8 History and Physical Examination

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Core Messages

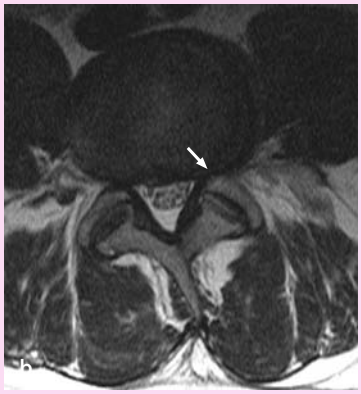
- ✔ Back pain is one of the most common causes for a medical consultation
- ✔ Up to 85 % of individuals will experience back pain at least once in their lifetime
- ✔ The high rate of benign back/neck pain increases the risk of overlooking serious spinal disorders
- ✔ Findings (red flags) suggesting serious pathology are: features of cauda equina syndrome, severe night pain, significant trauma, fever, unexplained weight loss, history of cancer, patient over 50 years of age, and use of intravenous drugs or steroids
- ✔ Back pain getting worse during the night may indicate a tumor or infection
- ✔ Tumors, discitis/spondylodiscitis, acute fractures, relevant pareses, or conus/cauda equina syndromes need immediate further diagnostic work-up in a specialized spine unit
- ✔ Spinal disorders can be classified as specific (with morphological correlates) vs. non-specific (without structural findings)
- ✔ Central (axial) pain should be differentiated from peripheral (radicular) pain
- ✔ The physical examination is facilitated when a certain sequence of different examining positions are used, i.e. walking, standing, sitting, lying supine, lying on the left/right side, lying prone
- ✔ The most important aspects of the clinical examination are the spinal balance and the neurological assessment
- ✔ The sagittal profile (lordosis/kyphosis) varies to a large extent
- ✔ In the flexed neck position, rotation of the upper cervical spine and in the extended position rotation of the lower cervical spine is assessed
- ✔ The Lasègue test is positive if radicular leg pain is provoked during lifting of the ipsilateral leg
- ✔ Abnormal illness behavior should caution one to consider a spinal intervention
- ✔ The reproducibility of the patient's history and examination is limited

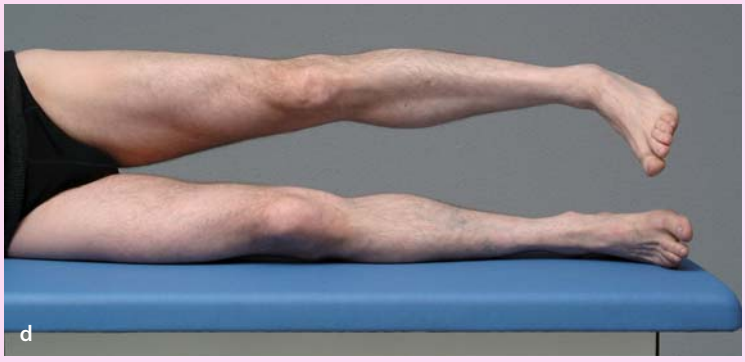
Epidemiology

Generally, spinal pain is common, benign, and self-limiting

Back and neck pain are a very common medical problem and a predominant cause for visits and medical consultations [15]. The reported **lifetime prevalence** of back pain ranges up to 84 % [5] and that of neck pain to 67 % [6]. Dorsal (thoracic) pain is much less frequent. The 1-year prevalence of dorsal pain was 17 % compared to 64 % for neck and 67 % for low-back pain in a Finnish study [25]. More than 90 % of patients initially presenting with back pain can be managed non-operatively with physical therapy and analgetic medication and will return to an acceptable pain level within 3 weeks, and even to normal within 3 months [10]. These figures indicate that spinal pain is a benign and self-limiting disorder (see Chapter 6).

About 85 % of patients can be classified as having **non-specific back pain** (see Chapter 21), i.e. no morphological correlate can be detected which would satisfactorily explain the pain [10, 30]. The **diagnostic challenge** in patients with spinal disorders is a result of the very high rate of benign spinal pain which poses a





Case Introduction

A 46-year-old male was referred for an imaging study of the lumbar spine and possible surgical treatment of an acute foot drop. The clinical history revealed a sudden onset (about 6 h), paresis of the left foot (long extensors of the greater toe and foot) with relevant muscle weakness (M1 – 2). However, the patient did not report any significant back pain and only mild pain in the lower limb. An MRI investigation was prompted because of the sudden onset of the paresis. **a** The sagittal T2 W image showed a minor disc protrusion (*arrowhead*) with contact to the nerve root L5 (*arrow*). **b** In the axial view, only a small foraminal disc protrusion is seen without clear neural compromise. The MRI could not satisfactorily explain the severe foot drop and the patient was reassessed clinically. **c** The patient was unable to extend his left foot while sitting on the examination table. **d** However, he was able to lift his left leg in a right sided position indicating normal muscle force for the hip abductors (L5). This discrepancy was indicative of a peripheral paresis of the peroneal muscles which was later documented by neurophysiology. Completion of the patient's history revealed that he was kneeling for several hours repairing a floor in his house the day before the onset of the foot drop.

Rule out specific causes of spinal pain

great risk of overlooking a serious pathology. Therefore, the most important aspect of the diagnostic work-up is to **rule out**:

- relevant paresis (<MRC Grade 3)
- bowel and bladder dysfunction
- tumor/metastasis
- infection
- inflammatory diseases
- occult (osteoporotic) fractures

A thorough and standardized clinical assessment allows for an effective triage and further diagnostic work-up of patients with suspected specific causes of back pain.

History

History contributes most to a clinical diagnosis

Due to the broad range of clinical entities that may present with back, dorsal and neck pain, a systematic and logical approach, a skillful interpretation, and a careful analysis of history data should be performed prior to the physical examination [8, 9]. In many cases a highly probable diagnosis can be made from the patient's history alone. Back and neck pain has a strong tendency to become chronic (see Chapter 6). Therefore, a rapid, pathomorphology-oriented diagnostic work-up and initiation of treatment is mandatory.

The **major goal of the clinical assessment** is to differentiate:

- specific spinal disorders, i.e. **with** a pathomorphological correlate
- non-specific spinal disorders, i.e. **without** an evident pathomorphological correlate

The diagnosis of non-specific neck/back pain is made by exclusion

In **specific spinal disorders** a pathomorphological (structural) correlate can be found which is consistent with the clinical presentation. Accordingly, in **non-specific spinal disorders** no such correlate can be detected. It is obvious that patients are classified in the latter group by exclusion. Unfortunately, the sources of patients' complaints remain unclear in the vast majority of cases (85–90%) despite a thorough clinical and diagnostic work-up [30]. However, in the individual case it can be difficult to differentiate specific and non-specific disorders and a final conclusion is only reached after a thorough further diagnostic work-up.

The most **devastating failure** of the clinical assessment is to overlook the presence of a tumor, infection, or a spinal compression syndrome. This can be avoided in most cases, if the examiner considers possible specific causes during history taking and physical examination. If suspicion is raised, the proper diagnostic work-up is prompted. The importance of this triage has led to the suggestion of a so-called **flag system** (see Chapter 6). The **red flags** are of particular relevance because they help to detect serious spinal disorders [1]:

- features of cauda equina syndrome
- severe and worsening pain (especially at night or when lying down)
- significant trauma
- fever
- unexplained weight loss
- history of cancer
- patient over 50 years of age
- use of intravenous drugs or steroids

Features of cauda equina syndrome include urinary retention, fecal incontinence, widespread neurological symptoms and signs in the lower limb, including gait abnormality, saddle area numbness and a lax anal sphincter [1]. A **relevant paresis** can be defined as the inability of the patient to move the extremity against gravity. It is particularly important to recognize a **progressive weakness** because emergency exploration and treatment is necessary. It is always astonishing that patients do not spontaneously report a disturbance of their **bowel and bladder** function because they do not suspect a correlation with a spinal problem. Other color (i.e. yellow, blue, black) flags indicate **obstacles to recovery** from an acute episode (Chapters 6, 21).

After red flags are explored, the clinical assessment focuses on the **three major complaints** which lead the patients to seek medical advice:

- pain
- functional impairment
- spinal deformity

Of these three complaints, pain is by far the most common aspect.

Pain

Although pain is the most common complaint in patients with spinal disorders, our understanding of the pathophysiology of pain is still scarce. However, molecular biology has recently unraveled some basic mechanisms of pain generation and persistence which help to better understand patients presenting with spinal pain (Chapter 5 is strongly recommended for further reading).

Differentiation of Pain

The most obvious differentiation of spinal pain syndromes is based on the **region** of the pain, i.e.:

- neck pain
- dorsal pain
- low-back pain

More important than the regional differentiation is the distinction with regard to pain **radiation**, i.e.:

- radicular pain
- referred pain
- axial pain

Radicular pain is a nerve mediated pain which follows a dermatomal distribution (Fig. 1). It can even occur without back or neck pain, e.g. in case of a disc herniation. A differential diagnosis of the segmental and peripheral innervation [11] is obvious and mandatory (Fig. 2). **Referred pain** usually originates from the back or neck but radiates into the extremities. It is musculoskeletal in origin and rarely radiates below the elbow or knee. However, knowledge of the so-called sclerotomes [7] is helpful in understanding otherwise unexplained musculoskeletal pain (Fig. 3). In the case of a L5 radiculopathy, for example, patients most frequently experience pain in the greater trochanter region (L5 sclerotome). **Axial pain** is defined as a locally confined pain in the axis of the spine without radiation. In this context, the most important questions are (Table 1):

Table 1. Important triage questions

• How much of your pain is in your arm(s)/hand(s) and how much in your neck?
• How much of your pain is in your legs(s)/(foot, feet) and how much in your lower back?

Pain which is exclusively or predominantly in the arms/hands is indicative of a radicular syndrome (disc herniation, spondylotic radiculopathy or myelopathy). Pain which is exclusively or predominantly in the legs/feet indicates a **radicular syndrome** (disc herniation, foraminal stenosis) or spinal claudication. A differentiation of axial pain is less straightforward and it remains difficult to relate a specific pathomorphological alteration to this pain.

Table 2. Pain descriptors

Sensory dimension		Affective dimension
• throbbing	• hot-burning	• tiring-exhausting
• shooting	• aching	• sickening
• stabbing	• heavy	• fearful
• sharp	• tender	• punishing-cruel
• cramping	• splitting	
• gnawing		

According to Melzack [21]

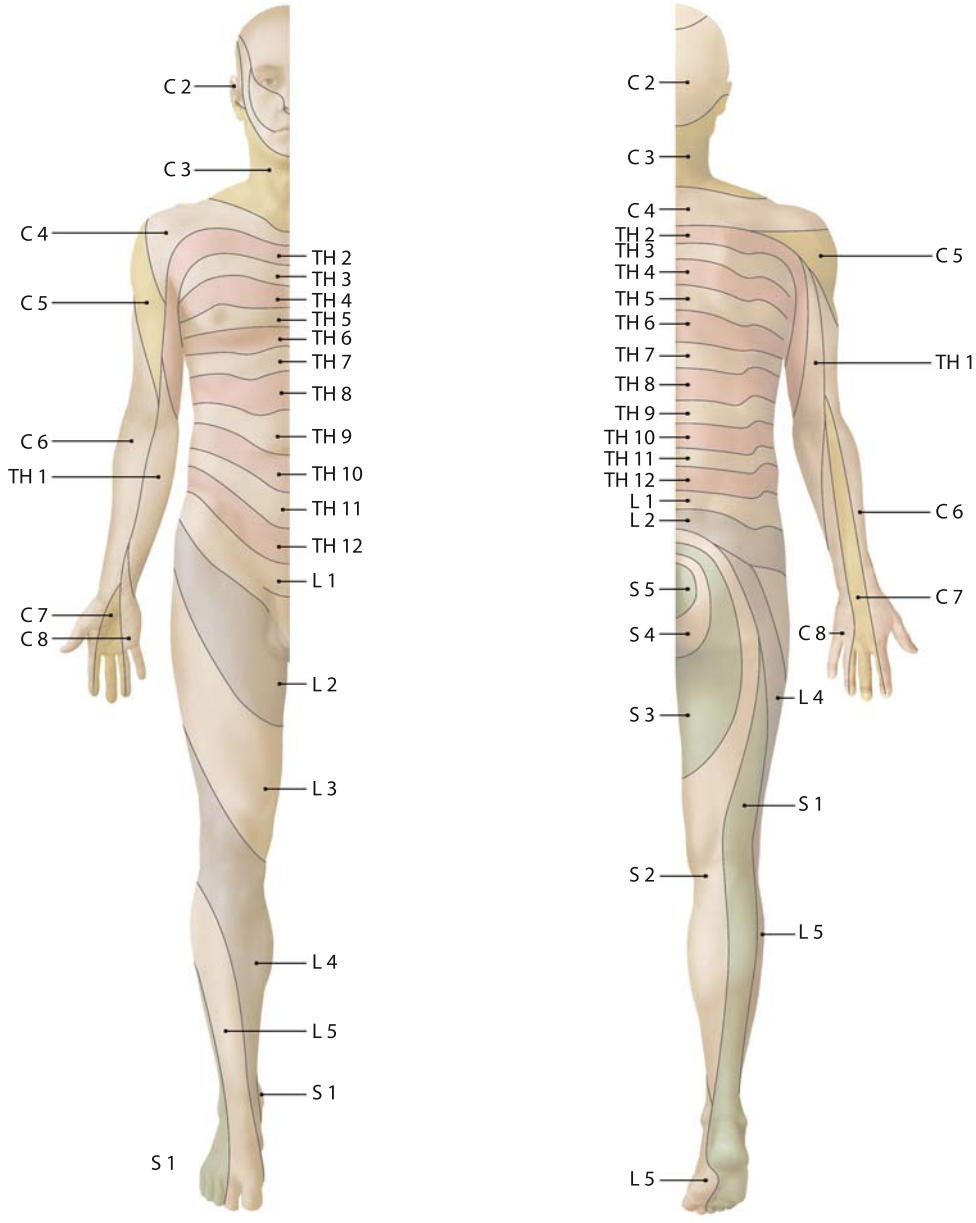


Figure 1. Segmental innervation of the skin

Pain can be further differentiated according to its **character.** Melzack [21] has developed a questionnaire which distinguishes **sensory** and **affective pain descriptors** (Table 2) which can be helpful in the assessment of the pain character.

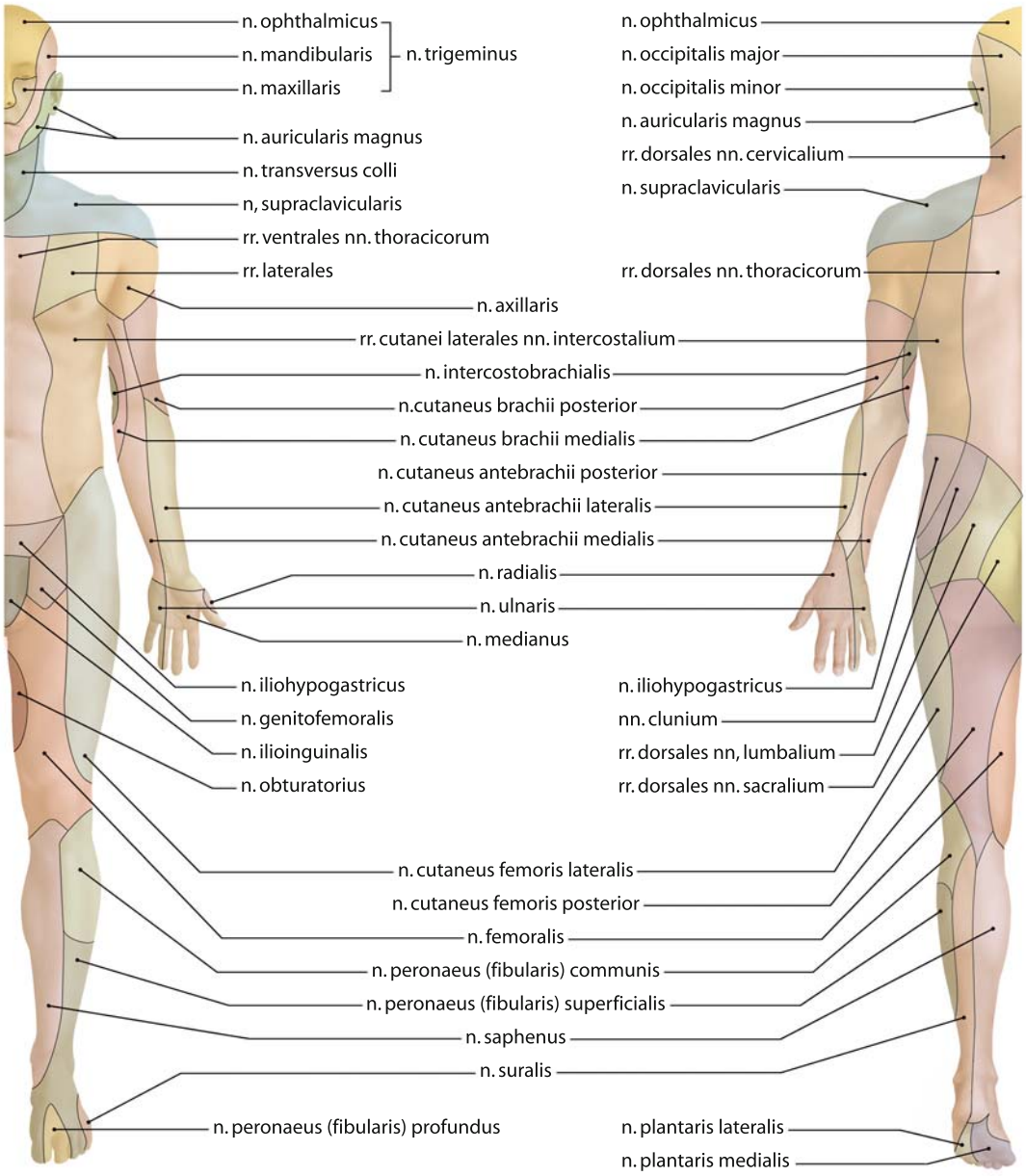


Figure 2. Peripheral innervation of the skin

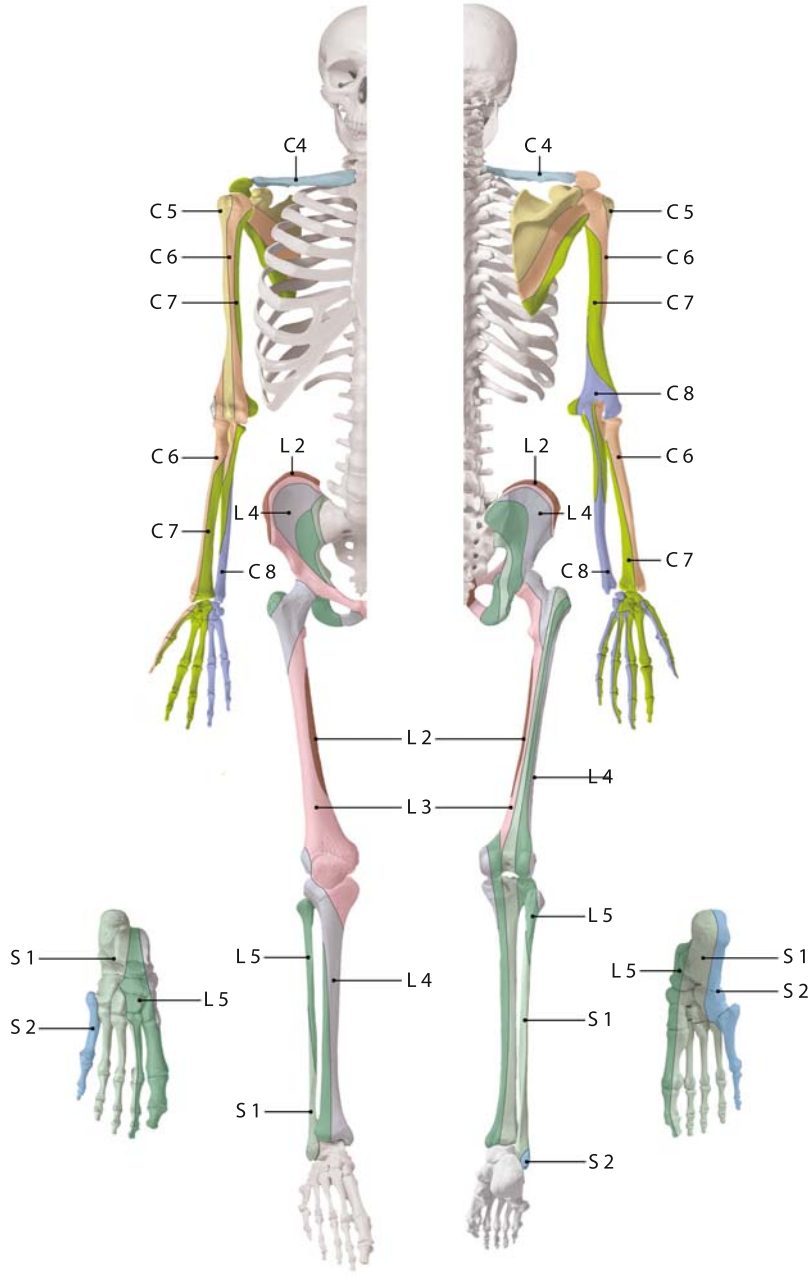


Figure 3. Segmental innervation of the bones

A classic differentiation of pain is often based on the **temporal course**, i.e.:

- acute – duration less than 1 month
- subacute – duration up to 3 months
- chronic – duration more than 3 – 6 months

Chronic pain is not simply prolonged acute pain

However, as outlined in Chapter 5, this differentiation is arbitrary and does not reflect the underlying pathomechanism. Chronic pain is not simply a prolonged acute pain but undergoes distinct alterations in the pain pathways.

Pain Intensity

Pain intensity is best assessed with a visual analogue scale

Based on the definition of the International Association for the Study of Pain (IASP), pain is always subjective [16]. An objective assessment of pain intensity is therefore very difficult. Today, **visual analogue scales** (VAS) have become a standard tool in assessing pain intensity. Pain intensity should routinely be assessed with regard to outcome assessment of a future treatment (see Chapter 40).

Excruciating pain may indicate neural compression or severe instability

Pain intensity is rarely a guide to the underlying pathology. However, acute **excruciating pain** should raise the suspicion of a neural compression or a severe instability. Myelopathic or radicular pain can sometimes be so severe that it is difficult to control it by analgesics.

Pain Onset

Slowly progressive pain worsening during the night is indicative of tumor/infection

The onset of pain can be helpful in inferring the underlying pathology. It is reasonable to explore whether the pain onset followed a **specific incident** or not:

- incident with immediate pain onset
- incident with delayed pain onset
- no incident, slowly progressive pain

It is most obvious in patients who sustained an **injury** (e.g. fall, motor vehicle accident) which immediately initiated the pain. In these cases, a fracture or fracture dislocation must be ruled out. Some elderly patients report a loud crack in their back as the onset of pain which is indicative of an acute osteoporotic fracture. Rear-end collision accidents typically result in a **delayed pain onset** (whiplash-associated disorders). More frequent and difficult to interpret is a situation in which the patient has sustained a minor incident (e.g. lifting accident, uncomfortable movement) with delayed pain onset. An acute onset of back pain which subsequently radiates into an extremity is indicative of a radiculopathy caused by a disc herniation. The vast majority of patients with spinal disorders do not report an incident but a **slowly progressive pain** and discomfort which initially is unrecognized. In the case of a slowly progressive pain which worsens during the night or rest, the examiner should suspect a tumor or infection.

Slowly progressive pain indicates degenerative disorders, but do not overlook tumor or infection

Pain Modulators

The assessment of modulators of pain is helpful for the diagnosis of specific pain syndromes and can guide the examiner to the underlying pathology. It is important to stress that the significance of these pain modulators is often not based on scientific evidence. Therefore, caution is prompted when interpreting pain modulating factors. The most helpful **positional and activity modulators** of spinal pain are listed in Table 3.

Besides these positional and activity modulators of pain, the **diurnal variation** is helpful in discriminating spinal pain syndromes (Table 4).

Table 3. Positional and activity modulators of pain

Modulator	Possible interpretation
forward bending	• increases pressure within the intervertebral disc • relieves the facet joints • widens the spinal canal
backward bending	• stresses the facet joints • narrows the spinal canal
sideward bending	• increases pressure within the intervertebral disc
side rotation	• stresses the facet joints
sitting	• increases pressure within the intervertebral disc • relieves claudication symptoms
standing	• stresses of the facet joints
rest	• improves pain related to segmental instability • worsens tumor/infection related pain • worsens arthritic facet joint pain
activity	• worsens pain related to segmental instability • improves arthritic facet joint pain
walking uphill	• increases pressure within the intervertebral disc • decreases claudication symptoms
walking downhill	• stresses the facet joints • increases claudication symptoms
climbing stairs	• increases pressure in the disc
descending stairs	• stresses the facet joints
vibration (e.g. riding a train, driving on uneven road)	• worsens pain related to segmental instability
walking	• initiates claudication symptoms • worsens pain related to segmental instability
lying prone	• relieves claudication symptoms • improves pain related to segmental instability
coughing, sneezing rotating the head (e.g. backwards while driving)	• aggravates radicular pain • stresses the cervical facet joint
working above arm level	• stresses the cervical facet joint (extension)

Table 4. Diurnal pain variation

Pain modulator	Possible interpretation
night pain	• tumor/infection related pain • arthritic facet joint pain
early morning pain	• arthritic facet joint pain • spondylarthropathy (ankylosing spondylitis)
pain relief after getting up	• arthritic facet joint pain
pain increase during the day	• pain related to segmental instability

Pain Medication

The assessment of the effect of medication on the pain is seldom indicative of the underlying pathology. However, myelopathic and radicular pain can be very severe and require strong narcotics. In the rare cases of an osteoid osteoma, non-steroidal anti-inflammatory drugs (**NSAIDs**) and particularly acetylsalicylate relieves symptoms and therefore may be diagnostic. On the other hand, non-specific chronic back pain does not respond well to pain medication. The **type and frequency** of pain medication should be noted as a future outcome parameter.

Non-specific back pain does not respond well to pain medications

Function

Assessment of the back/neck related function of the patient is important because many patients with spinal disorders are severely limited [35, 37]. However, Mooney outlined that the definition of the terms impairment, disability and handicap is not so straightforward and is often overlapping [23]. **Physical impairment** is an anatomical, physiological, or psychological abnormality leading to loss of normal bodily ability while **disability** is the resulting diminished capacity for everyday activities and gainful employment or the limitation of a patient's performance compared to a fit person of the same age and sex [23, 34]. **Handicap** can be seen as a product of an interaction of a person with impairment and disability and the environment [2] and thus resembles a loss or limitation of opportunities to take part in community life on an equal level compared to healthy persons.

Functional limitations including **activities of daily living** should be assessed with regard to:

- sitting (time)
- standing (time)
- self-care
- walking (distance, time)
- sleeping (time)
- weight lifting (maximum weight, position)
- driving
- reading
- working above head/shoulder level
- writing
- working with computer
- fine motor skills
- sex life
- social contacts (family, friends)
- work status

Functional impairment is best assessed with a standardized questionnaire

The functional impairment should best be assessed using a **standardized questionnaire** [12, 27], which allows for an evaluation of the treatment outcome (see Chapter 40).

Spinal Deformity

The assessment of spinal deformities requires some specific additional information from the patient (or parents). The patients should be explored with respect to:

- family history regarding spinal deformities
- course of pregnancy
- course of delivery
- developmental milestones (onset of walking, speaking, etc.)
- fine motor skills
- tendency to fall (clumsiness)
- onset of menses
- growth of beard
- growth spurt
- breaking of the voice
- evidence for metabolic or neuromuscular disorders

Physical Examination

In contrast to major joints of the extremities, which allow a passive examination even in the presence of severe painful pathology, the physical assessment of the spine is often hampered by strong muscle spasm. The patient with a spinal disorder is usually in pain and the examination often aggravates this pain. The physical examination should therefore be as short and effective as possible. In concordance with Fairbank and Hall [13], we suggest an **algorithm** which does not focus on the classic examination approach (i.e. inspection, palpation, functional testing) but on a succession of body positions which allow for a time-effective examination. The **different examination positions** consist of:

The examination should be done using a distinct succession of body positions

- walking
- standing
- sitting
- lying supine
- lying on the left/right side
- lying prone

The examination of the spine should **include the whole spine** and not only the affected part(s) because the spine is an organ which extends from the occiput down to the coccyx. Although as simple as it is obvious, it is important to stress that **patients should be examined undressed** (down to their underwear). The examination room should have enough space to allow free movement of the patient and contain an examination table (Table 5).

Walking

The physical assessment begins as soon as the patient enters the examination room with an inspection of the gait. It is noted whether the patient is able to walk unsupported or with support (e.g. by an accompanying person, crutches, or wheelchair). After the completion of history taking, the patient is asked to walk back and forth in the room. Any causes of limping must be differentiated, i.e.:

- pain
- muscle insufficiency
- paralysis
- ankylosis
- leg length discrepancy

Differentiate the cause of limping

The patient should walk on their tiptoes (S1) and heels (L4, L5) to assess muscle weakness in the lower limbs. Any evidence of atactic gait should be noted and further explored (Rhomberg's test, walking along a line; see Chapter 11).

Standing

Body height and weight should be assessed at least at the first clinical visit. For follow-up examination of patients with spinal deformities the assessment of body height (sitting and standing) is compulsory. The undressed patient should be inspected for any presence of **spinal stigmata** such as café-au-lait spots (neurofibromatosis), hairy patches (spina bifida occulta), and foot size differences (tethered cord). Any **scarring** must be noted and particular attention should be paid to previous spinal or thoracic surgery (putative secondary spinal deformity).

Table 5. Physical examination algorithm

Walking
Inspection for:
- limping (pain, muscle insufficiency, paresis, leg length discrepancy, ankylosis)
- weakness while walking on tiptoes (S1) and heels (L4, L5)
- difficulty walking along a line (atactic gait)

Standing
Assessment of:
- body height and weight

Inspection for:
- spinal stigmata
- sagittal and coronal spinal balance
- sagittal profile (hypo-/hyperkyphosis/lordosis)
- muscle atrophies
- level of shoulders
- waist asymmetries and pelvic rotation
- level of pelvis (in standing and flexed position)
- rib/lumbar hump (in standing and flexion)
- spinous process step-off

Functional testing of:
- finger floor distance/Schober and Ott test
- Trendelenburg test
- left/right side bending and rotation
- repetitive forward bending
- repetitive backward bending and rotation
- repetitive tiptoe standing (McNab's test)
- repetitive stool climbing
- jumping on one leg

Sitting
Palpation of the cervical spine:
- spinous processes, facet joints, transverse process of C2, mastoid
- tender points in paraspinal muscle

Functional testing of cervical spine:
- chin-sternum distance
- active forward/backward bending, left/right side rotation (neutral position)
- active left/right side rotation in flexion
- active flexion/extension/side rotation against resistance
- passive motion testing
- Spurling's test
- Roos and Adson's tests

Neurological assessment of:
- sensory qualities (light touch, pin prick, proprioception)
- muscle force (M0 – 5)
- muscle tendon reflexes

Lying supine
Assessment of:
- muscle strength for foot extension, eversion, inversion and leg lifting
- pathological reflexes (Babinski group, Trömner, Hofmann, and abdominal reflexes)
- spasticity (arms/legs)
- Lhermitte's sign
- straight leg raising test (Lasègue sign)
- hip mobility
- Patrick test, sacroiliac joint compression/distraction test
- peripheral pulses

Lying on left/right side
Assessment of:
- hip abduction force
- Mennell's test (sacroiliac joint)
- perianal sensitivity and sphincter tonus

Lying prone
Palpation of:
- spinous processes, paravertebral muscles, posterior superior iliac spine
- femoral stretch test (reversed Lasègue sign)

In the standing position, the **most important aspects** to observe are:

- coronal balance
- sagittal balance
- sagittal profile
- muscle atrophies

Search for sagittal and coronal imbalance

While the diagnosis of a coronal imbalance is easy to make with the plumbline deviated off the intergluteal groove, the assessment of the sagittal profile is not as obvious. A normal sagittal balance is present if the plumbline runs from the external acoustic meatus down to the acromion, greater trochanter, lateral condyle of the knee and the lateral malleolus. More difficult is the definition of the sagittal profile because of the high individual variability [3]. A thoracic kyphosis of 20–60 degrees is usually regarded as normal [3]. The definition of normal lumbar or cervical lordosis is even more controversial. The normal range in the literature for cervical lordosis (C2–7) ranges from 20 to 35 degrees [14]. However, Grob et al. [14] did not find a significant difference between patients with neck pain compared to healthy individuals with regard to the global curvature, the segmental angles, or the incidence of straight-spine or kyphotic deformity. In a recent study, the lumbar lordosis of young adult volunteers ranged from 26 to 76 degrees with an average of 46 degrees [31]. The sagittal profile should be noted but the **sagittal balance** is more important (Fig. 4). In particular, an anterior imbalance can only be compensated poorly. The spinal muscles must counteract this imbalance and thereby fatigue, which often results in severe pain. It is important to explore the sagittal imbalance in more detail and separate a global trunk imbalance from a head protraction (anterior shifting of the cervical spine). The anterior imbalance has a great impact because it increases the risk of progressive thoracic kyphosis (e.g. in patients with multiple osteoporotic fractures). Similarly, a severe double major scoliosis which is in balance is much less a clinical problem than a decompensated moderate size thoracic curve.

Sagittal disbalance is a frequent cause of back pain

A coronal dysbalance can cause pain in idiopathic scoliosis

The importance of a systematic inspection for **muscle atrophies** is self-evident. Furthermore, the presence of the following **deformity relevant aspects** should be noted during inspection:

- shoulder and pelvis level
- pelvic rotation
- thoracic asymmetry
- waist asymmetry
- rib and lumbar hump (during standing and forward flexion)
- trunk shift (disc herniation)
- spinous process step-off (spondylolisthesis)

In the forward flexed position, any asymmetries of the back contour and leg length discrepancy become more obvious. **Rib hump and lumbar hump** should be assessed either in millimeters or degrees. Leg length discrepancy with consecutive imbalance of the pelvis can be leveled with a wooden board of known height under the foot of the shorter leg to determine the amount.

The finger-floor distance is independent of lumbar mobility

The **finger floor distance** is not a measure of the mobility of the lumbar spine but of the hips and limited by the hamstring muscles. Tight hamstrings in an adolescent with a recent onset of back pain may indicate a spondylolysis/spondylolisthesis.

Sagittal spinal range of motion can be assessed with the Schober and Ott tests

The range of lumbar motion can be assessed during forward flexion with the so-called **Schober test**. A skin mark is made over the spinous process of S1 and 10 cm above. A normal lumbar range is present when the distance between the upper and lower skin mark increases from 10 to over 15 cm (documented as 10/15 cm) during forward flexion. The **Ott test** or thoracic Schober test is an equiva-

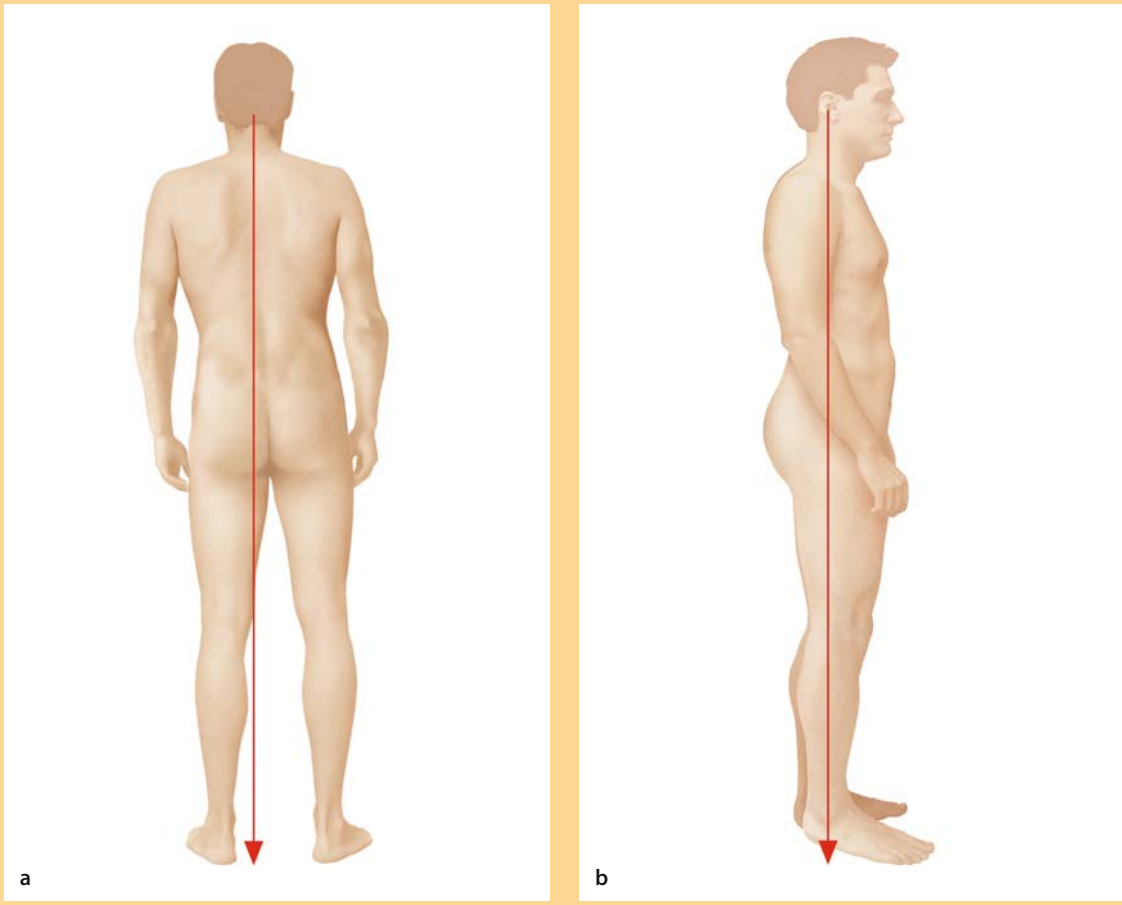


Figure 4. Coronal and sagittal balance

a In the coronal plane the gravity line should fall in the rima ani and between both feet. b In the sagittal plane the gravity originating from the external auditory canal should run along the acromion, greater trochanter, lateral knee condyle and lateral malleolus.

lent test for thoracic spine mobility. A skin mark is made at the spinous process of C7 and a second mark 30 cm below. The distance should range up to 38 cm (documented as 30/38 cm). However, both reproducibility and diagnostic value remain debatable. An important observation is to document an abnormal spinal motion pattern when the patient becomes erect from the forward flexed position. Some patients need the support of their hands on the thigh to straighten up again. This may indicate an underlying segmental instability.

The **motion of the lumbar spine** is best tested with hands crossed behind the neck (Fig. 5). The following **movements** should be tested:

- side bending
- side rotation
- backward bending
- backward bending with rotation

Repetitive motions can provoke typical symptoms

A precise and reproducible assessment is not possible. Therefore, we prefer to semiquantitatively estimate how much these movements are limited (reduced by a quarter, half, etc.). More important than the range of motion is the provocation of symptoms. Side rotation and backward bending stresses more the facet joints,

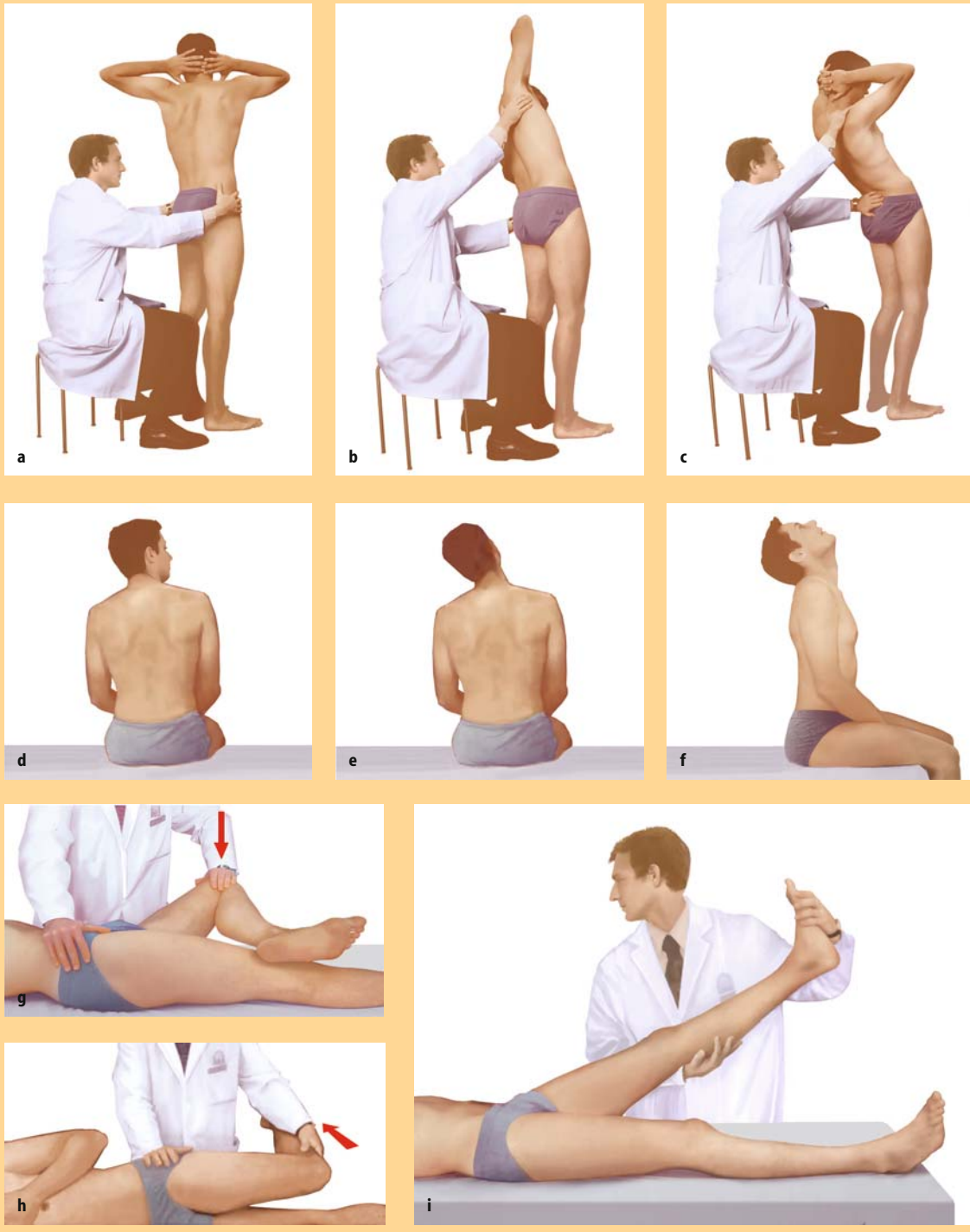


Figure 5. Physical assessments

a Lumbar spine: a left/right side rotation; b left/right side bending; c backward bending. Cervical spine: d left/right side rotation; e left/right side bending; f backward bending. g Patrick test; h Mennel test; i Lasègue test

while side and forward bending stresses more the intervertebral discs. Pain provocation during these movements may therefore be indicative of an underlying pathology of these structures. **Repetitive tests** may be useful in this context. In patients with disc herniation, side rotation and backward bending is likely to increase the pain because this test narrows the lumbar foramen.

Repetitive testing may disclose a subtle muscle weakness

A **global functional test** of the motor force of the lower extremities is applied when the patient is asked to jump on one leg. This ability excludes a relevant paresis of the lower extremities because all muscle groups are activated. Patients frequently present with only subtle motor weakness, which is often not detected during routine examination. A subtle weakness of the gastrocnemius muscle (S1) can be detected by standing on one leg with repetitive (e.g. 10 times on each side) tiptoe standing (**McNab's test**). A similar test for the quadriceps muscle (L3 – 4) is repetitive stool climbing. A subtle weakness will present with an earlier fatigue.

Repetitive tiptoe standing can reveal a subtle weakness

Sitting

The cervical spine is best examined when the patient is sitting on an examination table with their lower limbs and feet freely moving. In contrast to the lumbar spine, **palpation** of bony landmarks is easier in the cervical spine. The examiner should palpate:

- spinous processes C2 – 7
- transverse process of C1
- mastoid process
- facet joints

Always palpate where it is most painful mainly for psychological reasons

The palpation of the paravertebral muscles or osseous processus is seldom of diagnostic value but reasonable from a psychological point of view. If the examiner does not palpate the often painful muscles and provoke pain, the patient may get the impression that they are not being thoroughly examined. Palpation must include the supraclavicular fossae (enlarged lymph nodes, tumor, cervical rib) and the anterior structures (including the thyroid gland).

Functional testing of the cervical spine begins with the measurement of the chin sternum distance. This measure is useful to document the clinical course but not so much as an objective parameter. The **assessment of the mobility** of the cervical spine consists of:

- flexion/extension (chin-sternum distance: documentation, e.g. 2/18 cm)
- left/right rotation (normal: 60° – 0 – 60°) in neutral position
- left/right rotation (normal: 30° – 0 – 30°) in flexed position
- left/right rotation (normal: 40° – 0 – 40°) in extended position
- left/side bedding (normal: 40° – 0 – 40°)

Cervical spine motion is examined with active and passive motion and against resistance

In flexion, rotation only occurs at the upper cervical spine because the facet joints of the lower cervical spine are flexed and there the facet joint capsules are stretched resisting rotation. In extension the upper cervical spine joints are blocked only permitting rotation in the lower cervical spine. Differences in pain provocation in the flexed and extended position may indicate the level of pathology. In the case of limitation of active movements, the examination is repeated with **passive motion** to differentiate between a soft (muscle, pain) and a hard (bony) stop. Beside the assessment of the motion, the provocation of pain is recommended. This can be enhanced by examining the cervical spine **against resistance** and stresses the intervertebral discs (flexion, side bending) or facet joints (rotation, extension), respectively.

If a **cervical radiculopathy** is suspected, the following tests can be carried out to provoke the patients' radicular symptoms (Fig. 6):

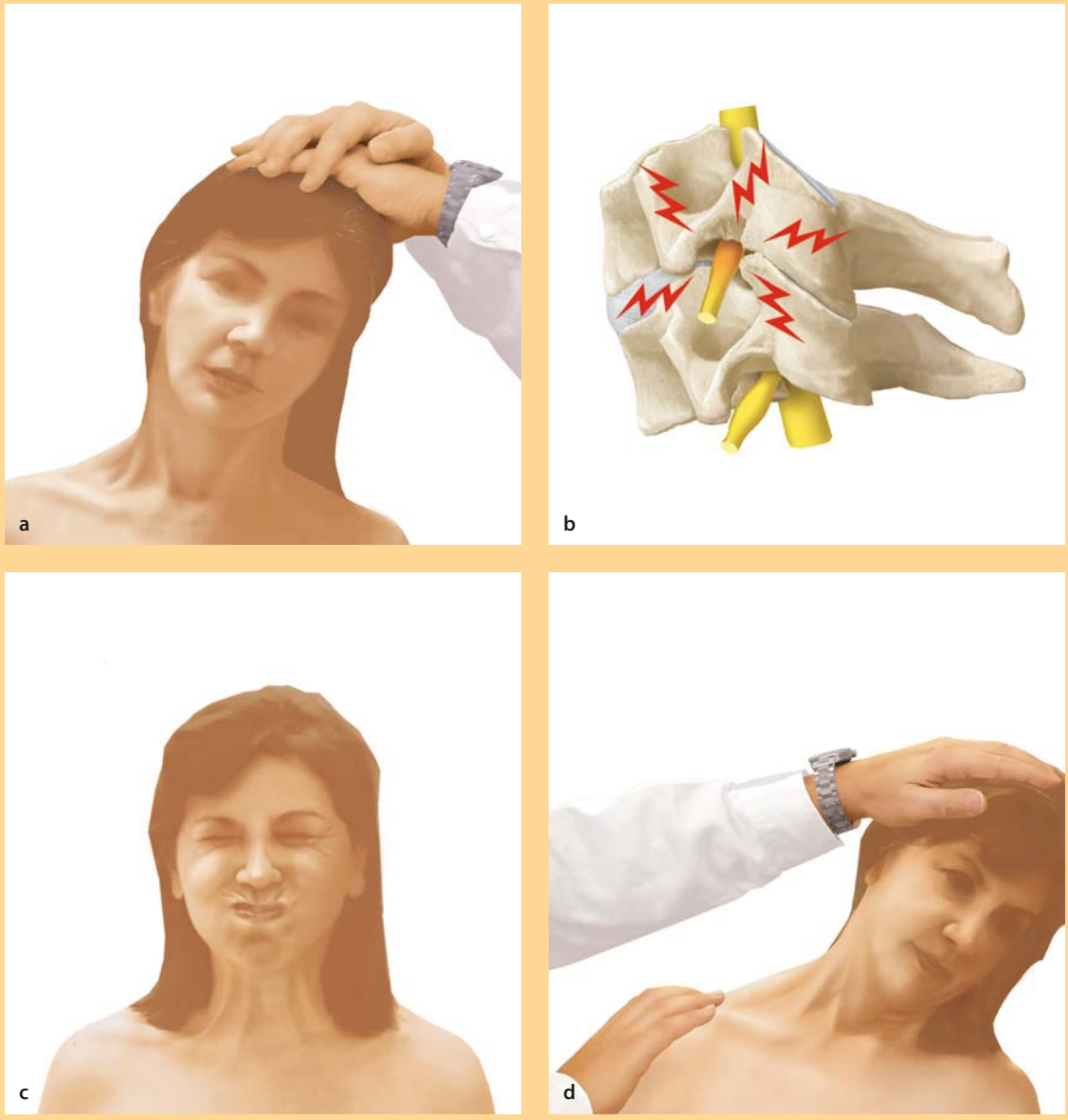


Figure 6. Provocation tests for cervical radicular pain

a **Spurling's test**: continuous (30–60 s) pressure is applied in different head positions (left/right side bending or rotation in neutral position, flexion and extension). b Depending on the target level the different rotation positions further narrow the spinal foramen and may elicit typical radicular pain. c **Valsalva maneuver**: this test may elicit pain by increasing the intradural pressure. d **Shoulder depression test**: this test stretches an affected nerve root and may cause radicular arm pain.

- Spurling's test
- Valsalva maneuver
- shoulder depression test

In the case of a potential differential diagnosis of **thoracic outlet syndrome**, Adson's and the Roos tests can be carried out. **Adson's test** consists of hyperextending the neck and turning the head to the affected side while holding breath. The maneuver leads to a decrease of the radial pulse and tingling in the hand. The **Roos test** is carried out with both arms 90 degrees abducted and externally

Consider thoracic outlet syndrome in the case of arm pain

rotated. The individual rapidly opens and closes the hand for 3 min. The test is positive if the hand becomes pale or blue and the maneuver provokes the typical symptoms.

A thorough neurological examination is compulsory

The **neurological assessment** can be best performed with the patient either in the supine or the seated position. We prefer the latter position because it allows for a better testing of muscle force (e.g. shoulder abduction, hip flexion, knee extension). A prerequisite for a thorough neurological assessment is a profound knowledge of the dermatomal (Fig. 1) and peripheral (Fig. 2) skin innervation. Multiple sensory qualities (heat–cold, pain, touch, pressure, static and dynamic two-point discrimination, vibration sensation) can be distinguished. The most important examinations are:

- light touch
- pin prick
- proprioception

Light touch can still be preserved in the presence of nerve root compression when pin prick is already decreased (see Chapter 11). The cross-over innervation for pain is much less pronounced than for the sensory quality of light touch. The assessment of proprioception (vibration) is important in the differential diagnosis of radiculopathy and peripheral neuropathy. Each dermatome must be systematically assessed in order to allow for a differential diagnosis of a radicular vs. a peripheral neuropathy.

The assessment of each **key muscle** and **tendon reflex** (Table 6) can easily be done in the seated position. A differential diagnosis of peripheral nerve palsies is necessary and diagnosis can be done clinically in many cases (Fig. 7). However, the differential diagnosis can sometimes be very difficult and require

Table 6. Motor innervation and muscle tendon reflexes

Nerve root	Muscle	Reflex	Differential diagnosis for peripheral neuropathy
C3/4	diaphragm deltoid muscle	deltoid reflex (inconsistent)	phrenic nerve (tumor)
C5	deltoid muscle, biceps muscle	biceps reflex	axillary nerve musculocutaneous nerve (normal innervation of the brachioradialis muscle, normal sensation of the thumb)
C6	biceps muscle extensor carpi muscle	biceps reflex, brachioradial reflex	musculocutaneous nerve radial nerve
C7	triceps, wrist flexors, finger extensors	triceps reflex	median nerve (carpal tunnel syndrome, disturbed sweat secretion)
C8	abductor digiti minimi muscle interossei muscles	–	ulnar nerve (sharp sensory deficit of the ulnar half of the ring finger)
L2	iliopsoas muscle (hip flexion)	adductor reflex (inconsistent)	obturator nerve
L3	quadriceps muscle	patellar tendon reflex	lateral cutaneous nerve (meralgia paresthetica – normal motor function)
L4	tibialis anterior	patellar tendon reflex	femoral nerve (intact innervation of the saphenous nerve)
L5	extensor hallucis longus muscle, gluteus medial muscle	tibialis posterior reflex (inconsistent)	peroneal nerve (intact hip abduction)
S1	peroneus brevis, triceps muscle	Achilles	tibial nerve (extensor hallucis longus weakness)

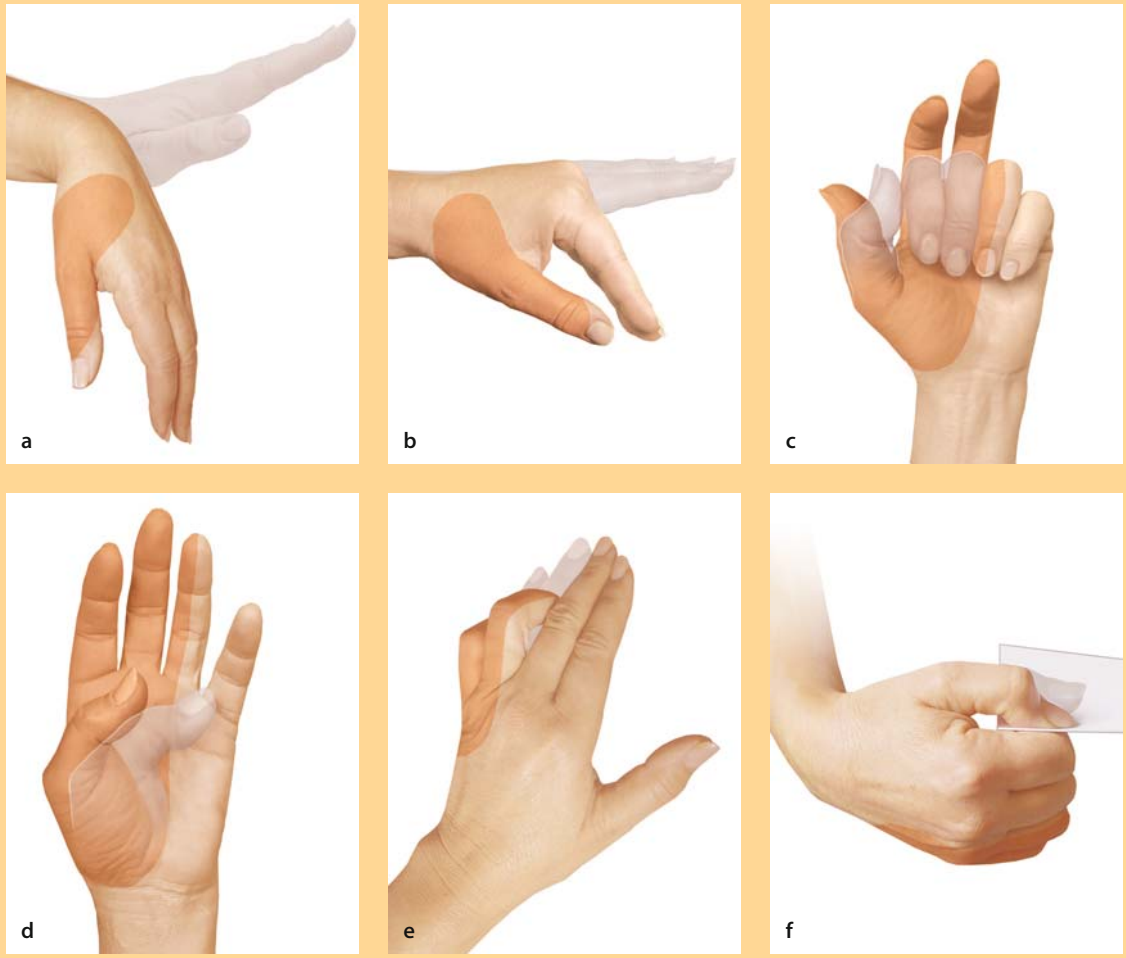


Figure 7. Peripheral nerve palsies

a, b **Radial nerve palsy**: The patient is unable to extend a his wrist and b fingers in the metacarpophalangeal joints. c **Median nerve palsy**: inability to close the hand to a fist to firmly grip a bottle and d to oppose the thumb and fingertips. e **Ulnar nerve palsy**: hyperextension of the metacarpophalangeal joints of the ring and little finger indicates a paralysis of the intrinsic muscles and f inability to adduct the thumb without flexion of the interphalangeal joints (Froment's sign). Note the autonomic regions of innervation for the respective nerves (darker color).

Table 7. Clinical motor strength grading

Motor grade	Findings
5	full movement against full resistance
4	full movement against reduced resistance
3	full movement against gravity alone
2	full movement only if gravity eliminated
1	evidence of muscular contractions or fasciculations
0	no contractions or fasciculations

detailed neurological assessments and neurophysiological studies for further differentiation (see Chapters 11, 12). The muscle force should be assessed according to a standardized protocol either following the guidelines of the British Medical Research Council (Table 7) or as modified by the ASIA Standards (see Chapter 11).

Lying Supine

In the supine position, the **neurological examination** can be completed with regard to the assessment of:

- muscle strength [dorsiflexion of the foot (L4) and greater toe (L5)]
- muscle strength for inversion (L5) and eversion (S1) of the foot
- long tract signs (Babinski, Gordon, Oppenheimer, Rossolimo, see Chapter 11)
- abdominal reflexes (see Chapter 11)
- presence of any spasticity of the lower extremities (see Chapter 11)
- Lhermitte sign
- Straight leg raising test

Radicular pain provocation is the key aspect of the Lasègue sign

The **Lhermitte sign** is provoked by forceful flexion of the head. The test is positive if the patient has a sensation of electrical shocks in the body and lower extremities. This sign is indicative of a severe spinal cord compression. There is a plethora of descriptions of the **Lasègue sign** (test). We regard the test as positive in the presence of radicular leg pain. It is important to precisely ask the patient what they are experiencing while the straight leg is raised. We always note the elevation degree when radicular pain is experienced. Any other sensation than radicular pain is not regarded as a true Lasègue sign and can be described as a **pseudolasègue sign**. The latter sign does not exclude the presence of a radiculopathy but is often caused by a severe muscle spasm. Most frequently, the patient is just experiencing tension in the popliteal fossa as a result of tight hamstrings. A **cross-over sign** is present when the patient experiences radicular pain in the affected leg while raising the contralateral leg and is highly predictive of a large median disc herniation [18].

Do not overlook a hip joint disorder

While the patient is in the supine position, the hips should be examined so as not to overlook a **hip pathology**, which is frequent in elderly patients. The diagnosis of an affection of the **sacroiliac joint** is very difficult clinically because this joint is not easily accessible. It is possible to compress or distract the sacroiliac joint and provoke pain in the case of an affection. However, we can also use the femur as a lever to move the sacroiliac joint. The so-called **Patrick test** is performed by flexing the ipsilateral hip and knee and placing the external malleolus of the ankle over the patella of the opposite leg. The examiner gently pushes the ipsilateral knee down until a hard resistance is felt. At this point, the examiner gives a short impulse on the ipsilateral knee, i.e. pushing it towards the examination table. The test is positive if the patient feels the usual buttock pain (Fig. 5).

The examination in the supine position is completed by assessing the arterial pulses with regard to an important differential diagnosis of neurogenic claudication.

Lying on Left/Right Side

Hip abduction differentiates L5 radiculopathy and peroneal nerve palsy

The patient is asked to lie on their left and right side, respectively. In this position, the **hip abduction** is tested with the lower knee flexed and the upper knee extended. Normal hip abduction force (L5) in the presence of a foot drop is indicative of a paresis of the peroneal nerve (Case Introduction).

In this position, a further test for sacroiliac joint affection can be done (**Mennell test**). The upper hip is extended and the knee flexed. The examiner places one hand on the ipsilateral hip and with the other hand extends the hips gently until a hard stop is felt. At this point the examiner gives a short impulse by pulling the leg in more extension. The test is positive if the patient feels the usual buttock pain.

In the lateral position, the perianal sensitivity and sphincter tone can be tested to rule out a cauda equina syndrome.

Lying Prone

The reversed Lasègue sign is tested with the leg extended

In this position, the **reversed Lasègue sign** or femoral stretch test can assess lumbar disc herniations at higher levels (L2 – 4). The test is positive if extension of the straight leg is causing anterior thigh pain. It is important to perform the test with the leg straight, because flexion of the knee stretches the quadriceps muscle, which makes it difficult to separate neural and muscular pain.

Palpation is rarely diagnostic

Finally, the spinous processes, paraspinal muscles and the posterior superior iliac spine can be palpated. Although this examination seldom provides a clue for the underlying pathology, it is psychologically important as outlined above.

Abnormal Illness Behavior

Positive Waddell signs suggest non-organic causes of symptoms

If there is some doubt regarding the severity or genuineness of the patient's complaints, not only the patient's pain drawing [26] will show frank exaggeration or non-anatomic pain patterns [38], but several tests might also be useful in this setting. Waddell [36, 39] described **five signs** to help reveal functional overlay in back pain patients.

- presence of widespread superficial tenderness
- pain on axial loading or simulated rotation
- postural differences in straight leg raising test
- regional non-anatomic sensory/motor disturbances
- overreaction (crying out, facial expression, sweating, collapsing)

Vertical compression on the head in the standing position is not translated to the lumbar spine. When the patient is standing and presses their arms firmly against the greater trochanters, the first 30 degrees of rotation occur in the hip joints. Both tests therefore should not cause low-back pain unless psychological overlay is present. Large differences (< 20 degrees) of the straight leg raising test between sitting and lying cannot be explained pathoanatomically and are indicative of abnormal illness behavior.

Reproducibility

The reproducibility of history and physical findings is limited

It is important to note that findings during history taking and physical assessment are hampered by a poor or only modest reproducibility. This has to be borne in mind when using this data for outcome evaluation and scientific projects [4, 20, 24, 28, 32, 33, 40]. The reproducibility of history of having ever experienced back pain has been reported to be around 80 % [4, 40]. The same has been found for **pain drawings** made by patients [19]. Retrospective data obtained by means of subjective patient statements should be handled with great caution. With regard to physical signs, only a few studies have addressed the issue of reproducibility [4, 20, 22, 24, 29]. McCombe found that reliable signs consisted of measurements of lordosis and flexion range, determination of pain on flexion and lateral bend, nearly all measurements associated with the straight leg raising test, determination of pain location in the thigh and legs, and determination of sensory changes in the leg [20].

Differential Diagnosis of Spinal Pain Syndromes

The differential diagnosis of spinal disorders in general and low-back pain particularly is far reaching. The differential diagnosis of spinal pain syndromes includes neoplasia, infection, inflammatory disease, as well as pelvic organ disorders, and renal and gastrointestinal disorders. Jarvik and Deyo differentiate non-mechanical spinal conditions and visceral disease (Table 8) from mechanical low-back pain in the differential diagnosis of low-back pain [8, 17].

Table 8. Differential diagnosis of low-back pain

Non-mechanical spinal conditions (1%)	Visceral disease (2%)
Neoplasia (0.7%) • multiple myeloma • metastatic carcinoma • lymphoma and leukemia • spinal cord tumors • retroperitoneal tumors • primary vertebral tumors	*Pelvic organ involvement* • prostatitis • endometriosis • chronic inflammatory disease • chronic pelvic inflammatory disease
Infection (0.01%) • osteomyelitis • septic discitis • paraspinous abscess • epidural abscess	*Renal involvement* • nephrolithiasis • pyelonephritis • perinephric abscess
Inflammatory arthritis (0.3%) • ankylosing spondylitis • psoriatic spondylitis • Reiter syndrome • inflammatory bowel disease	*Gastrointestinal involvement* • pancreatitis • cholecystitis • penetrating ulcer
Paget disease	*Aortic aneurysm*

Figures in parenthesis indicate estimated percentage of patients with these conditions among all adult patients with signs and symptoms of low-back pain according to Jarvik and Deyo [17]

Recapitulation

History. The high rate of benign self-limiting low-back and neck pain can disguise serious underlying causes of spinal pain. The most important task of the clinical assessment is to **rule out serious illness** indicated by the so-called **red flags**, i.e., features of cauda equina syndrome, severe worsening pain (especially at night or when lying down), significant trauma, fever, unexplained weight loss, history of cancer, patient over 50 years of age, and use of intravenous drugs or steroids. Tumors and infections must be ruled out. Furthermore, a **relevant paresis** (motion of the extremity against gravity impossible) must be detected early and treated. After red flags are ruled out, the clinical assessment focuses on the three major complaints which lead patients to seek medical help, i.e. pain, functional impairment, and spinal deformity. The most important differentiation of pain is the distribution between central (back/neck) and peripheral pain (leg/arm). **Radicular pain** must be distinguished from **axial** (central) pain. Radicular pain is usually attributable to a pathomorphological correlate. Pain intensity should be assessed with a visual analogue scale. The assessment of **positional** and **activity modulators of spinal pain** is very helpful for further differential diagnosis of the pain syndrome. Physical impairment should be differentiated from disability and handicap. The history of patients with **spinal deformity** should include the assessment of spinal deformities requiring some specific additional information from the patient (or parents). The patients should be explored with respect to: family history, course of pregnancy and delivery, developmental milestones (onset of walking, speaking,

etc.), fine motor skills, tendency to fall (clumsiness), onset of menses, and evidence of metabolic or neuromuscular disorders.

Examination. The physical examination is performed with the patient in different positions, i.e. walking, standing, sitting, lying supine, lying on the left/right side, lying prone. During **walking** the presence of a limp, ataxia, and muscle force (walking on hips/tiptoes) is assessed. The most important aspect for the examination in the **standing position** is the assessment of the sagittal and coronal balance. The sagittal profile (lordosis/kyphosis) is largely variable. **Finger floor distance** is an assessment of the hip flexion and muscle stretch. Repetitive testing of a motion (tiptoe standing, stepping up on a stool) may disclose a subtle muscle weakness. In the **seated position**, the examination for sensory deficits, muscle weaknesses and tendon reflexes is facilitated. Similarly, the examination of the cervical spine is best performed with the patient in this position. Rotation in flexion examines the upper cervical spine and rotation in extension of the lower cervical spine. In the seated position **radicular provocation tests** (Spurling's test, Valsalva maneuver, and shoulder depression test) can be performed to provoke typical radicular pain. In the supine position, the straight leg raising test (Lasègue sign) is performed. The most important read-out of this test is the provocation of radicular pain, which is pathologically independent of the degree of hip flexion. Elicited non-radicular pain can be classified as a pseudolasègue sign. The assessment of hip and sacroiliac joint function as well as vascular status should not be forgotten. In the **left/right side position**, assessment of the hip abduction force is important for a differential diagnosis of L5 radiculopathy and peroneal nerve palsy. In this position, the perianal sensitivity and sphincter tonus are best assessed. In the **prone position**, the reversed Lasègue sign (for nerve root compromise, L2 – 4) can be tested. The palpation of the dorsal and lumbar spine is hardly ever diagnostic but should not be discarded for psychological reasons. The assessment of abnormal **illness behavior** is mandatory. In general, the reproducibility of history taking and physical examination is limited. The differential diagnosis of spinal pain syndromes includes cancer, infection, inflammatory disease, as well as pelvic organ disorders, and renal and gastrointestinal disorders.

Key Articles

Biering-Sorensen F, Hilden J (1984) Reproducibility of the history of low-back trouble. Spine 9:280 – 6
This paper reports on the reproducibility of auto-anamnestic information concerning low back trouble. The authors found that within a year, only 84 % of people recall ever having had back pain, which the authors explained by forgetfulness. They made the statement that data obtained by means of subjective statements should be handled with caution.

Deyo RA, Rainville J, Kent DL (1992) What can the history and physical examination tell us about low back pain? JAMA 268:760 – 5
Excellent overview article on important findings during history taking and physical assessment.

Vroomen PC, de Krom MC, Wilmink JT, Kester AD, Knottnerus JA (2002) Diagnostic value of history and physical examination in patients suspected of lumbosacral nerve root compression. J Neurol Neurosurg Psychiatry 72:630 – 4
This paper deals with patient characteristics, symptoms, and examination findings in the clinical diagnosis of lumbosacral nerve root compression. Various clinical findings were found to be associated with nerve root compression on MR imaging, i.e. the tests tended to have a lower sensitivity and specificity than previously reported. The straight leg raise test was not predictive. Most of the diagnostic information revealed by physical examination findings had already been revealed by the history items.

Spratt KF, Lehmann TR, Weinstein JN, Sayre HA (1990) A new approach to the low-back physical examination. Behavioral assessment of mechanical signs. Spine 15:96 – 102
This study systematically explores the test-retest reliability, a low-back physical examination tool. Patients' reports of pain location were quite stable across time but reports of

pain aggravation were generally less consistent across time than were later observed pain behaviors.

Waddell G, McCulloch JA, Kummel E, Venner RM (1980) Nonorganic physical signs in low-back pain. Spine 5:117 – 25
Landmark article on the clinical significance of non-organic signs in low-back pain.

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