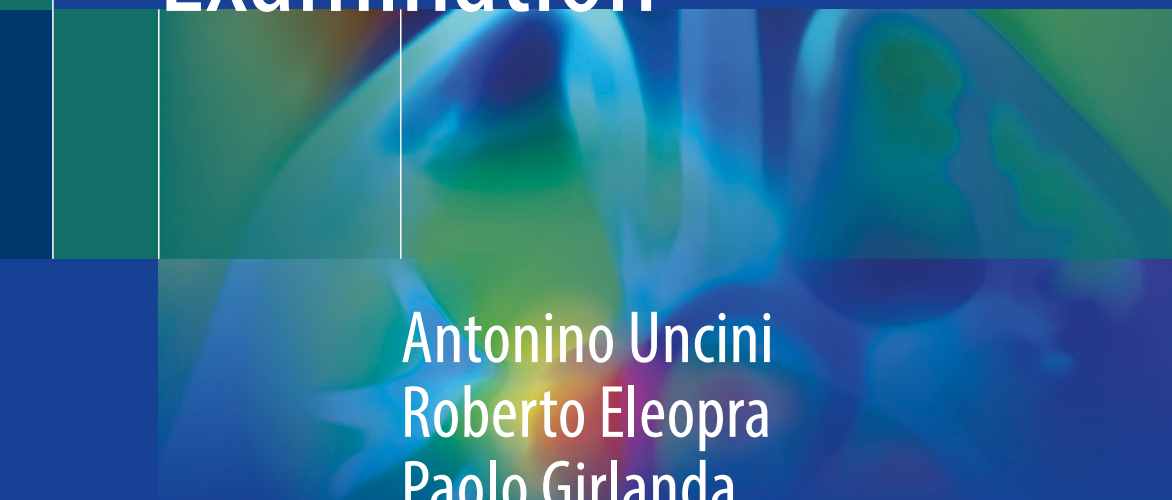
A Companion to Peripheral Nervous System Examination



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Preface

The Italian Society of Clinical Neurophysiology (Società Italiana di Neurofisiologia Clinica, SINC) is pleased to present: *A Companion to Peripheral Nervous System Examination*. This manual is configured as a practical, quick, bedside reference with the intent to help the trainee in the clinical and electrophysiological examination of the peripheral nervous system.

The manual contains three parts.

The Part I is a brief introduction to the clinical examination of the peripheral nervous system with reference figures and tables that are helpful to localize the lesion site.

In the Part II, after a concise explanation of some basic principles on nerve conduction studies, are illustrated the most common techniques to perform motor, sensory, and mixed nerve conduction studies as well as some special studies. The description follows the same schematic structure with the indication of the nerve fibers tested, their route and the placement of recording and stimulating electrodes. Control values for each technique as well exemplificative recordings are reported. Comments on technical pitfalls and clinical correlations are also provided.

In the Part III, after an introduction to needle electromyography, it is described, and shown by photographs, how to test the strength and activate the muscles that are more frequently examined. The needle insertion point is shown and described using, when appropriate, anatomical landmarks. Moreover, by means of anatomical cross sections, oriented according to the viewpoint of the examiner, the relationships between the muscle to be examined and adjacent muscles and structures are demonstrated remarking how to avoid common pitfalls. This section contains also, for a rapid consultation, diagrams of plexuses and peripheral nerves with the muscles which they supply.

The authors hope that this handbook will be of some practical value for those approaching the sometimes difficult, though often rewarding, electrodiagnosis of the peripheral nervous system.

Antonino Uncini

On behalf of the Italian Society of Clinical Neurophysiology (SINC)

Contents

Abbreviations

A	Active electrode
CMAP	Compound muscle action potential
CTS	Carpal tunnel syndrome
CV	Conduction velocity
DML	Distal motor latency
EMG	Needle electromyography
ENMG	Electroneuromyography
G	Ground electrode
LLN	Lower limit of normal
m/s	Meter/second
mA	Milliampere
ms	Millisecond
MUP	Motor unit potential
mV	Millivolt
N	Nerve
PNS	Peripheral nervous system
R	Reference electrode
SNAP	Sensory nerve action potential
ULN	Upper limit of normal
μV	Microvolt

Part I

Principles of Peripheral Nervous System Testing

Clinical Examination

1

The main goal of the neuromuscular examination is to localize the disorder to a specific component of the peripheral nervous system (PNS). Always keep in mind that nerve conduction studies and needle electromyography (EMG) are an extension of the clinical examination; a brief history and a focused examination should always be performed. The duration, type, and distribution of symptoms, along with the physical examination, help to formulate the differential diagnosis, which is at the basis of the electroneuromyography (ENMG) plan.

1.1 Symptoms

The main symptoms in patients with neuromuscular disorders are weakness, sensory disturbances, and pain in varying combinations. Patients with sensory abnormalities most commonly report a reduction or loss of sensation in skin areas described as numbness and medically termed hypesthesia, or sensations of pins and needles, tingling, prickling, and burning, commonly termed paresthesias. Getting a precise localization of the abnormal sensation is an important step toward a diagnostic localization. However, not all patients can delineate accurately the affected area. For example, patients with carpal tunnel syndrome (CTS) often describe numbness of all fingers of the hand, and only if they are asked to think about it and be more precise do they describe a more restricted distribution. Motor symptoms also vary. Patients may complain of muscle twitching, cramps, clumsiness in a limb, or weakness.

1.2 Muscle Testing

Muscle testing is an essential part of the neuromuscular examination. A muscle may act as a prime mover, synergist, fixator, or antagonist. Testing individual muscles in relation to the movement of a single joint, rather than muscle groups, is important

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for diagnosis in peripheral nervous system (PNS) disorders. When a one-joint and a multi-joint muscle act together in a movement, the action of the one-joint muscle can be differentiated by placing the multi-joint muscle at a mechanical disadvantage. For example, in testing the hip extension by gluteus maximus, the action of hamstrings is decreased by flexing the knee so that the hamstrings are in their most shortened position. Regarding synergistic muscles, for example, to isolate the action of the pronator quadratus from the pronator teres, the elbow can be flexed to induce the maximal shortening of the pronator teres, making its action less effective. In the third section of the manual, for brevity, only one method of testing for each muscle is shown, and we recommend applying the test as illustrated to eliminate possible pitfalls. The strength of muscles should be always quantified. The simplest and most widely used grading scale for muscle weakness is that of the British Medical Research Council (Table 1.1).

Grades 4−, 4, and 4+ may be used to indicate movement against slight, moderate, and strong resistance, respectively.

Examining the strength of individual muscles helps to localize the lesion. This can be done by referring to diagrams of roots, plexuses, and peripheral nerve supply of muscles. Figures 1.1 and 1.2 show the most common patterns of segmental spinal root innervation of muscles (myotomes) in upper and lower limbs. However, these charts should be used with some caution because of individual variation of muscle innervation by roots. Moreover, regarding the possibility of attributing any clinical or EMG pattern to a specific root level, it should be reminded that muscles are seldom innervated by only one spinal root.

Table 1.1 Medical Research Council (MRC) scale for the evaluation of muscle strength

0 = no muscle contraction
1 = visible contraction not resulting in movement
2 = active movement with gravity eliminated
3 = active movement against gravity
4 = active movement against moderate resistance
5 = normal strength

Nerve/Muscles	C5	C6	C7	C8	T1
Dorsal scapular nerve					
Rhomboid major/minor					
Suprascapular nerve					
Supraspinatus					
Infraspinatus					
Axillary nerve					
Deltoid					
Musculocutaneous nerve					
Biceps Brachii					
Median nerve					
Pronator teres					
Flexor carpi radialis					
Flexor pollicis longus					
Abductor pollicis brevis					
Ulnar nerve					
Flexor carpi ulnaris					
Abductor digiti minimi					
First dorsal interosseous					
Radial nerve					
Triceps					
Brachioradialis					
Extensor carpi radialis longus/brevis					
Extensor digitorum communis					
Extensor indicis proprius					

Fig. 1.1 This chart shows the most useful muscles to examine clinically and electromyographically in radiculopathies of the upper limb arranged according to nerve and root innervation. Red boxes indicate the predominant roots innervating the muscle, yellow boxes indicate the contribution by other roots

Nerve/Muscles	L2	L3	L4	L5	S1	S2
Inferior gluteal nerve						
Gluteus maximus						
Superior gluteal nerve						
Gluteus medius						
Tensor fascia latae						
Obturator nerve						
Adductor longus						
Femoral nerve						
Iliacus						
Vastus lateralis/medialis						
Sciatic Nerve						
Medial Hamstrings						
Lateral hamstrings						
Deepperoneal nerve						
Tibialis anterior						
Extensor hallucis longus						
Superficial peroneal nerve						
Peroneus longus						
Tibial nerve						
Medial gastrocnemius						
Tibialis posterior						
Abductor hallucis brevis						

Fig. 1.2 This chart shows the most useful muscles to examine clinically and electromyographically in radiculopathies of the lower limb arranged according to nerve and root innervation. Red boxes indicate the predominant roots innervating the muscles, yellow boxes indicate the contribution by other roots

Diagrams of plexuses and peripheral nerves with the sequence of the branches that innervate the muscles are reported in the third part of the manual. There are several pitfalls in motor examinations. Weakness may be unreliable because the patient may be confused, inattentive, uncooperative, malingering, or having a functional neurological disorder. Coexisting pain may interfere with strength testing, masking weakness; on the other hand, if weakness is also complained of, the relief of pain may demonstrate that muscle strength is normal.

1.3 Sensory Examination

Sensory testing takes time and needs good cooperation from the patient. The purpose is to identify sensory abnormalities and delimit precisely the site, the extent, and the sensory modality affected. The sensory examination begins by asking the patient to delineate the area of sensory abnormality. Then, with the patient's eyes closed, light touch can be tested by something soft such as cotton wool or a piece of paper, but the examiner's finger is frequently sufficient by checking from the insensitive toward the sensitive area. Superficial pain is tested by a pin moving from the analgesic area outward. The size of the insensitive pinprick area is usually inferior to the one of light touch. The timing of stimulation should be irregular so that the patient does not know when to expect the next touch or pinprick. It is useful to compare light touch and pinprick sensation in abnormal and normal areas on the same side (i.e., median versus ulnar innervated digits of the same hand) or with the same area of the unaffected side. Occasionally testing for two-point discrimination by a caliper, or simply by the two points of an unfolded paper clip, can reveal subtle sensory abnormalities not detectable by light touch or pinprick. The normal two-point discrimination varies in different body parts, and in the fingertips, it should be no more than 5 mm. Testing vibration sense with a 64 or 124 Hz tuning fork placed on various bony prominences is also useful in evaluating peripheral neuropathies. The distribution of sensory loss is usually partial except in the most severe nerve lesion. For example, in CTS, paresthesias and sensory loss are usually confined only to the fingertips rather than to the whole cutaneous distribution of the median nerve, possibly because the longest nerve fibers are more susceptible to compression. In other CTS patients, sensory abnormalities may be confined to one digit. This is possibly due to predominant damage of specific fascicles within the nerve. The conventional representation of skin areas supplied by spinal nerve roots (dermatomes) is shown in Fig. 1.3. It should be reminded that the skin area supplied by any nerve root varies considerably from one individual to another and dermatomes overlap considerably. Therefore, it is unusual in an isolated radiculopathy to develop a severe sensory disturbance in the whole dermatome.

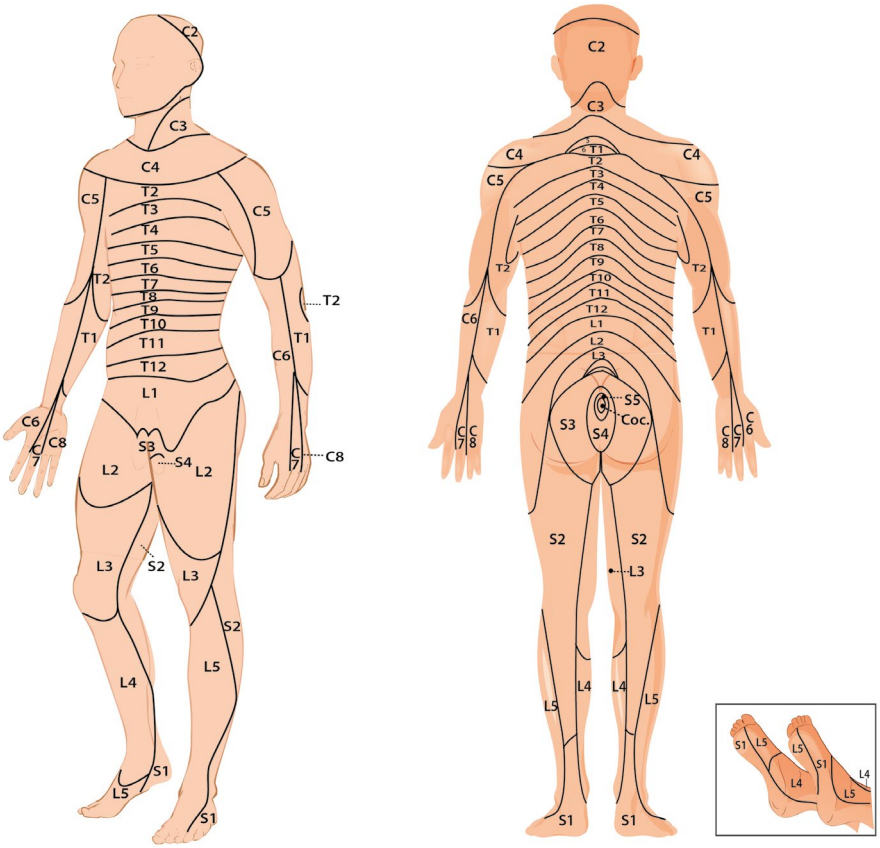

Fig. 1.3 The dermatomes of the body

Dense numbness and sensory loss usually are more indicative of a peripheral nerve lesion. The cutaneous distribution of the nerves of the body is shown in Fig. 1.4.

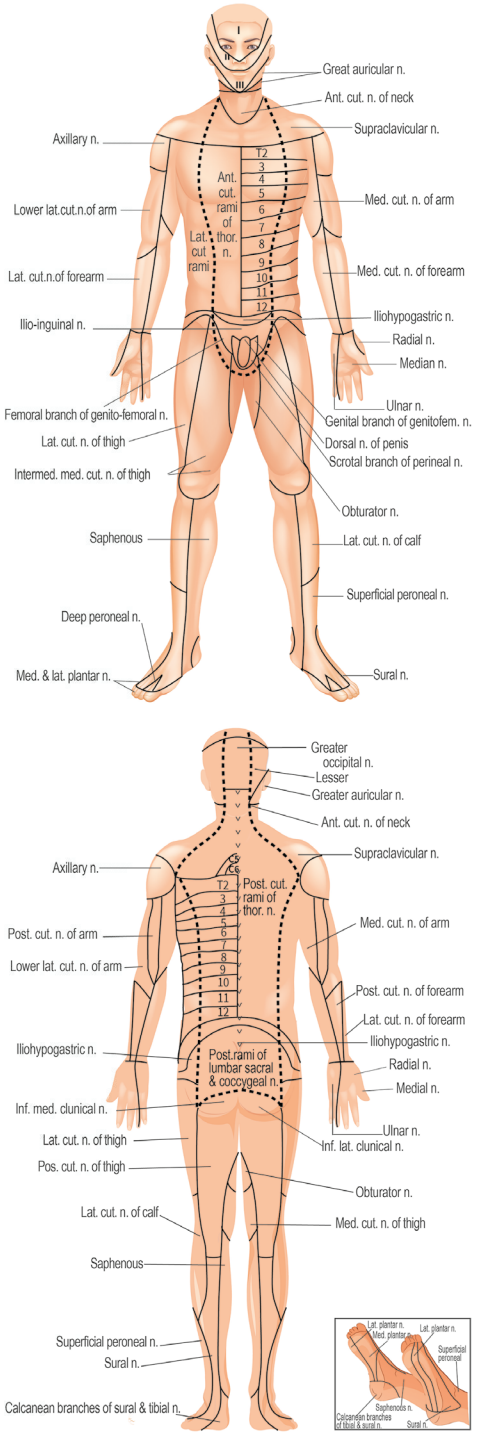

Fig. 1.4 The cutaneous distribution of the nerves of the body

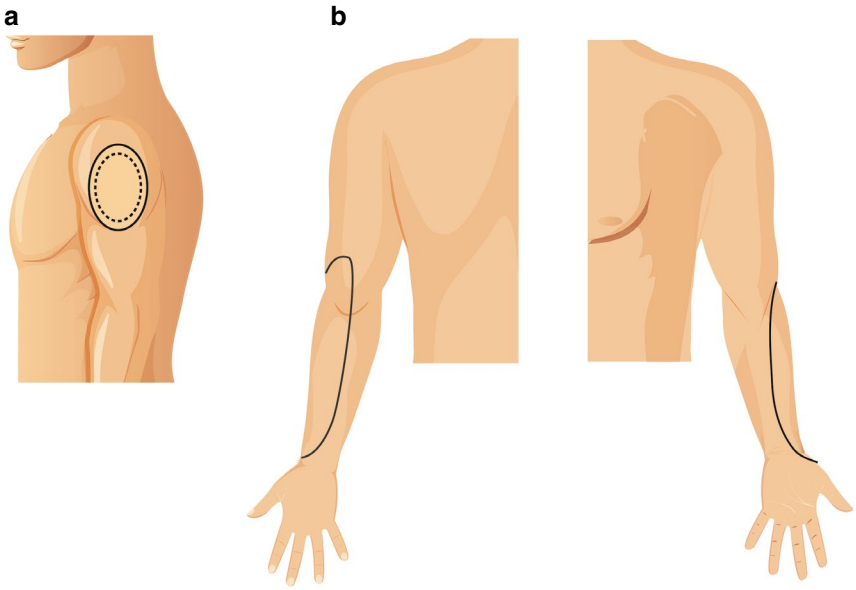

Fig. 1.5 The approximate area within which sensory changes can be found in lesions of (**a**) the axillary nerve and (**b**) the musculocutaneous nerve (lateral cutaneous nerve of the forearm), posterior and anterior view

In Figs. 1.5, 1.6, 1.7, 1.8, 1.9 and 1.10 are reported the approximate area of sensory loss in the nerves most frequently injured. In these figures, the continuous line individuates the loss of light touch, whereas the dotted line identifies the loss pinprick sensation.

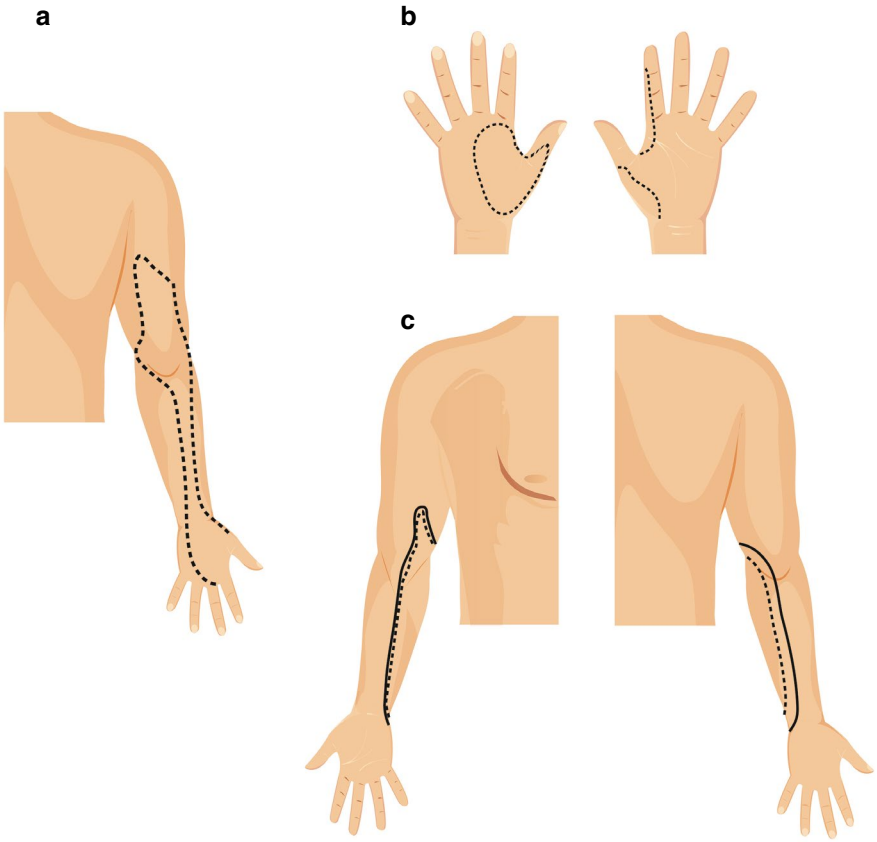

Fig. 1.6 The approximate area within which sensory changes can be found in lesions of (**a**) the radial nerve above the origin of the posterior cutaneous nerve of the arm and forearm; (**b**) the radial nerve below the origin of the posterior cutaneous nerve of the forearm, dorsal and volar view; and (**c**) the medial cutaneous nerve of the forearm, anterior and posterior view

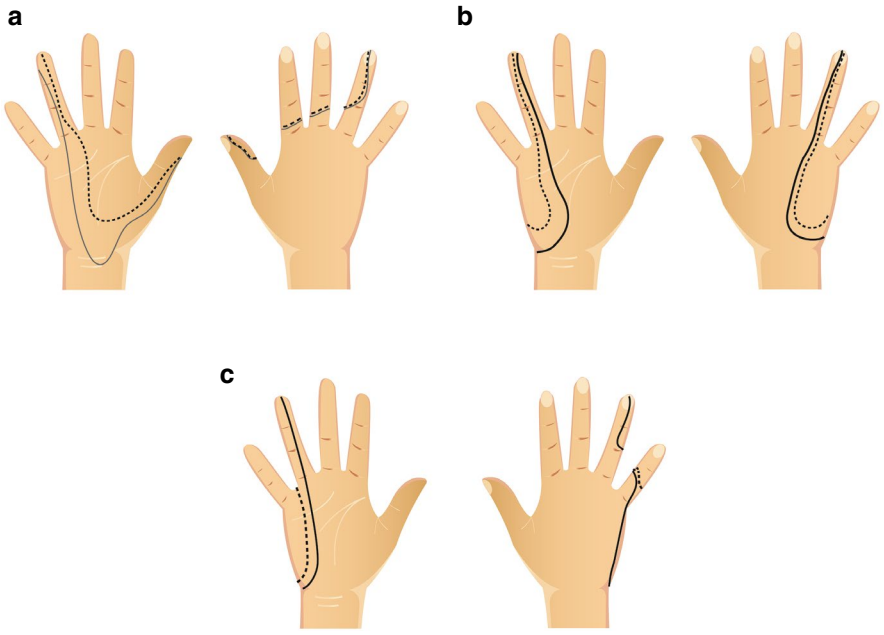

Fig. 1.7 The approximate area within which sensory changes may be found in lesions of (**a**) median nerve, volar and dorsal view; (**b**) ulnar nerve, volar and dorsal view; (**c**) ulnar nerve below the origin of dorsal branch, volar and dorsal view

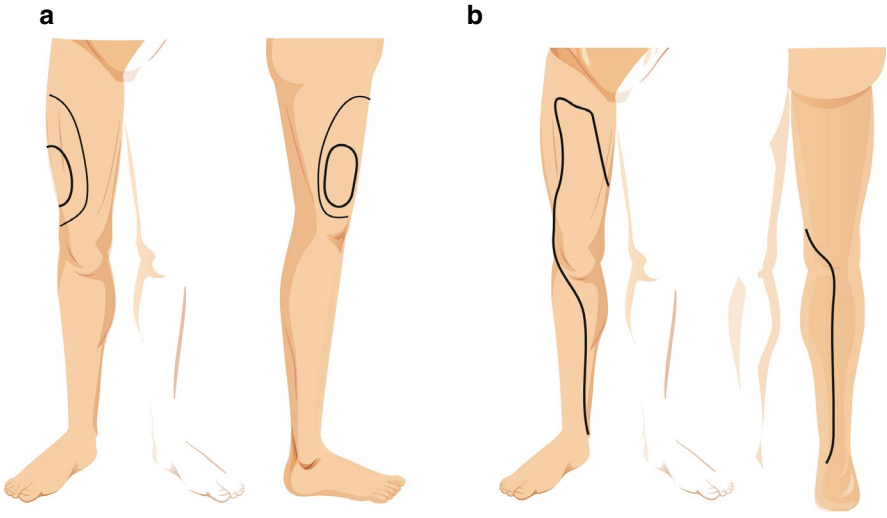

Fig. 1.8 The approximate area within which sensory changes may be found in lesions of (**a**) lateral femoral cutaneous nerve, anteromedial and lateral view; (**b**) femoral nerve (intermediate and medial cutaneous nerve of the thigh and saphenous nerve), anteromedial and posterior view

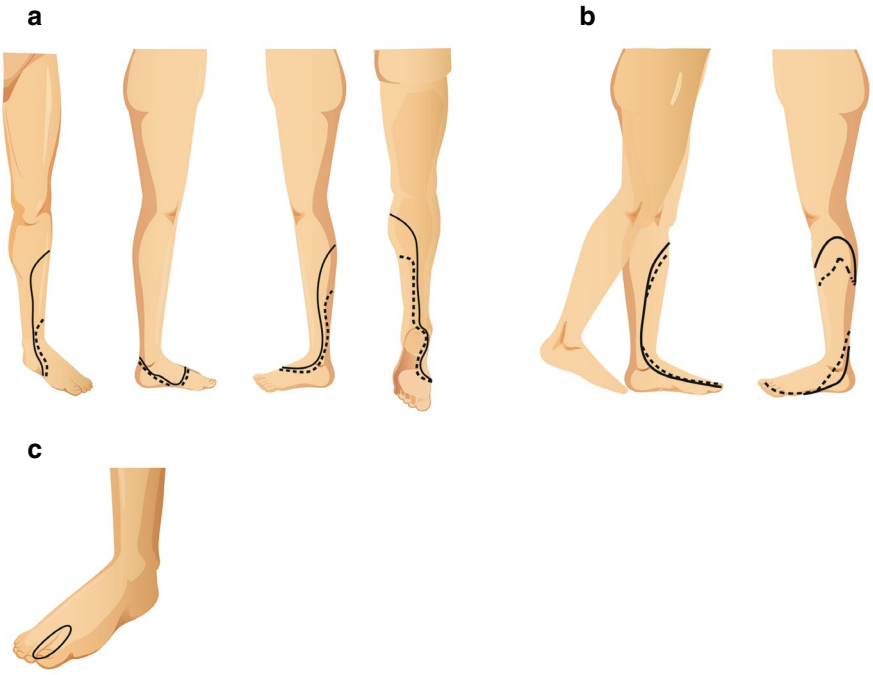

Fig. 1.9 The approximate area within which sensory changes may be found in lesions of (**a**) sciatic nerve below the branch of the posterior cutaneous nerve of the thigh, anterior, medial, lateral and posterior view; (**b**) common peroneal nerve above the origin of the superficial peroneal nerve, medial and lateral view; (**c**) deep peroneal nerve