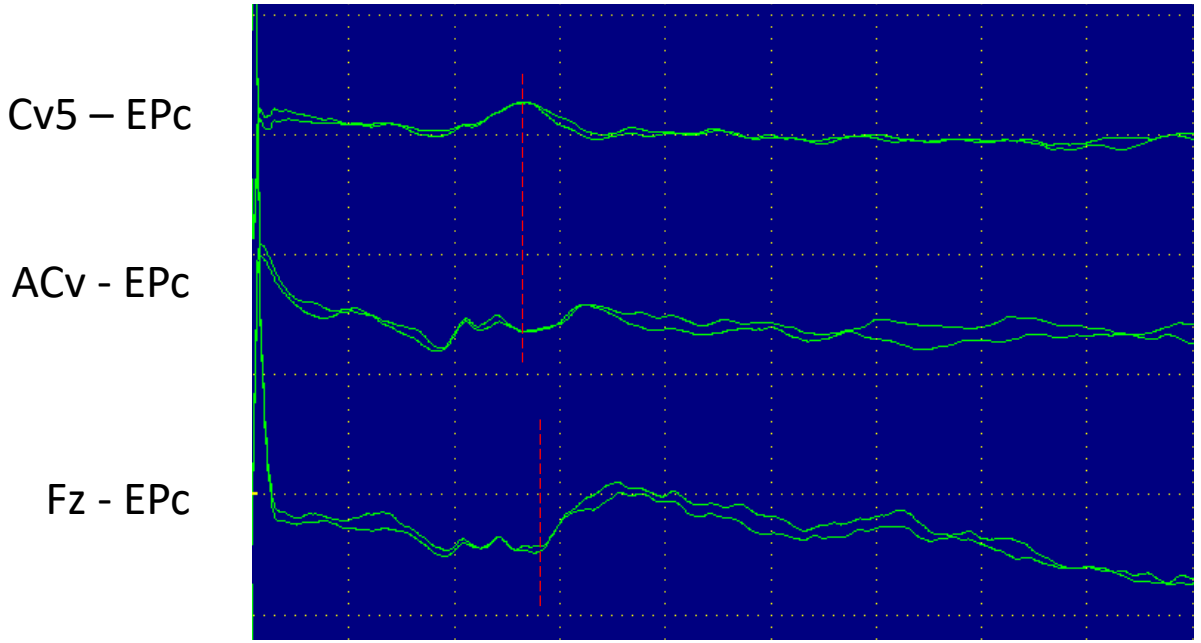
Inadequacy of the Fz reference

Cv5 – EPc

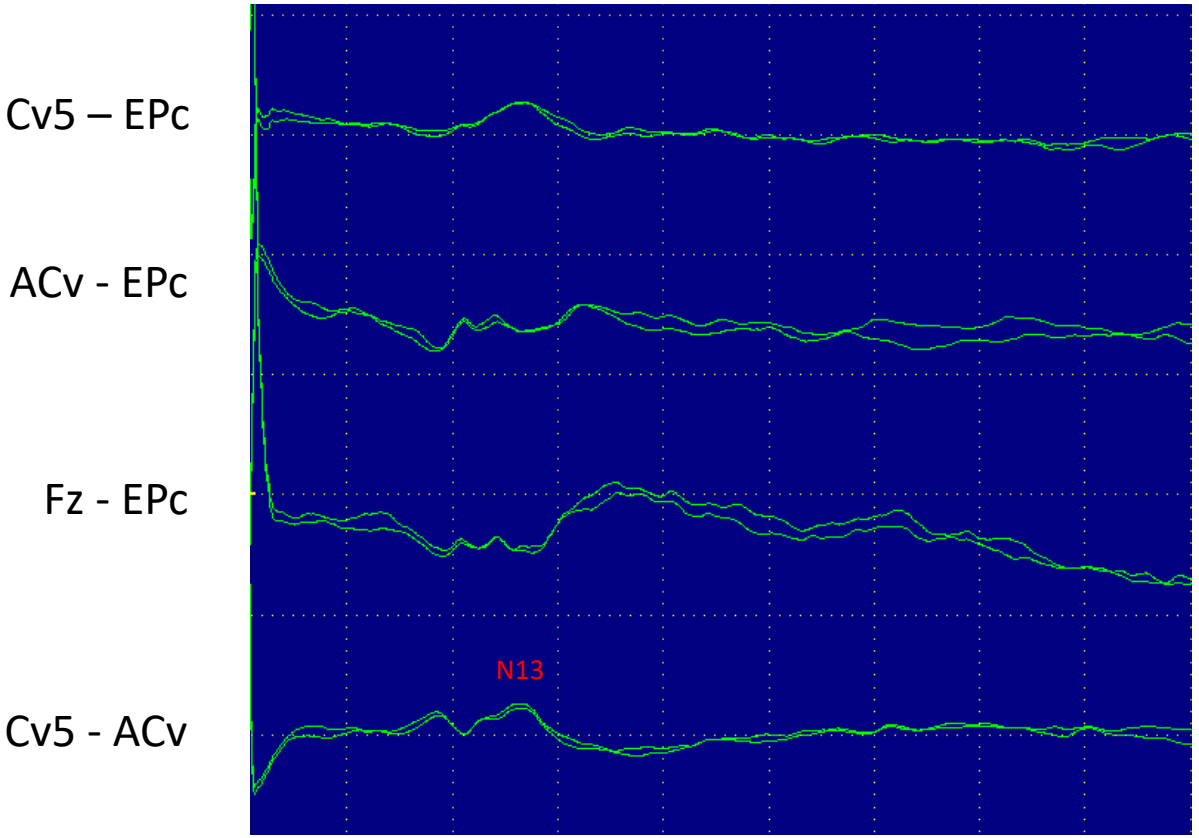
ACv - EPc



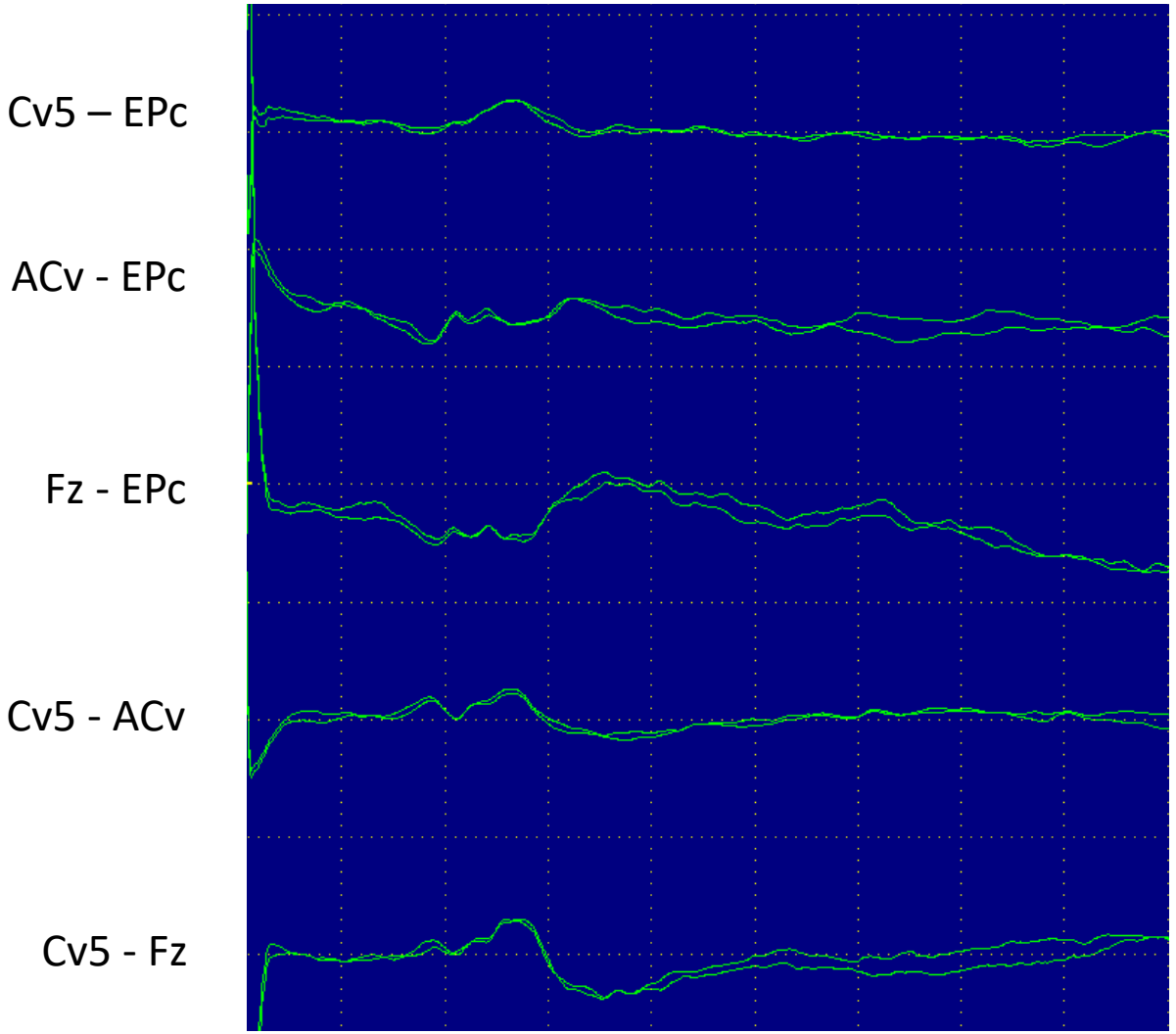
Inadequacy of the Fz reference



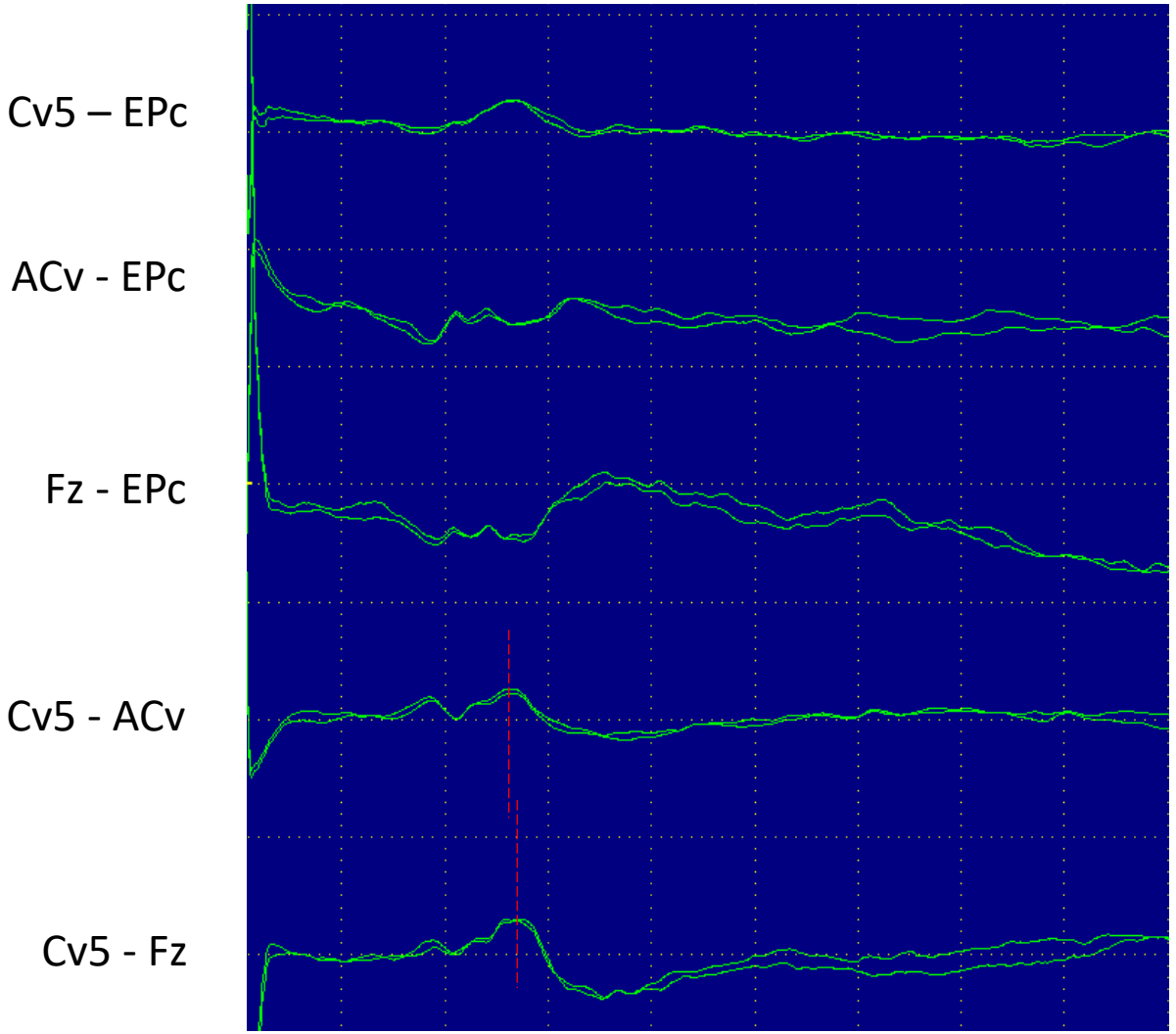
Inadequacy of the Fz reference



Inadequacy of the Fz reference

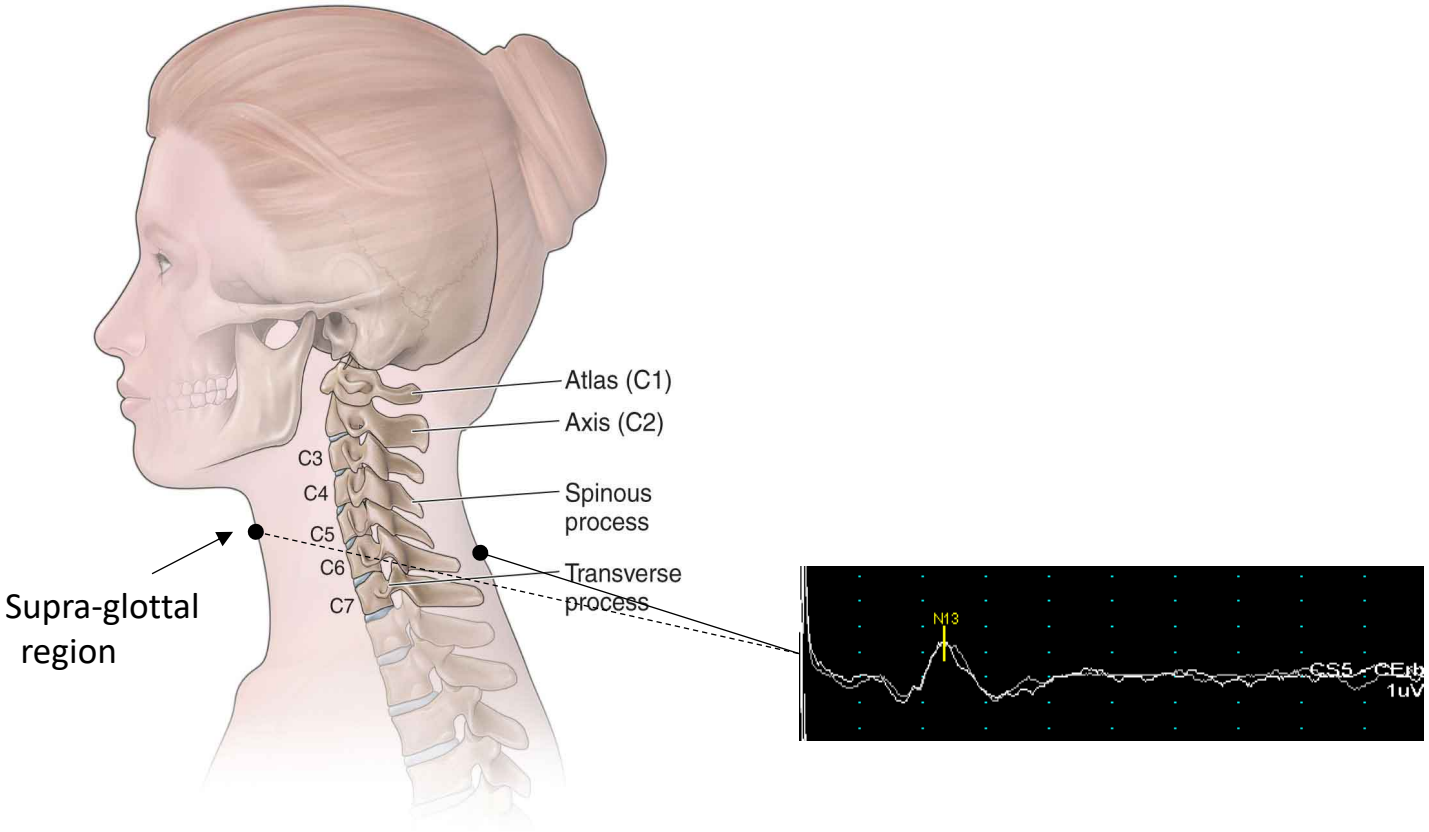


Inadequacy of the Fz reference

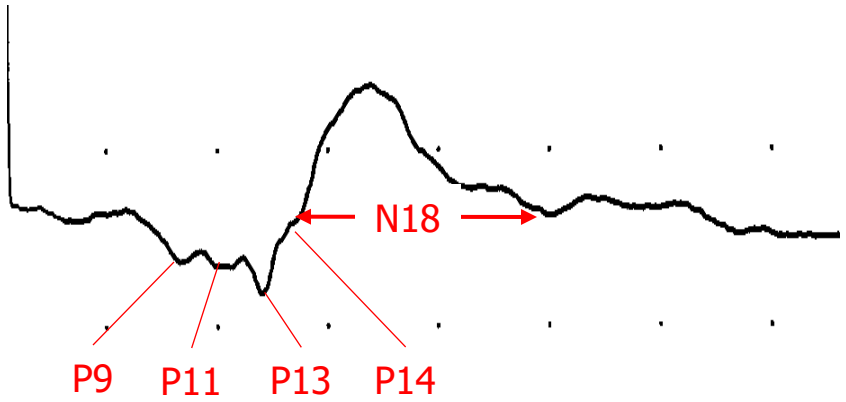


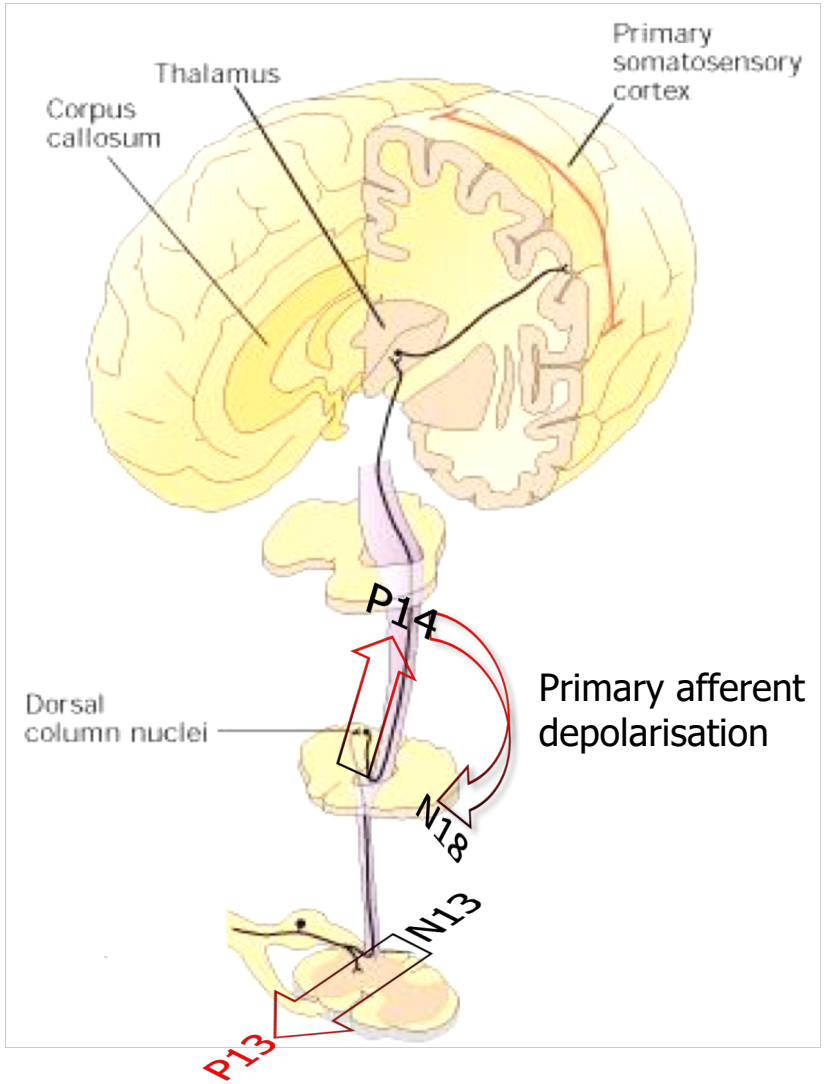
Cervical potential

Guideline – The posterior spinal electrode is located over the lower cervical region (C5-C7) to record the stationary cervical potential (N13). It is recommended that an anterior cervical electrode placed over the supra-glottal region is used a reference, so that near-field potentials generated in the cervical spinal cord are distinguished from more rostrally generated far-field potentials (P14 and N18) that are recordable from wide areas of the scalp (including Fz).



Far-field potentials

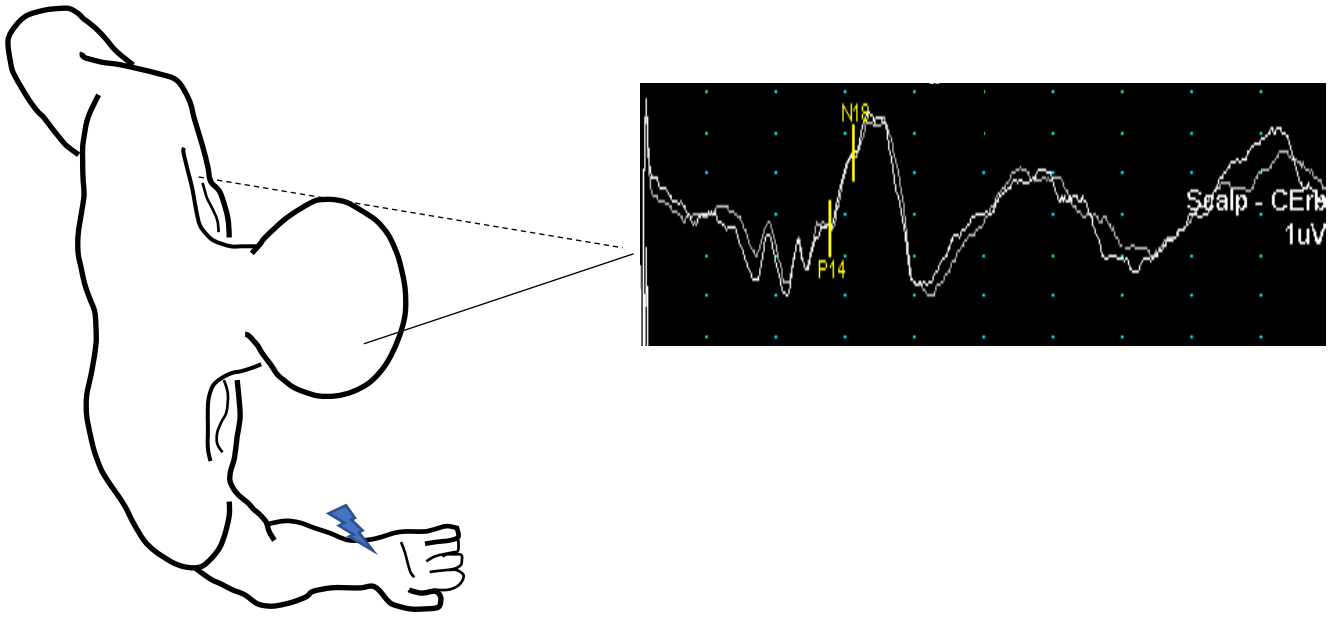




Far-field potentials

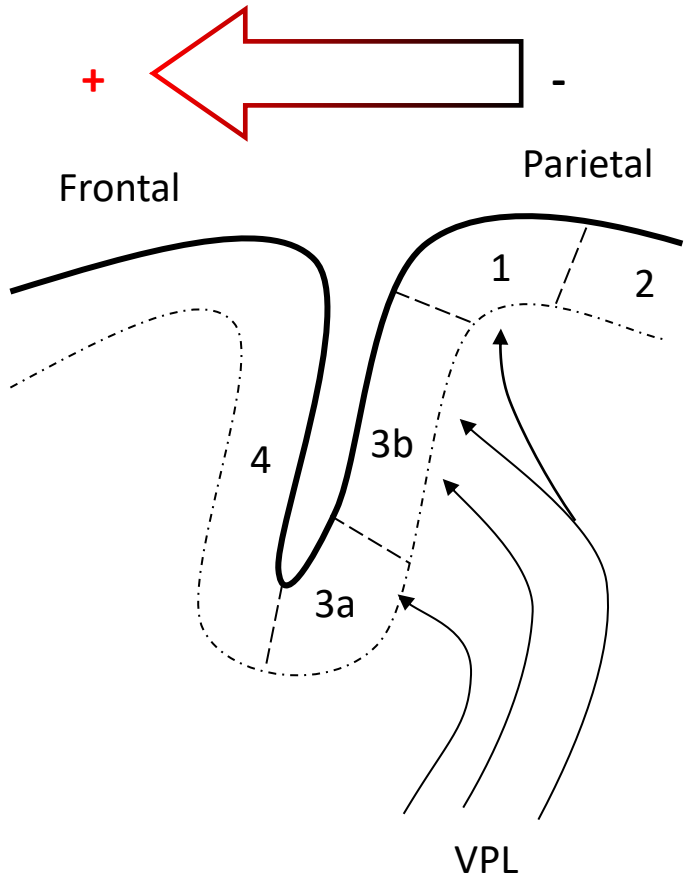
Guideline – A scalp to non-cephalic channel is used to record subcortical far-field potentials arising from the brainstem (P11, P13 and P14 and N18) The P14 probably reflects post-synaptic activity from the cuneate nucleus and caudal medial lemniscus structures at the cervico-medullary junction level. The N18 is a long lasting negative potential reflecting post-synaptic activity between the foramen magnum and thalamus originating from multiple generators.

The far-field potentials can be recorded using a scalp (Ci/Cc or Fz) site referenced to non-cephalic site (Erbs point contralaterally or mastoid)



The cortical N20 generator

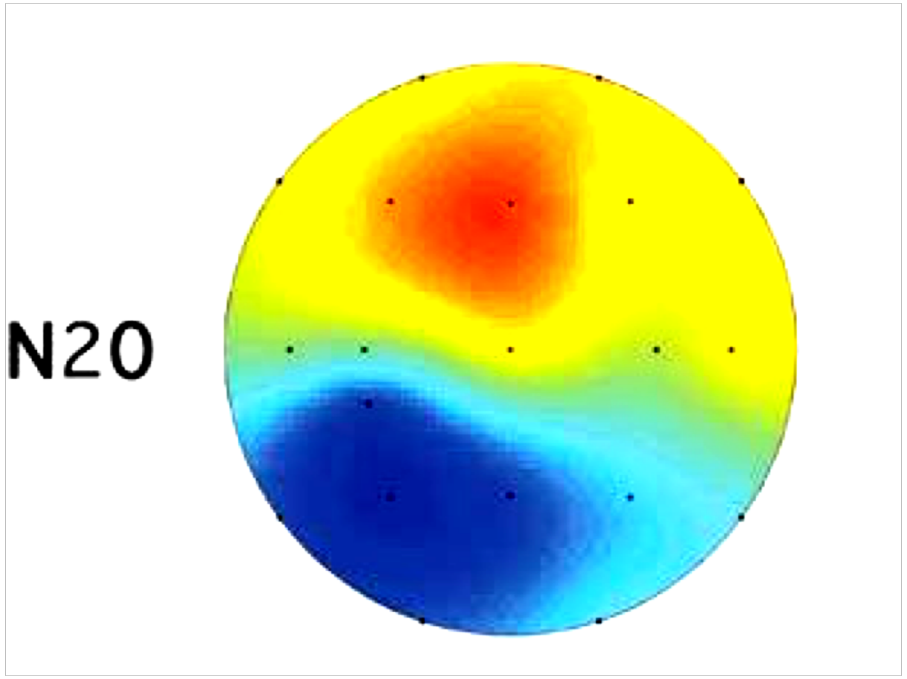
			Reference			
			Fz	Ci	Cz	EPc
Active	Cc (C3/C4)		245 (96%)	5	2	7
	Cz		10			
incomplete		10				



The cortical N20 potential

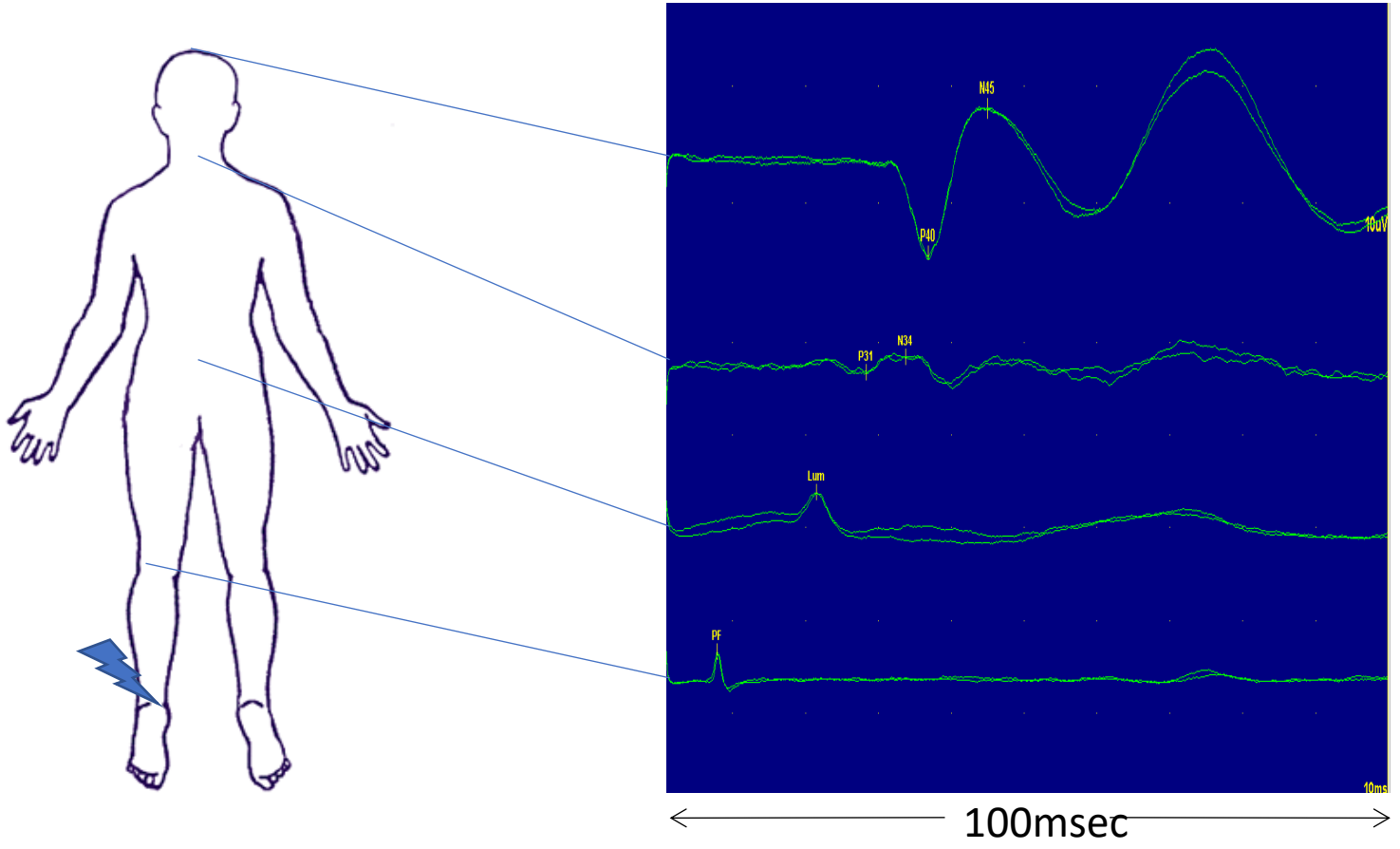
Guideline – A contralateral post-central/parietal electrode site (Cc) is referenced to Fz of the 10-20 system to record the cortical N20 potential.

Option – A transverse Cc-Ci or ipsilateral Ci-Fz montage may distinguish the cortical N20 potential from far-field potentials.



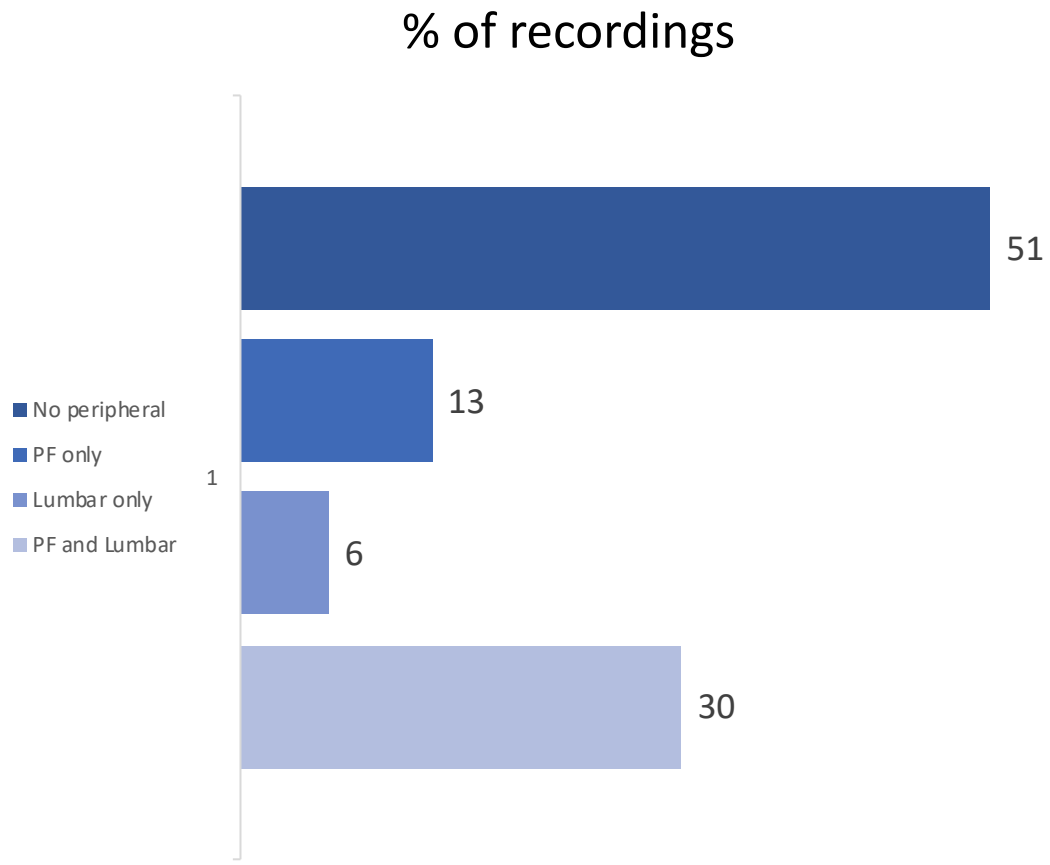
Standard 3 – Lower limb SEPs

It is suggested that a *minimum* of 4 channels are recorded as a standard after independent bilateral stimulation, so that absolute conduction of the peripheral nerve to the popliteal fossa, lumbar cord and cortex can be assessed, along with inter-latency differences and inter-side differences for the conduction time between the lumbar spinal cord and brainstem and brainstem to cortex to be calculated.



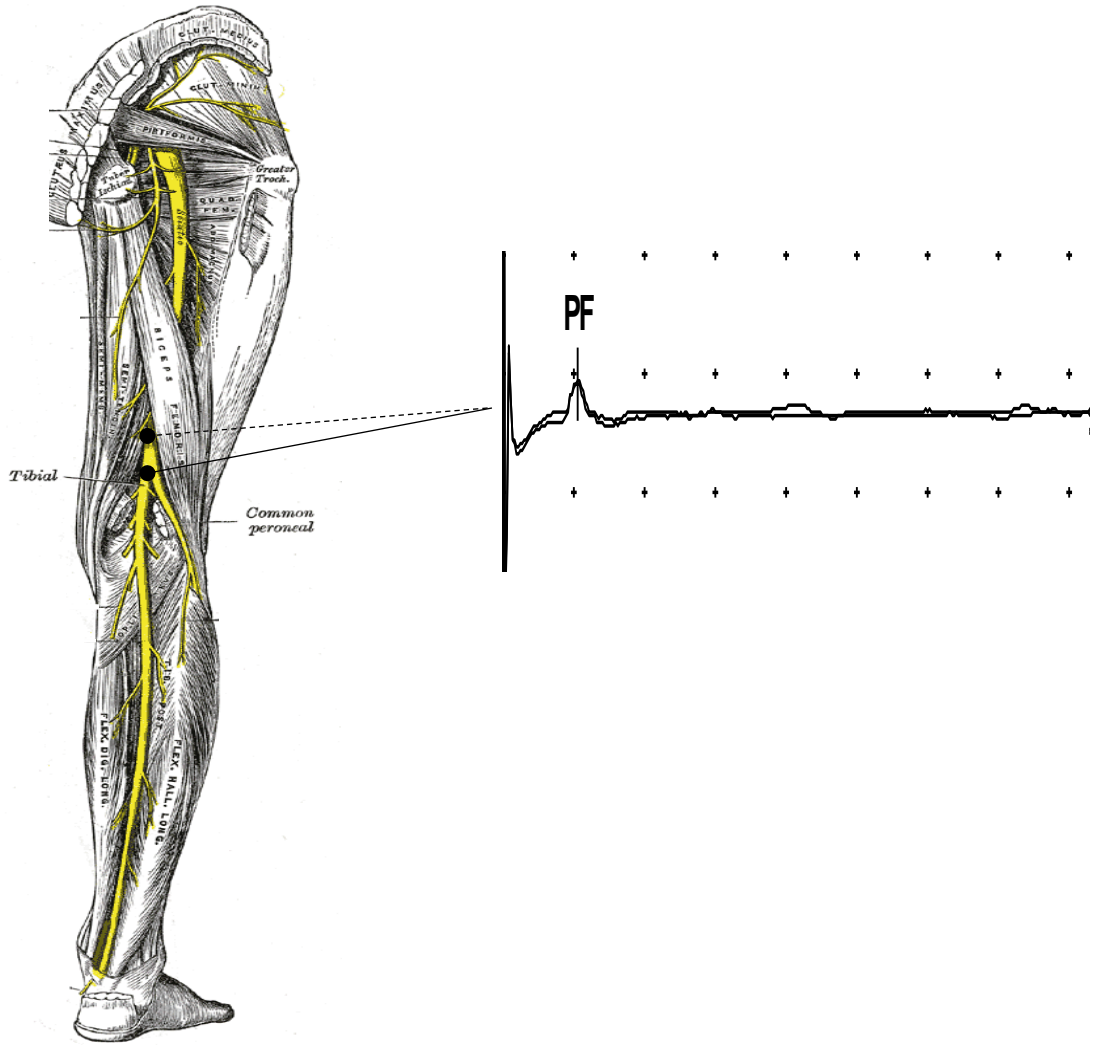
Peripheral and lumbar recordings

	Number
No Popliteal Fossa **or** Lumbar	190
Popliteal Fossa **only**	47
Lumbar **only**	23
Popliteal Fossa **and** Lumbar	110



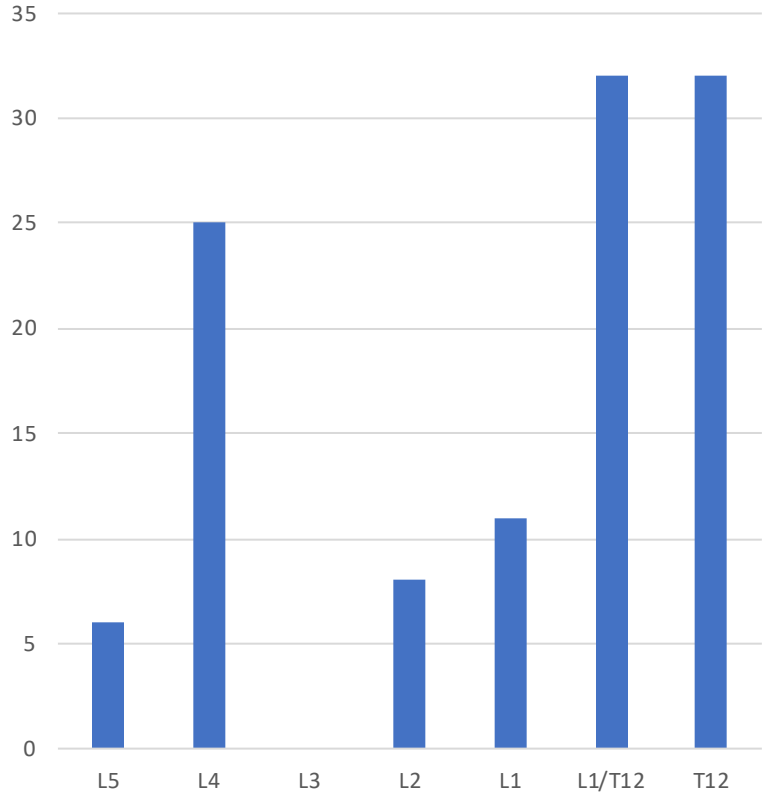
Popliteal Fossa

Guideline – The peripheral compound nerve action potential is measured from a recording electrode placed 4-6cm above the popliteal crease (mid-way between the tendons of the semimembranosus-semitendinosus muscles medially and the biceps femoris laterally). The reference electrode can be placed 3-4cm proximally along the course of the posterior tibial nerve or medially on the femoral condyle.

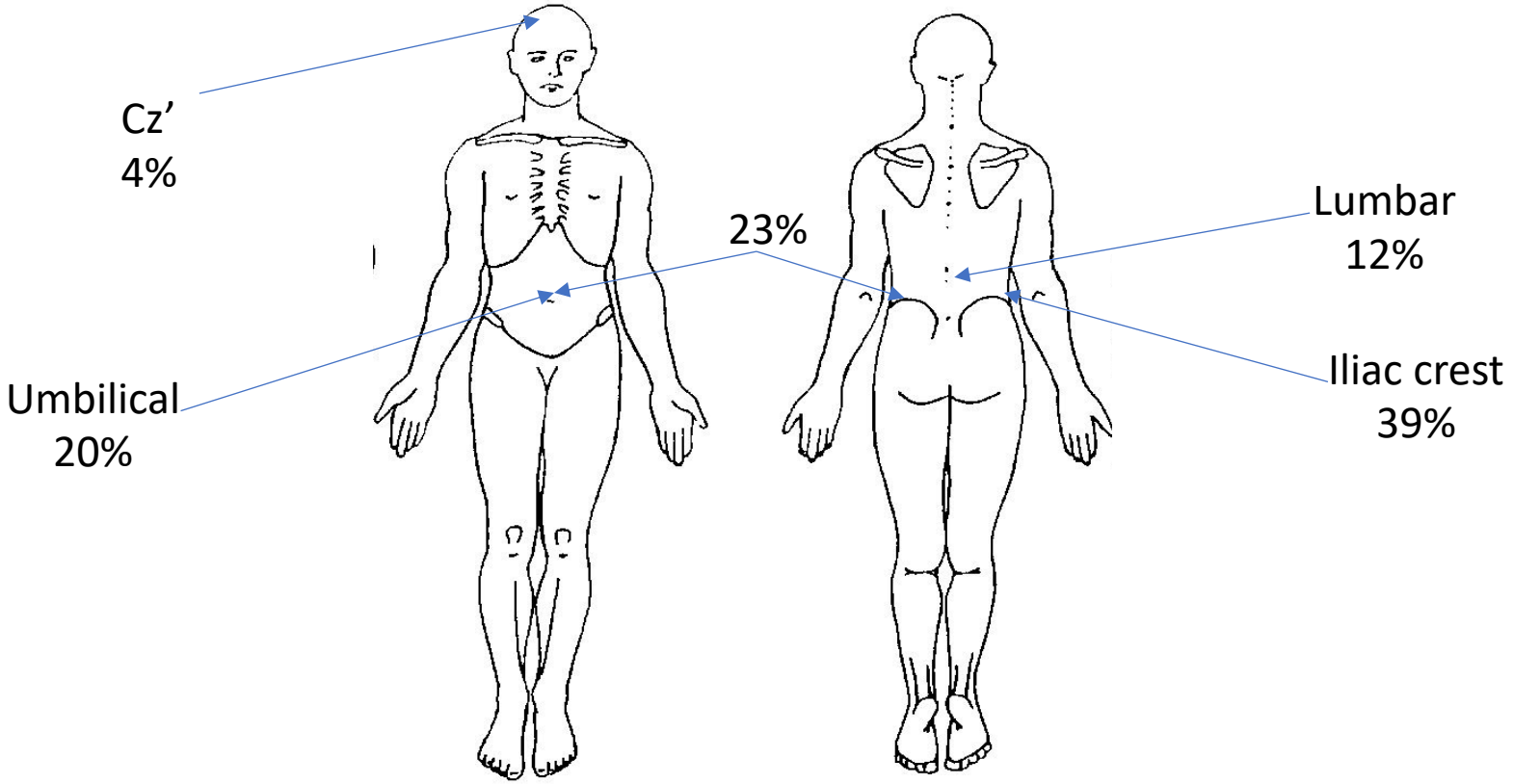


Lumbar – active and reference recording sites

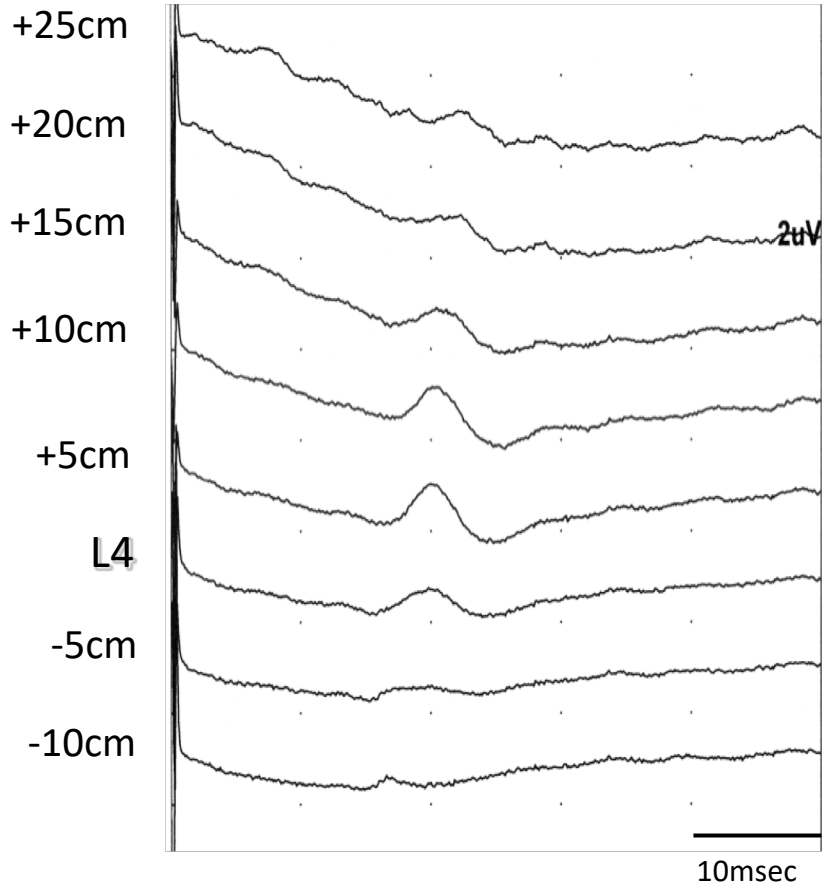
Active recording site



Reference recording site



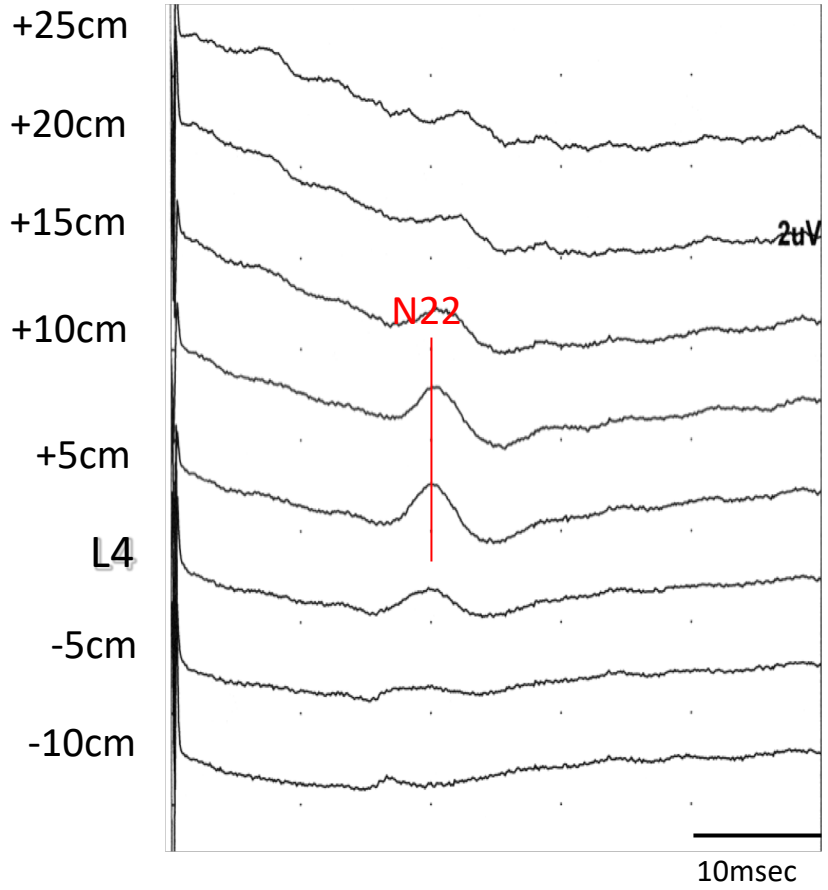
Lumbar spinogram



Stim:
Left tibial

Ref:
R Iliac crest

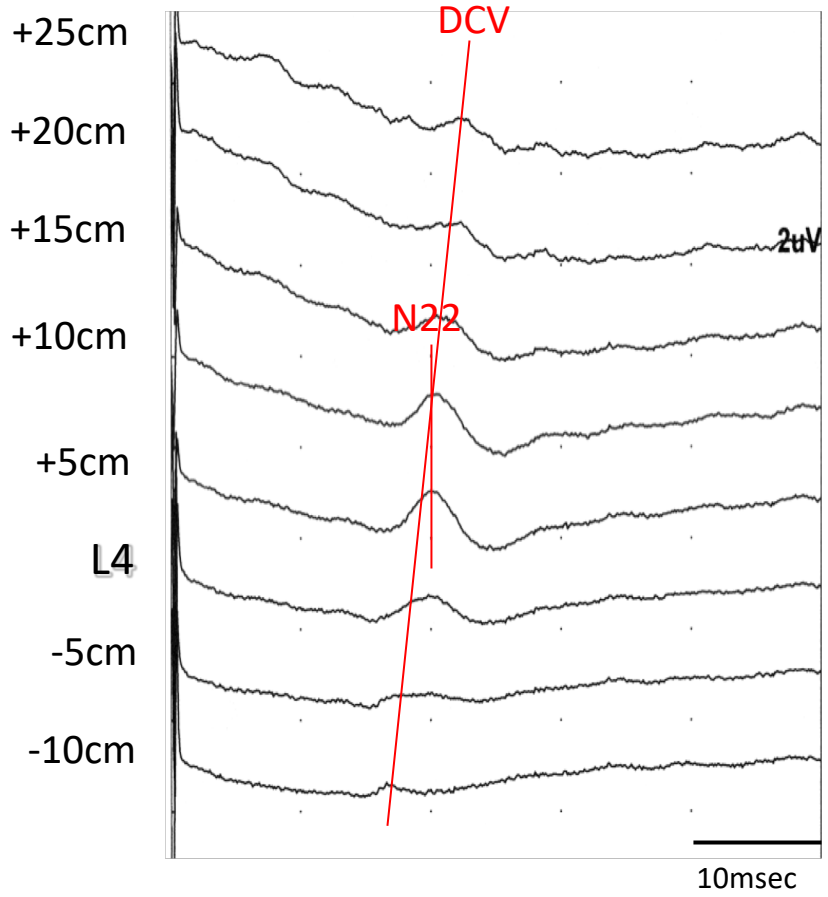
Lumbar spinogram



Stim:
Left tibial

Ref:
R Iliac crest

Lumbar spinogram

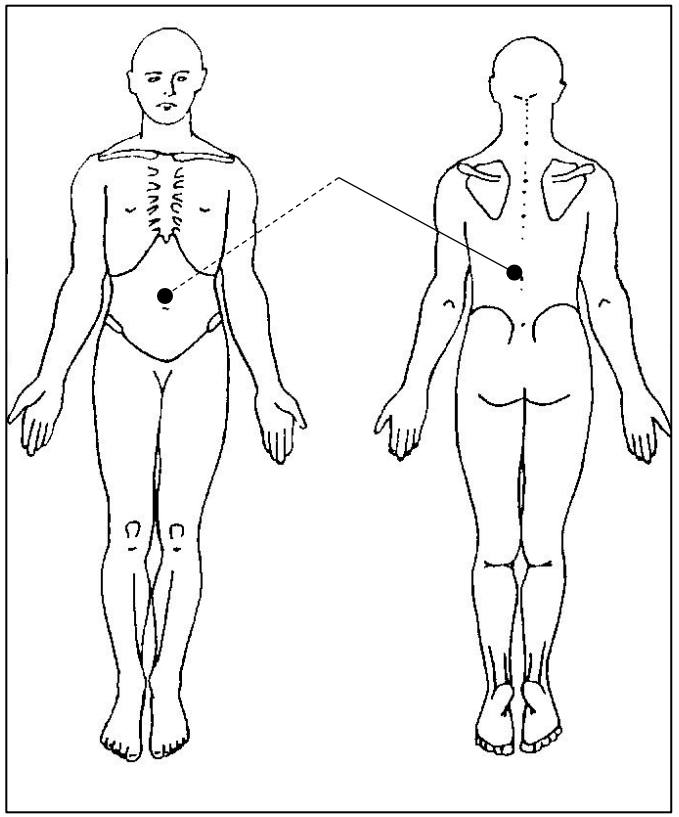


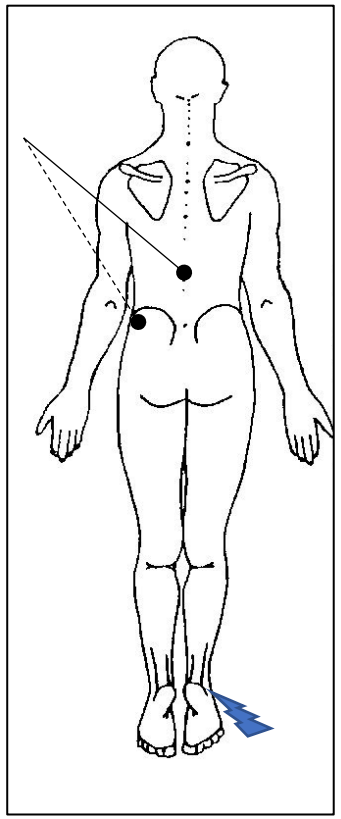
Stim:
Left tibial

Ref:
R Iliac crest

Lumbar- active and reference recording sites

Guideline – An upper lumbar (L1/L2) site is referenced to a supra-umbilical or contralateral iliac crest electrode to record the stationary post-synaptic activity of the lumbro-sacral cord.

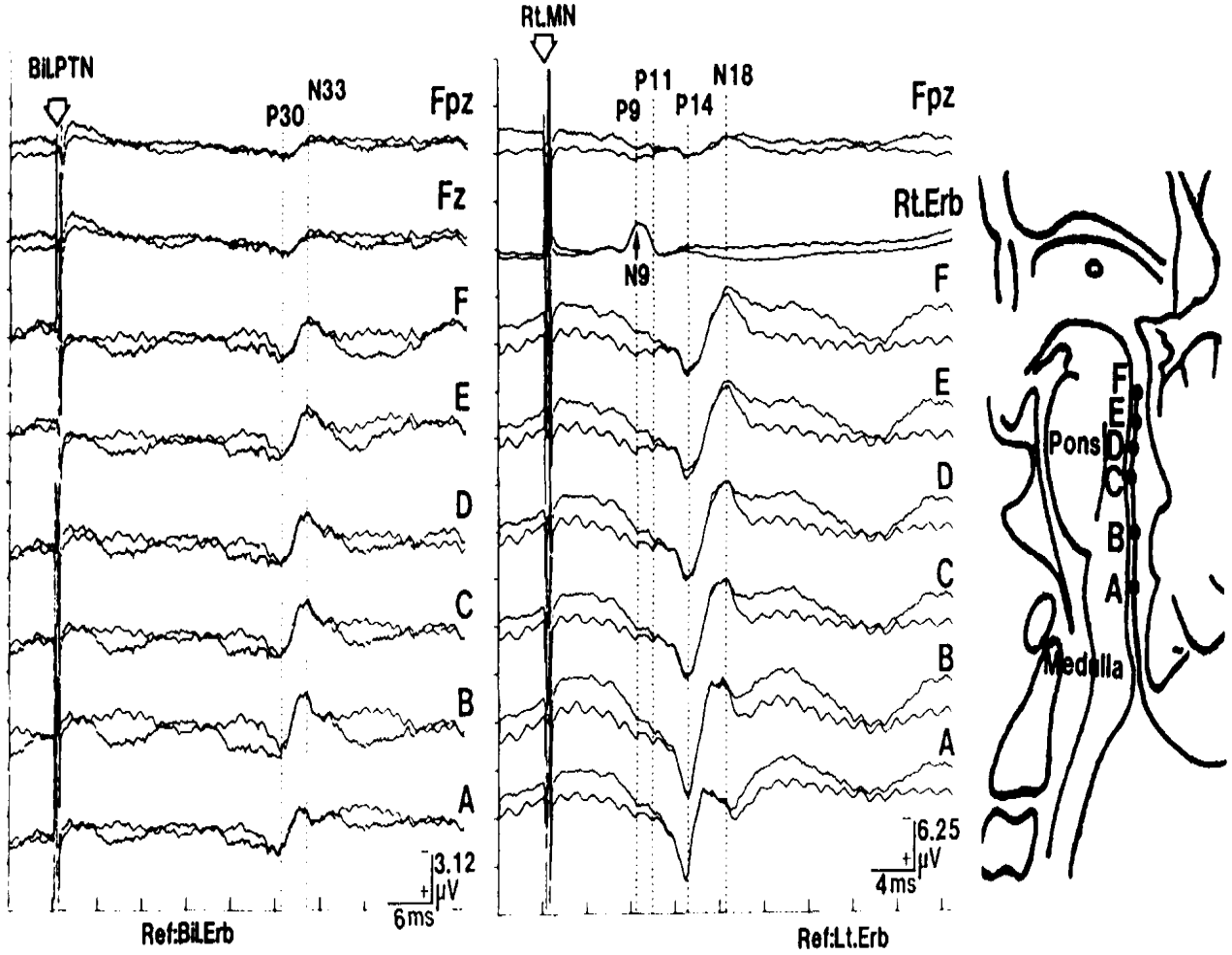




Far-field potentials

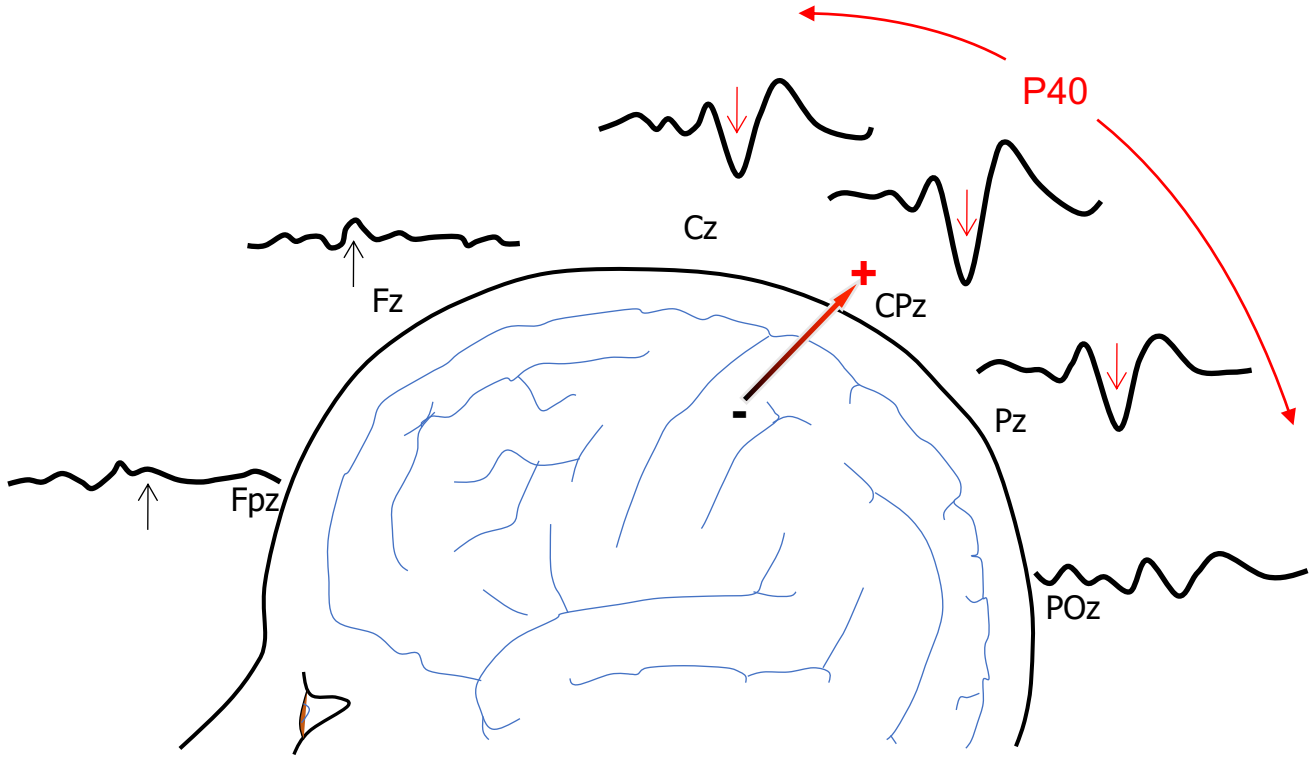
Guideline – After lower limb stimulation a widespread positive potential (P30) is recorded with a frontal preponderance, and is likely to be analogous with the upper limb P14 potential, arising from supraspinal generators at the cervico-medullary region. This potential is followed by a negative potential (N34) that arises from multiple sub-cortical generators between the lower brainstem and thalamus and is likely to be analogous to the N18 potential of the upper limb.

The far-field potential can be recorded using a mid-frontal (Fz) to non-cephalic (Cv) reference site.

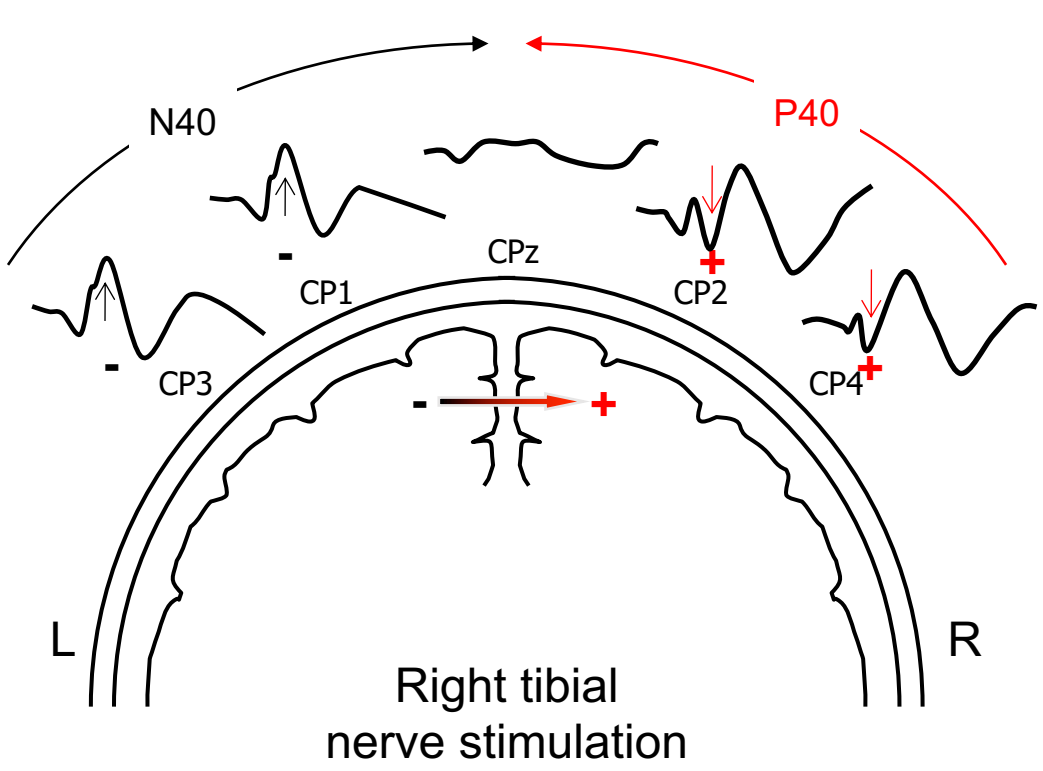


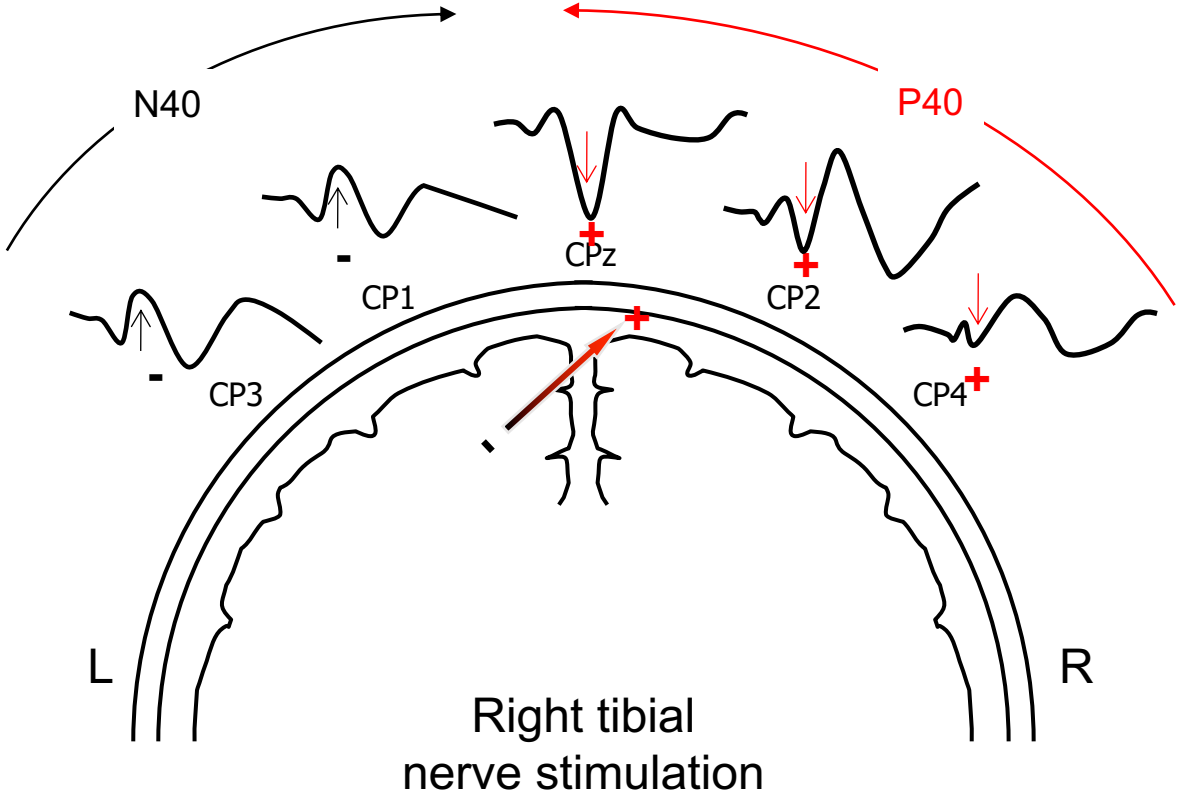
The P40 cortical potential

		Reference		
		Fz	Ci	Cc
Active	Cz’	244 (67%)	40*	
	Ci			64*
	Ci/Cc	15*		
No data		9		



The P40 cortical potential - paradoxical lateralisation





The P40 cortical potential

Guideline – A midline post-central/parietal electrode site (Cz') is referenced to Fz of the 10-20 system to record the major positive potential arising from the sensory cortex.

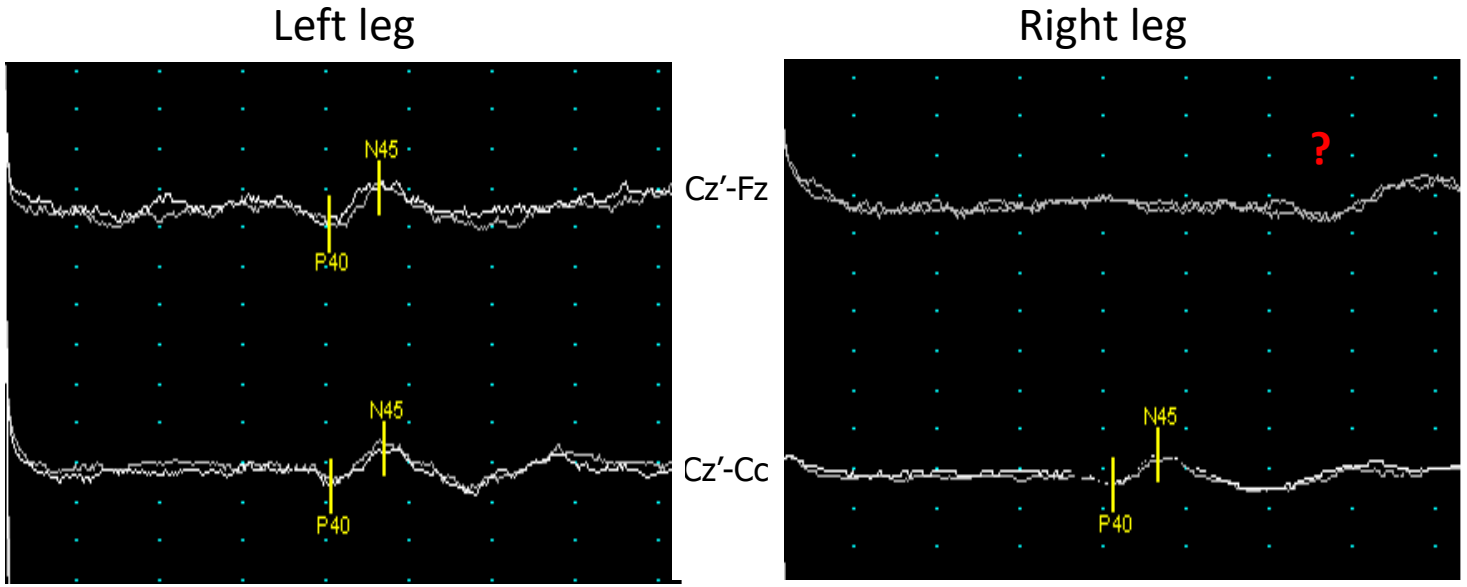
Option – Additional channels may be utilised to distinguish the distribution of the major positive potential

i.e. Cz'– Cc,*

Cc – Fz,

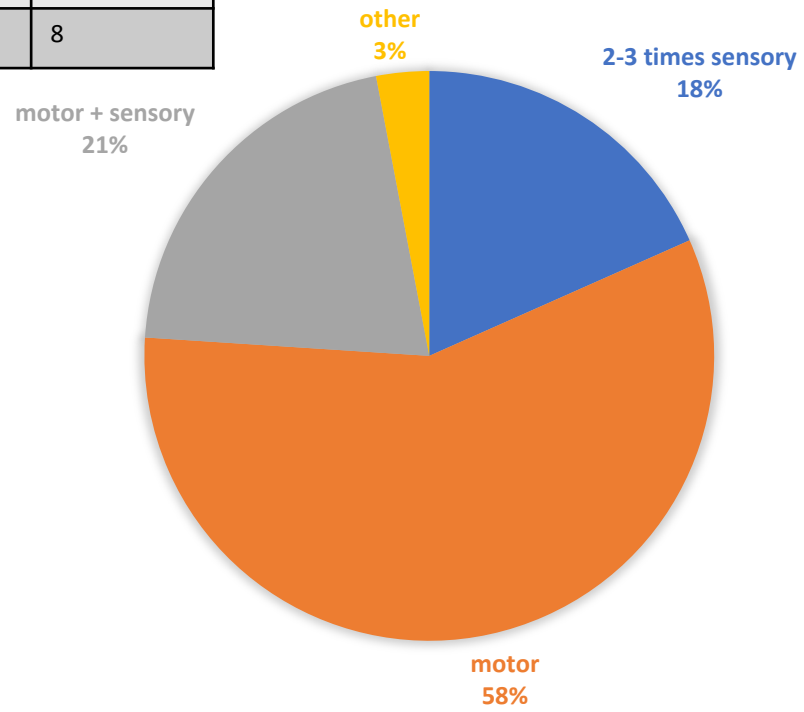
Ci – Fz,

Ci – Cc

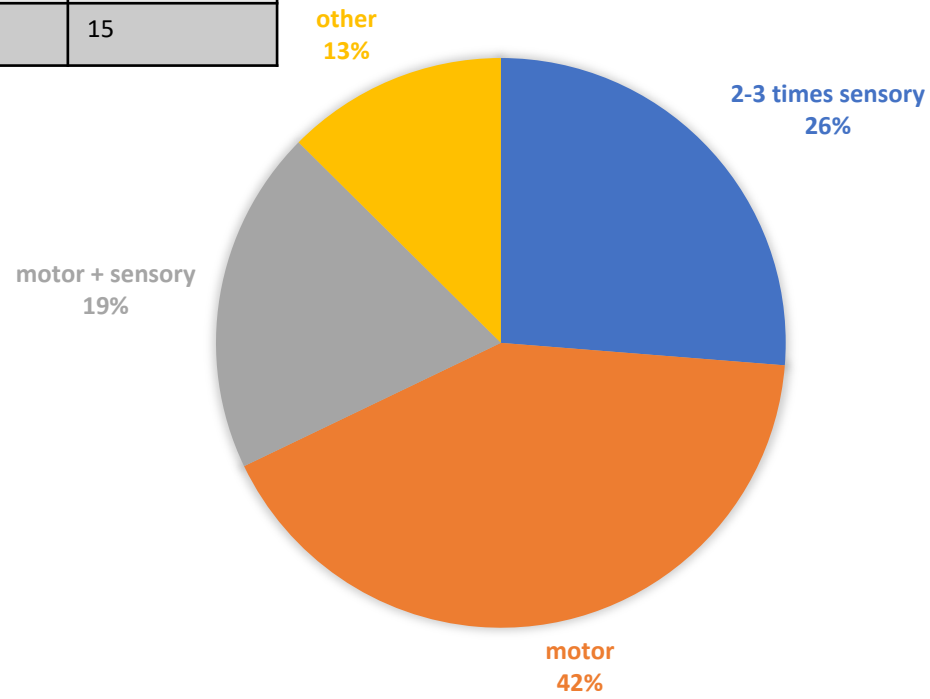


Stimulus intensity

Upper Limb	number
2-3 times sensory	49
Motor	154
Sensory + Motor	53
Other Motor + 50% Motor x2 Supramaximal	 2 3 1
No data	8



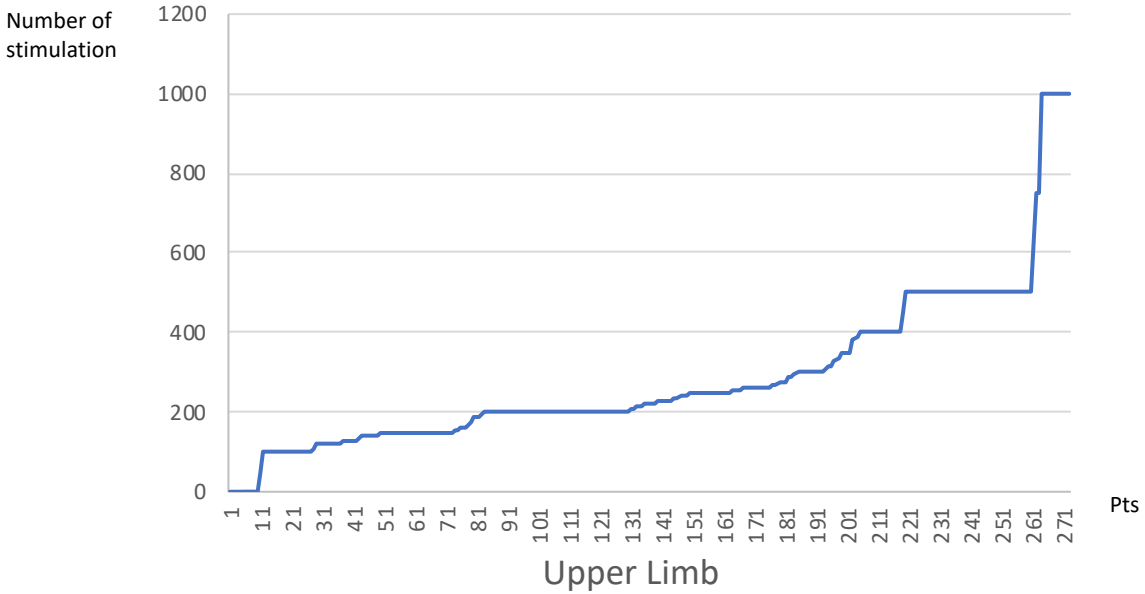
Lower Limb	number
2-3 times sensory	94
Motor	149
Sensory + Motor	70
Other Motor + 50% Motor x2 “good twitch”	45 10 12 18
No data	15

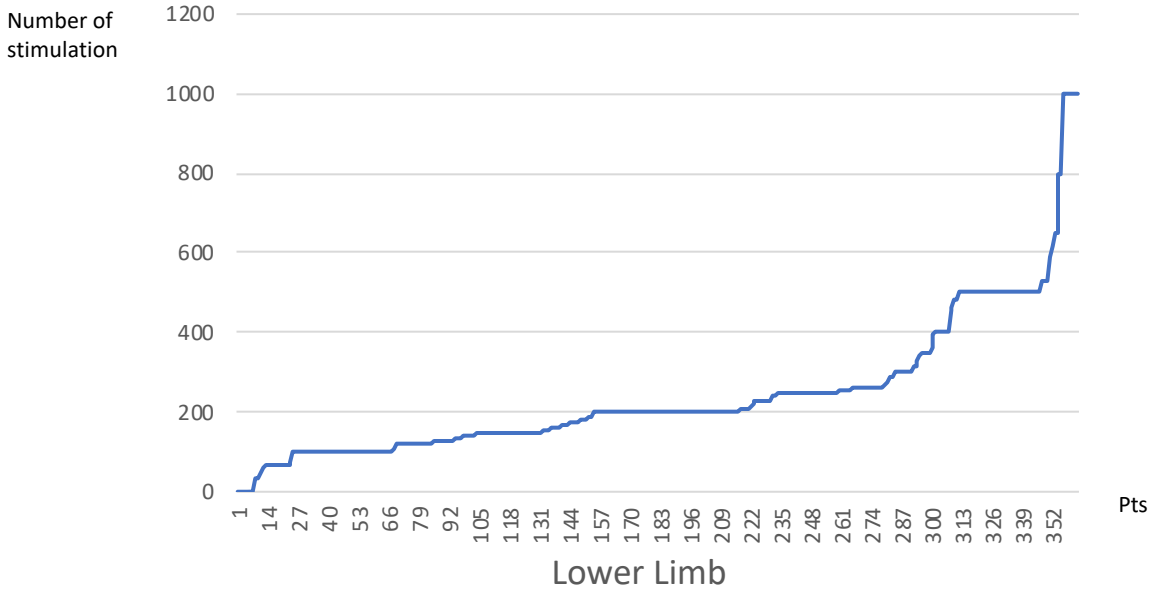


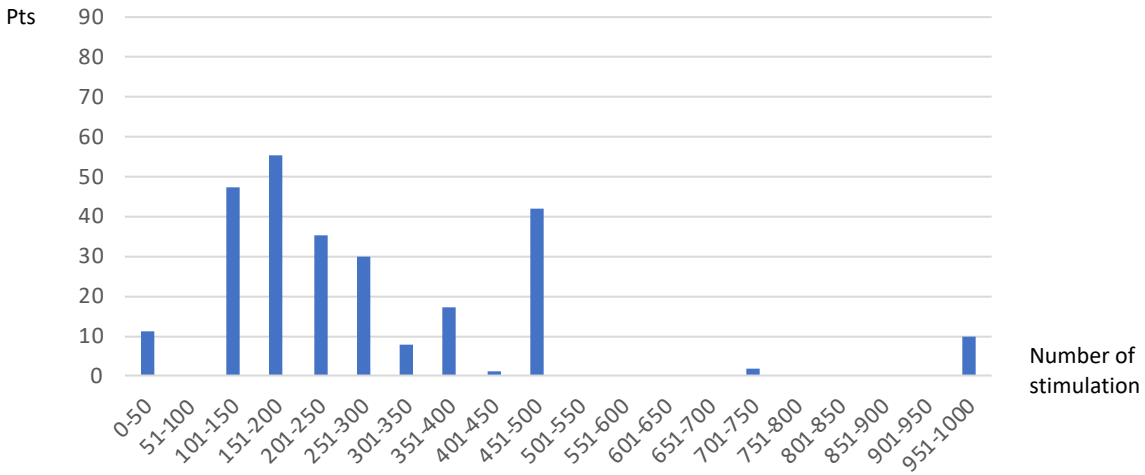
Standard 4

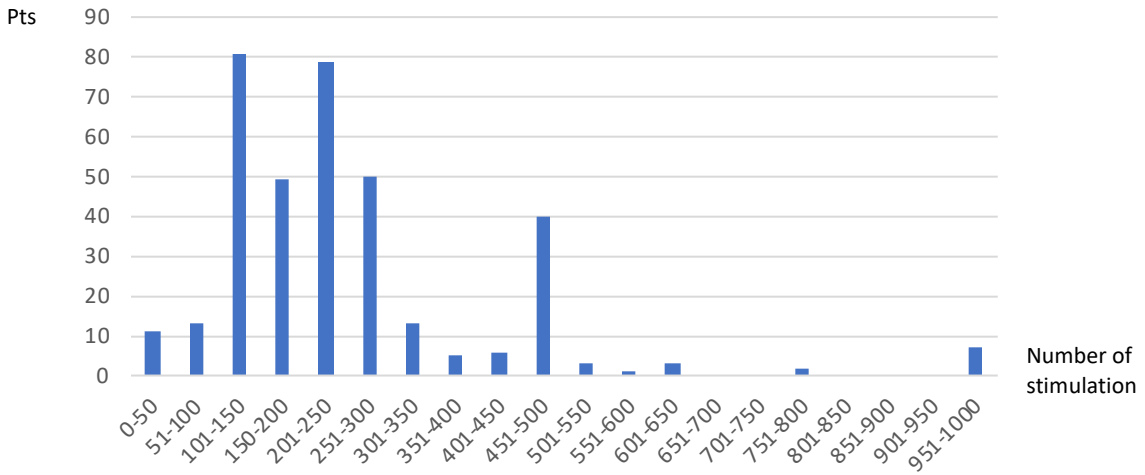
For stimulation of mixed sensory-motor nerves the intensity is set above motor threshold, or at motor plus sensory threshold, to obtain a consistent reliable muscle twitch. For cutaneous nerves the stimulus is set at a tolerable intensity (~3-4 times sensory threshold).

Number of stimuli

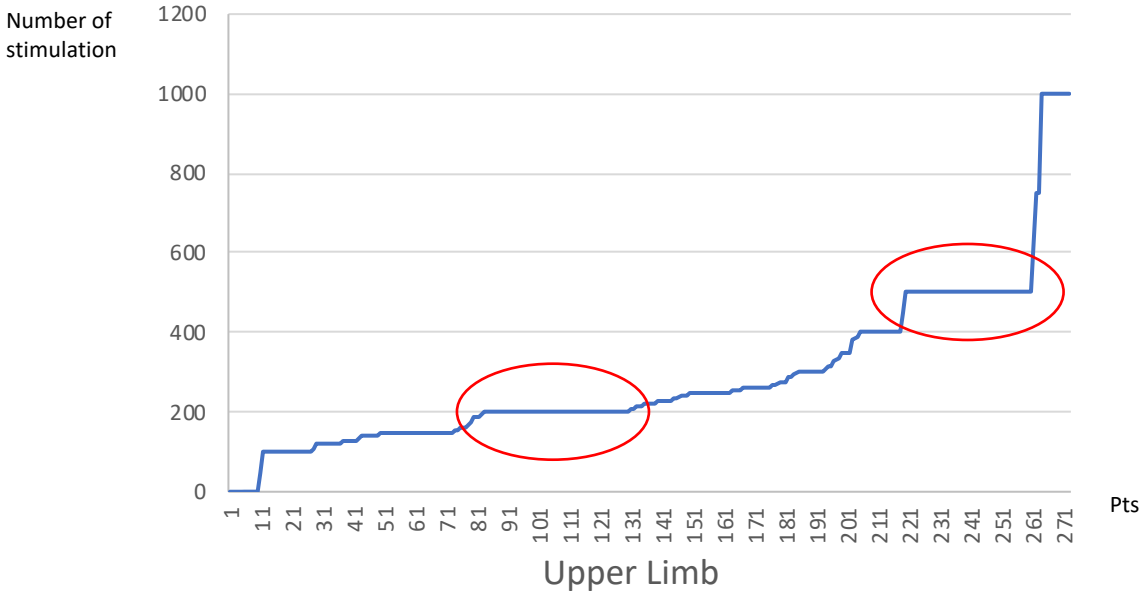


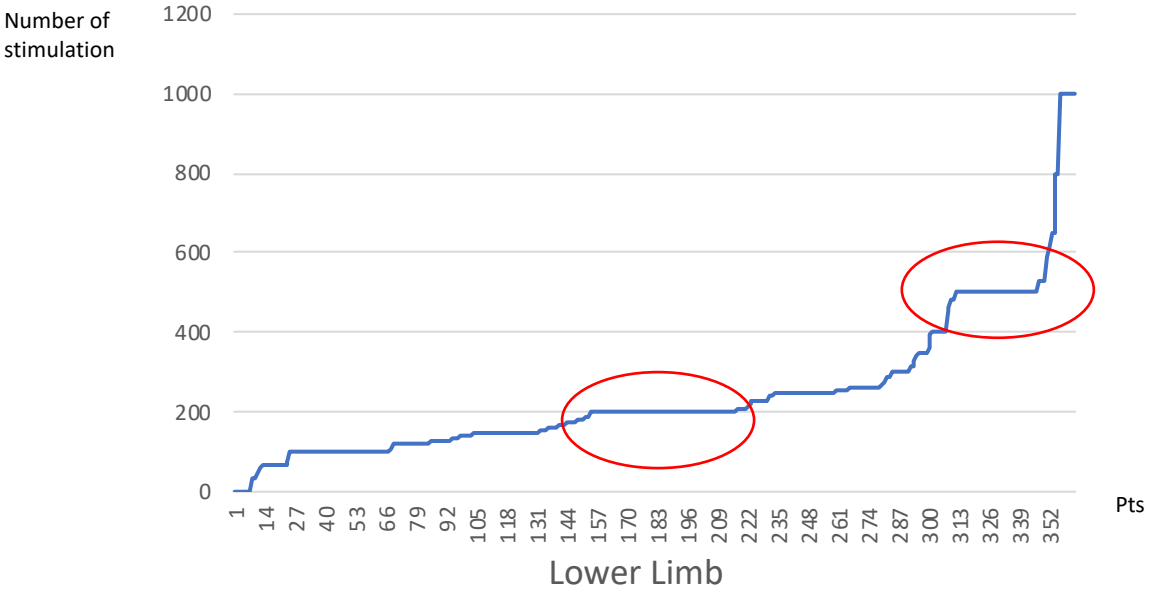


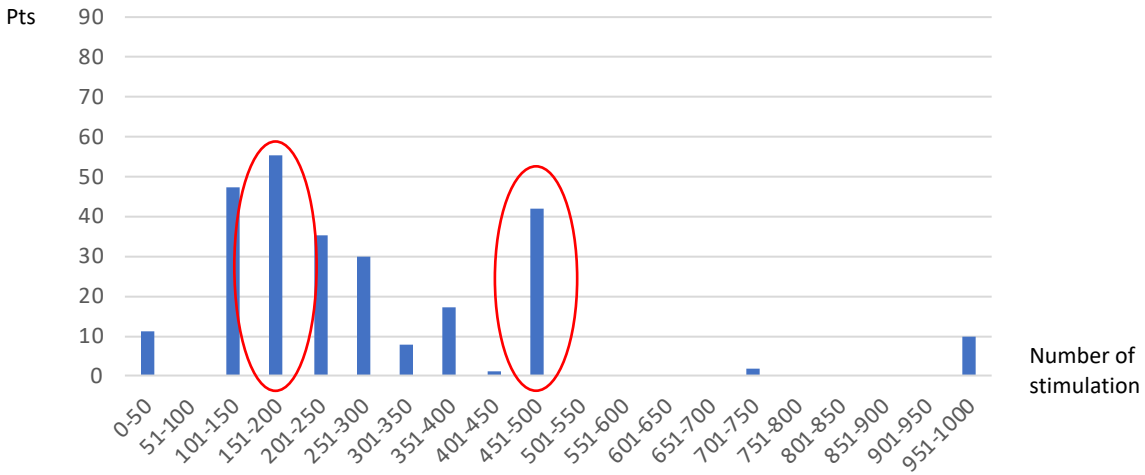


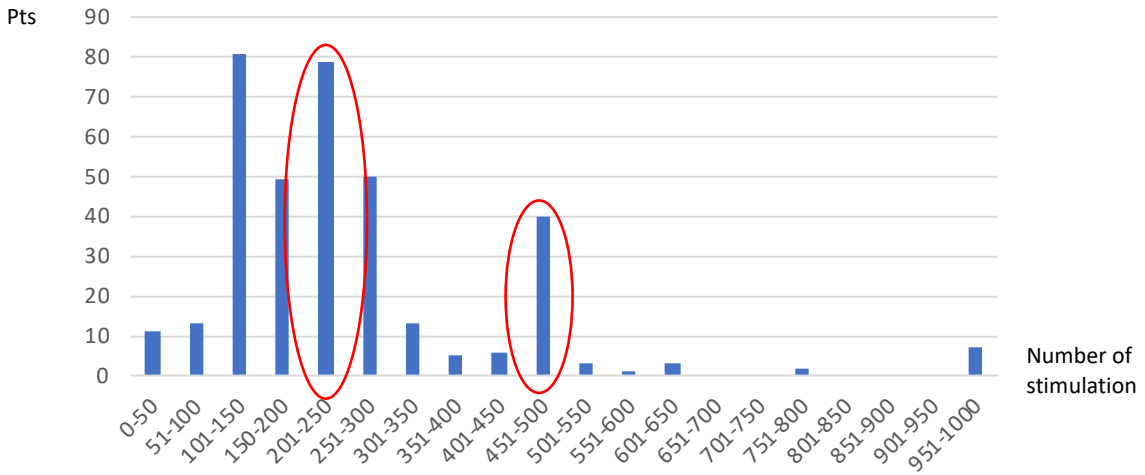


Number of stimuli









Standard 5

In most clinical recordings 200-500 individual trials are averaged to record reliable peripheral and cortical potentials.

For spinal and sub-cortical potentials additional averages may be required, depending on the signal-to-noise ratio.

Replication and superimposition

	Upper limb		Lower limb	
Were the traces replicated?	273/275	99.9%	363/372	97.5%
Where the traces superimposed?	220/273	80.6%	274/366	74.8%

Standard 6

The evoked potential waveforms are replicated and are superimposed to demonstrate the consistency of the latency and morphology of the component measured.

Latency values should be within 0.5-1% of the total sweep time and amplitude replication should be within 15-20%.

Data included in the report

	Upper Limb SEPs		Lower Limb SEPs	
Numerical data only	139	51%	192	53%
Waveforms only	0		1	
Waveforms **AND** numerical data	105	39%	134	37%
No waveforms **OR** numerical data	25	9%	34	9%
No data	6		10	

Professional status and reporting

		Upper Limb	Lower Limb
Was the professional status of the person performing the test included in the report?	Yes	65%	75%
	No	34%	24%
	No data	14	7%
Was the professional status of the person reporting the test included in the report?	Yes	100%	97%
	No		3%
	No data	12	2
Was the report signed?	Yes	91%	88%
	No	8%	12%
	No data	13	14

Standard 7

The report of the investigation contains the numerical data. It makes a statement on any abnormality detected. The professional status of the practitioner performing the investigation and report is identified.

Option - The report contains illustrations of recorded waveforms.

Standard 8

The report is signed by the practitioner taking medico-legal responsibility for it.

References

Mauguiere, F. *et al., (1999)* Somatosensory evoked potentials. *Recommendations for the Practice of Clinical Neurophysiology: Guidelines of the IFCN* (EEG Suppl, 52)

Crucco, G. *et al.,* (2008) Recommendations for the clinical use of somatosensory-evoked potentials. *Clin Neurophysiol*, 119 pp. 1705-1719.

ANS Evoked Potential writing group. (2013) Somatosensory evoked potentials. *Journal of the Association of Neurophysiological Scientists,* 6 pp. 9-32.

Mauguiere, F. and Restuccia, D. (1991) Inadequacy of the forehead reference montage for detecting abnormalities of the spinal N13 SEP in cervical cord lesions. *Electroencephalogr Clin Neurophysiol*, 79 pp. 448-456.