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Dermatomal Somatosensory Evoked Potentials of the Lumbar and Cervical Roots

Method and Normal Values

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Summary. We describe a method for obtaining cortical evoked potentials after stimulation of the lumbosacral and cervical dermatomes in healthy volunteers. Such dermatomal evoked potentials are expected to contribute to the diagnosis of lumbar and cervical root entrapment. Normative data are presented for each dermatome including left-right differences. A significant correlation was found between absolute latencies and body length for the lumbosacral segments. This correlation was virtually absent in the cervical segments. The latency difference between the same cervical or lumbosacral dermatome left and right was also independent of body length for all segments.

Key words: Dermatome – Somato sensory evoked potential (SEP)

Introduction

In recent years several papers have been published on the usefulness of evoked potentials in the diagnosis of root entrapment in the lumbar and cervical region. A variety of recording methods has been presented. Some authors use stimulation of mixed nerves, such as peroneal or tibial nerves (Feinsod et al. 1982), whereas others use sensory nerves, such as sural, saphenous, or superficial peroneal nerves (Eisen et al. 1983; Perlik et al. 1986). Only a few authors have described the use of dermatomal stimulation (Aminoff et al. 1985a, b; Scarff et al. 1981). The method of stimulating peripheral nerves seems to have limited value, as these nerves generally contain fibers coming from more than one root; in consequence evoked potentials can be normal in the case of monoradiculopathy, since normal conducting nerve fibers of spared roots will conduct the evoked potential. For this reason we expected dermatomal stimulation to have more diagnostic value in monoradiculopathies. We present reference data on the lumbosacral dermatomes L3, L4, L5, and S1 and on the cervical dermatomes C5, C6, C7, and C8. These data add normal values of a large number of dermatomes to the normative data of L5 and S1 described by Katifi et al. (1985, 1986).

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Materials and Methods

Recordings from the cervical regions were made on 35 volunteers, 18 male and 17 female, aged 18–56 years (mean 28). Recordings from the lumbar region were made on 37 volunteers, 18 male and 19 female, aged 18–56 years (mean 27). None of them had a history of complaints of brachial or ischiadic pain, or pain in the neck or back and none of them showed any neurological deficit. The recordings were made with the subject in the supine position. The skin temperature was kept at least at 30°C and the room temperature at 23°C. During the recording session the subjects were instructed to relax. The recordings were partly made at the Medical Centre Leeuwarden and partly at the Radboud University Hospital Nijmegen under the same conditions and with the same equipment.

Disc electrodes were placed at Cz′ (between Cz and Pz of the international 10–20 system) when stimulating the legs and at C4′ and C3′ (between C4 and P4, and C3 and P3) when stimulating the arms. The reference electrode was placed at Fz, the ground electrode at Fpz. Bipolar surface electrodes were used for stimulation with an interelectrode distance of 2 cms. The cathode was placed proximally.

The places of stimulation of dermatomes were chosen in such a way that no large nerve trunks could be stimulated, and in accordance with the clinically and anatomically known dermatome borders (Clara 1959; Nieuwenhuys 1975). The stimu-

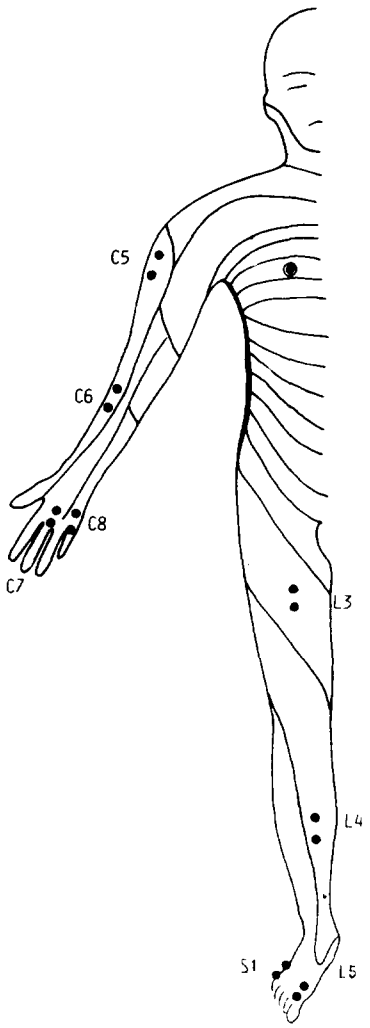


Fig. 1. Stimulation points of the lumbosacral and cervical dermatomes

lation points are summarized in Fig. 1. For S1 this stimulation point was at the lateral side of the fifth metatarsal bone, for L5 at the medial side of the second metatarsal bone. The stimulation point of L4 was defined at the midpoint of a line between the medial malleolus and the medial epicondyle of the tibial bone. L3 was defined midway along a line between the anterior superior iliac spine and the medial condyle of the tibia. For the cervical segments the stimulation point for C8 was chosen on the lateral side of the fifth metacarpal bone, for C7 just between the second and third metacarpal bones. For C6 this point was at one-third of the styloid process of the radius. For C5 it was located at one-third along a line between the tip of the acromion and the lateral epicondyle of the elbow.

For each dermatome the threshold of sensation was measured and the stimulus intensity was set 3 times above this level, without exceeding the pain threshold and avoiding visible contractions of underlying muscles. The stimulus rate was 2.3/s, and pulse duration was 0.2 ms. The data were obtained using a Nicolet Pathfinder II. The amplifier bandpass was 5–250 Hz. A prestimulus interval of 45 ms was part of the 150 ms display window. Automatic artifact rejection was used. The amplification was set to 50 μV full scale. Two series of averages were made for each dermatome, each consisting of 200 single stimulus responses. Both averages were overlayed for inspection of reproducibility. Four somatosensory evoked potential (SEP)s on the left side and the corresponding SEPs on the right side could be displayed simultaneously on the screen (Fig. 2).

Results

Dermatomal cortical SEPs resembled cortical evoked responses after stimulation of the tibial nerve: they consisted of two positive and two negative peaks. The first positive peak was the most consistent and the most sharply distinguishable. From the dermatomes of both sides the latency and amplitude top-to-top of this first positive peak was measured. Then the latency and amplitude differences between left and right of each dermatome were calculated. The Student's *t*-test was performed to see whether the data from the two hospitals belonged to one group. The *P* values for the several dermatomes varied from 0.24 to 0.97, except the *P* value for C5, which was 0.03. This meant that the chance the given data did not belong to the same group was significantly small, even for C5. Therefore the data were merged.

Mean Latency and Correlation with Body Length

Table 1 shows the mean latency of each dermatome together with the SD; the latencies increased from C5 to S1. A positive correlation between the absolute latencies of the lumbosacral dermatomes and body length was expected as this has been found for evoked responses after stimulation of the tibial nerve. For each dermatomal SEP the correlation between latency (mean left, right) and body length was calculated, as well as the regression lines and the 98% confidence limits. From Fig. 3 it is clear that there was a significant correlation with respect to the lumbosacral dermatomes, whereas there was virtually no correlation with respect to the cervical dermatomes (only the regression line for C7 is presented in Fig. 3).

Latency Differences Between Left and Right

For each dermatome SEP the mean latency difference of the first positive peak was calculated between left and right, as well as the SD. Table 2 shows the mean latency differences and 2.5 times the SD, which represented the 98% confidence limits. By way of example Fig. 4 shows the regression line of the latency differences of L4 on body length. The results for the other dermatomes were the same. It can be concluded that the latency differences between left and right did not correlate with body length.

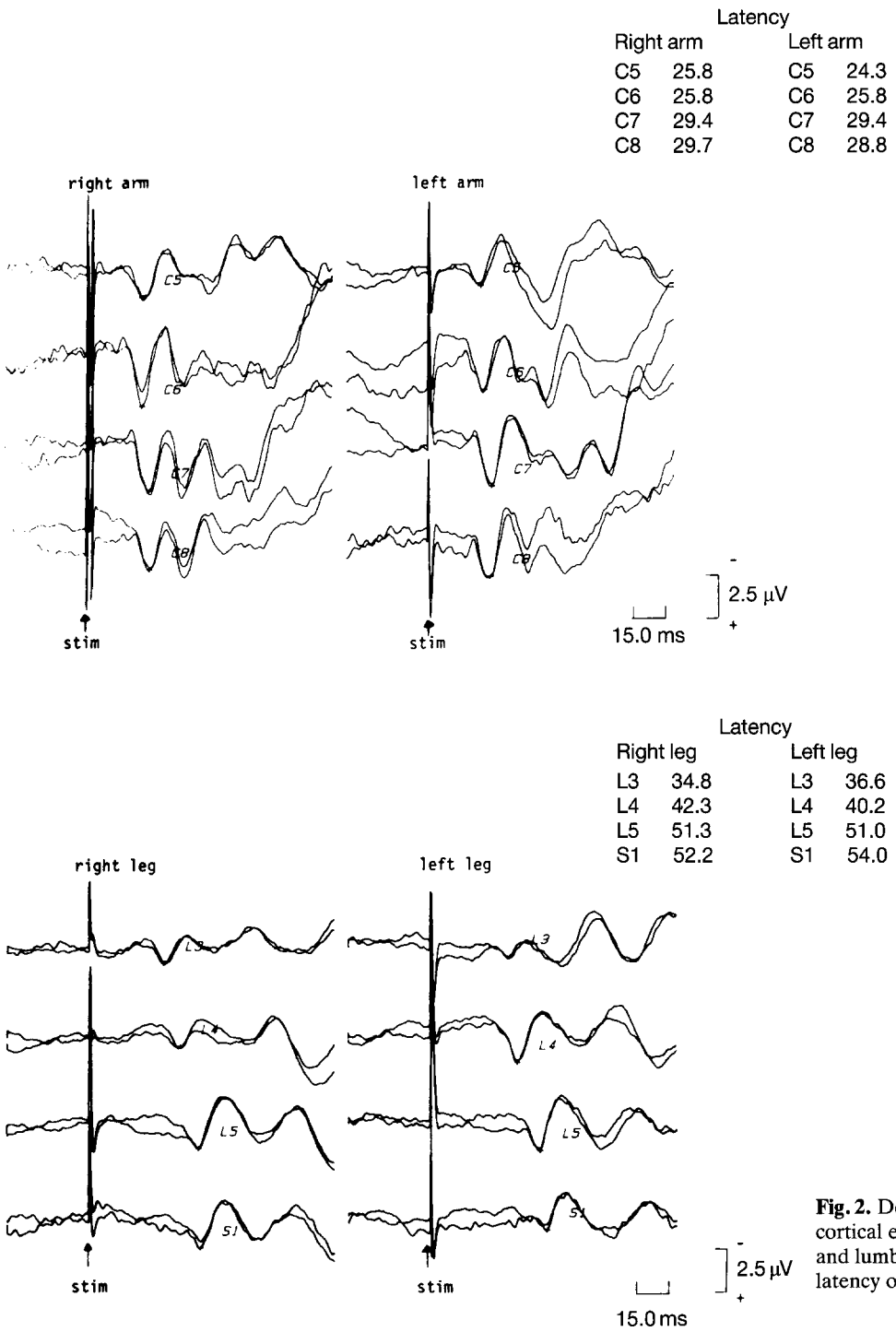


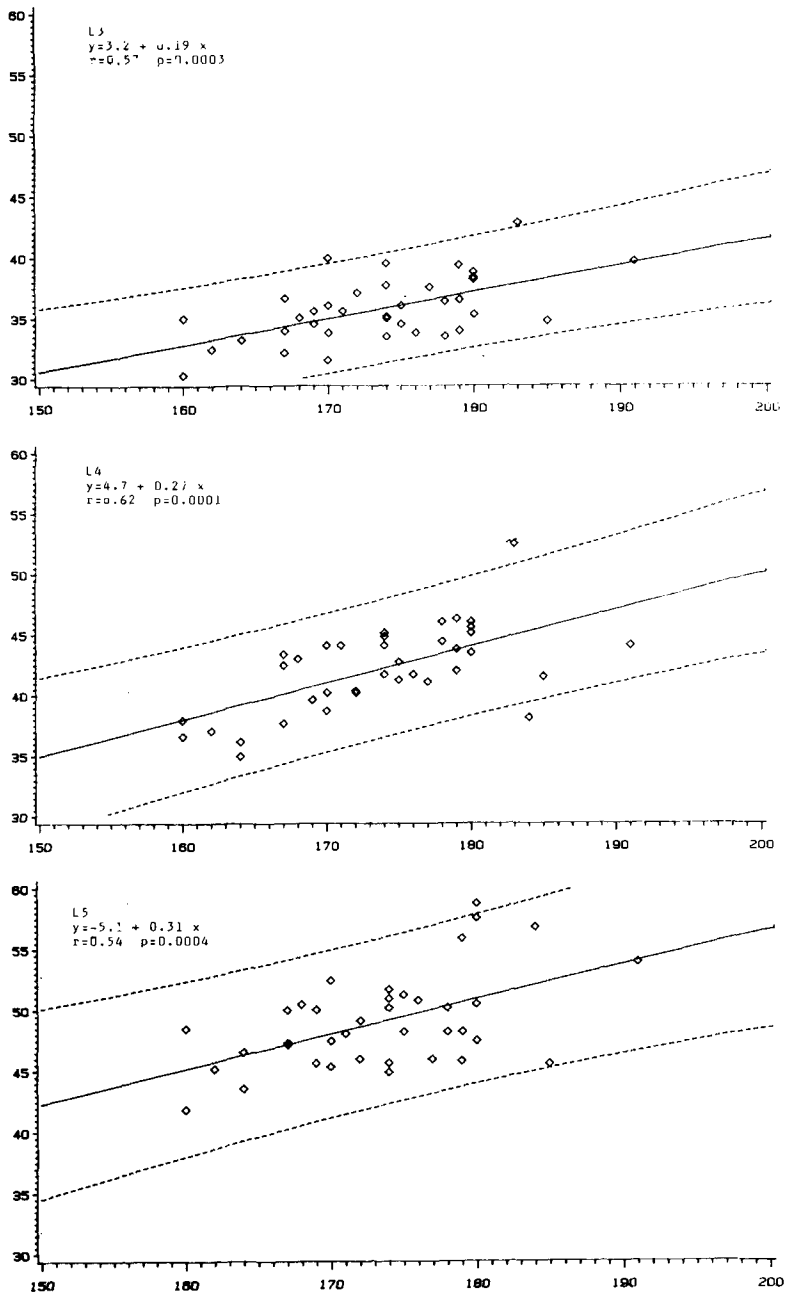
Fig. 2. Dermatomal somatosensory cortical evoked potentials of the cervical and lumbosacral dermatomes with the latency of the first positive peak in ms

Amplitude Difference Between Left and Right

The amplitude of the first positive peak of each dermatome SEP left and right was measured, and the mean ratio was calculated for each dermatome between the smallest and the largest amplitude, as a percentage of the largest one. Table 3 shows the low limit values as the mean minus 2.5 times the SD of these amplitude differences. It shows that the amplitude varied more in the lumbosacral region than in the cervical region.

Discussion

A significant correlation was found between latency and body length with respect to lumbosacral dermatome SEPs, whereas this correlation was absent



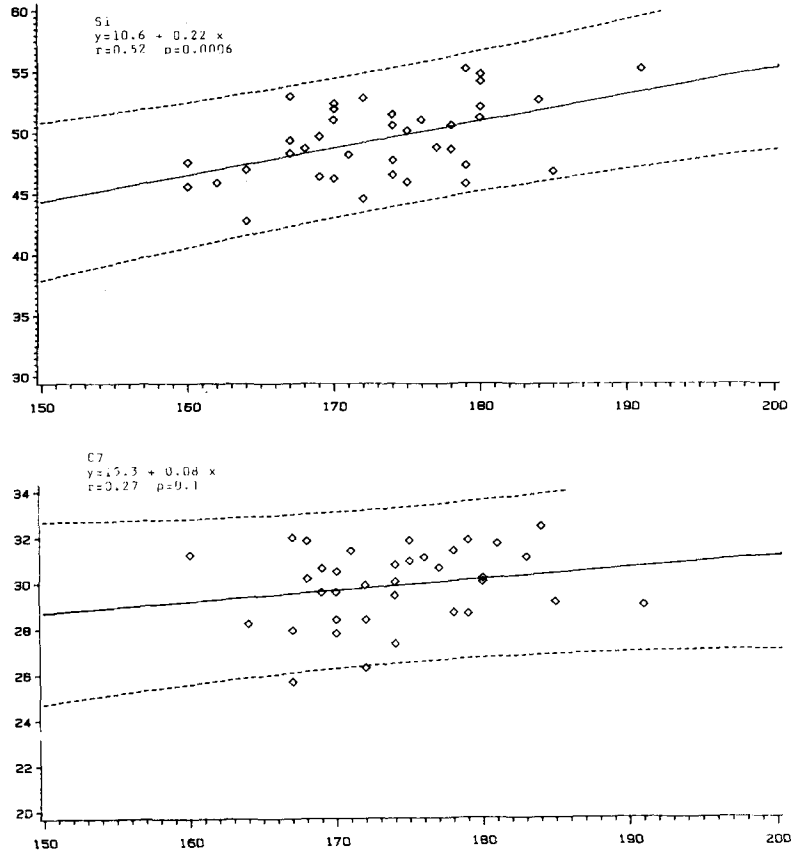


Fig. 3. Scattergrams of the latency of the first positive peak in ms (y-axis) against body length in cm (x-axis) for several dermatomes. The regression line is given as solid, the dotted lines indicate the 98% confidence limits. The regression line formula, the correlation coefficient and its significance are given

Table 1. Mean latency and SD of the first positive peak of the evoked potentials of cervical and lumbosacral roots in ms

		Left		Right	
$n = 35$	C5	24.13	1.55	24.78	1.86
	C6	26.0	1.72	26.48	1.80
	C7	30.13	2.13	30.18	2.38
	C8	29.74	2.50	30.0	2.33
$n = 37$	L3	35.62	2.70	35.81	2.90
	L4	42.18	3.56	41.87	3.80
	L5	49.14	4.30	49.57	4.96
	S1	49.30	3.85	50.20	3.63

Table 2. Mean latency difference in ms between left and right of the lumbosacral and cervical roots with 2.5 times the SD

	$n = 35$			$n = 37$	
	Mean	2.5 × SD		Mean	2.5 × SD
C5	0.63	3.6	L3	0.19	4.9
C6	0.48	2.9	L4	−0.16	5.5
C7	0.05	4.0	L5	0.43	5.4
C8	0.26	4.1	S1	0.90	4.7

with respect to the cervical dermatomes. Tsuij et al. (1984) and Ganes (1980) showed that the central conduction time of the median nerve and tibial nerve evoked potentials is independent of body length. Campbell et al. (1981) and Soudmand et al. (1982) reported that the conduction velocity of the peripheral nerves in the leg has a negative correlation with body length. This dependence is absent in the arm. Their explanation for this phenomenon was the abrupt distal axonal tapering of the nerves in the leg, whereas the nerves in the arm do not show such distal tapering. We suggest that this phenomenon could be one of the reasons for the difference in body length dependence of the dermatomal evoked potentials of arm and leg, because the cutaneous afferent nerves which are stimulated in the dermatomal method (Katifi and Sedgwick 1986) join the large mixed nerves in the arm and leg.

Table 3. 2.5 times SD of the amplitude ratio of the dermatome left and right somatosensory evoked potentials

	$n = 35$		$n = 37$
C5	22%	L3	15%
C6	32%	L4	19%
C7	39%	L5	14%
C8	33%	S1	20%

The dermatome L4 showed the highest correlation between latency and body length ($r = 0.62$; $P = 0.001$). Even in this case no correlation between the left-right latency differences of the L4 dermatome SEPs and body length was found. So in contrast to the latency, the latency difference between the same dermatome left and right appears to be independent of body length.

The amplitude differences of the several dermatome SEPs left and right varied in the cervical region from 1:3 to 1:4, and in the lumbosacral region from 1:5 to 1:7. This wide range in normal individuals makes the amplitude of limited value for the detection of pathological changes. Katifi and Sedgwick (1986), Aminoff et al. (1985b), and Scarff et al. (1981) considered a difference of more than 75% as significant for abnormality, agreeing with our results.

Criteria for abnormality are in our opinion:
- a latency difference between left and right exceeding the value of 2.5 times the SD of a given dermatome,
- an absent response on one side,
- too long latencies of the dermatome SEPs of both sides, which must be corrected for body length when studying the lumbosacral dermatomes.

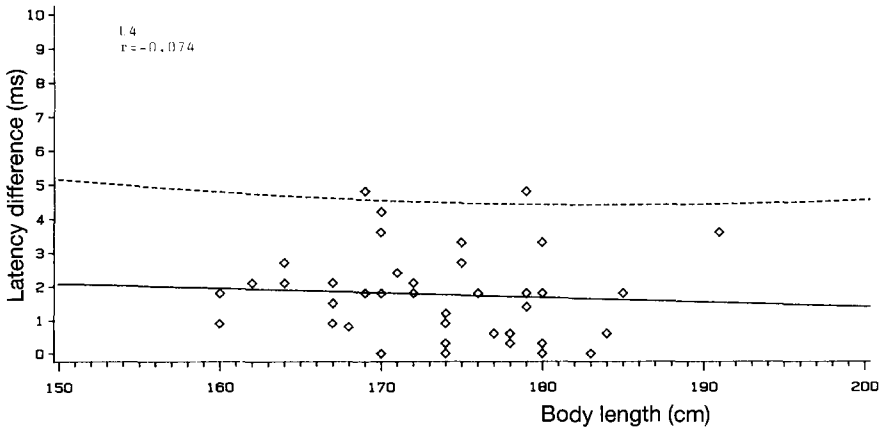


Fig. 4. Scattergram of the latency difference between L4 left and right against body length with the regression line *(solid)* and the 98% confidence limit *(dotted)*

Registration of dermatomal SEPs is a simple, non-invasive, and reliable investigation, which can play an important role in the diagnostic field of cervical and lumbosacral root dysfunctions. Our normative data are in accordance with findings of other authors with respect to S1 and L5 and add reference values for other dermatomes.

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References

Aminoff M, Goodin D, Barbaro N, Weinstein P, Rosenblum M (1985a) Dermatomal somatosensory evoked potentials in unilateral lumbosacral radiculopathy. Ann Neurol 17: 171–176

Aminoff M, Goodin D, Parry G, Barbaro N, Weinstein P, Rosenblum M (1985b) Electrophysiologic evaluation of lumbosacral radiculopathies: electromyography, late responses, and somatosensory evoked potentials. Neurology 35:1514–1518

Campbell W, Ward L, Swift Th (1981) Nerve conduction velocity varies inversely with height. Muscle Nerve 4:520–523

Clara M (1959) Das Nervensystem des Menschen. Johan Ambrosius Barth Verlag, Leipzig

Eisen A, Hoirch M, Moll A (1983) Evaluation of radiculopathies by segmental stimulation and somatosensory evoked potentials. Ann J Neurol Sci 10:178–182

Feinsod M, Blau D, Findler C, Hadani M, Beller A (1982) Somatosensory evoked potentials to peroneal nerve stimulation in patients with herniated lumbar discs. Neurosurgery 11:506–511a

Ganes T (1980) A study of peripheral cervical and cortical evoked potentials and afferent conduction times in the somatosensory pathway. Electro-enceph Clin Neurophysiol 49:446–451

Jörg J (1977) Die elektrosensible Diagnostik in der Neurologie. Springer, Berlin Heidelberg New York

Katifi H, Sedgwick E (1986) Somatosensory evoked potentials from posterior tibial nerve and lumbosacral dermatomes. Electroencephalogr Clin Neurophysiol 65:249–259

Katifi H, Sedgwick E (1987) Evaluation of the dermatomal somatosensory evoked potential in the diagnosis of lumbosacral root compression. J Neurol Neurosurg Psychiatry 50:1204–1210

Katifi H, Sedgwick E, Nicpon K (1985) Evoked potentials from lumbosacral dermatomes. Electroencephalogr Clin Neurophysiol 61:2p

Nieuwenhuys R (1975) Bolk's studies of segmental anatomy. Acta Morphol Neurol-Scand 13:7–33

Perlik S, Fisher M, Patel D, Slack C (1986) On the usefulness of somatosensory evoked responses for the evaluation of lower back pain. Arch Neurol 43:907–913

Scarff T, Dalleman D, Bunch W (1981) Dermatomal somatosensory evoked potentials in the diagnosis of lumbar root entrapment. Surg Forum 32:489–491

Soudmand R, Ward L, Swift Th (1982) Effect of height on nerve conduction velocity. Neurology 32:407–410

Tsuji S, Lüders H, Lesser R, Dinner D, Klem G (1984) Subcortical and cortical somatosensory potentials evoked by posterior tibial nerve stimulation: normative values. Electroencephalogr Clin Neurophysiol 59:214–228

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