3.1 Spine, trunk

3.1.1 Examination of the back

History

- *Trauma history:* Has *trauma* occurred?
  If so:
  - When did the trauma occur?
  - What was the patient doing (sport, playing, normal routine)?
  - Direct or indirect trauma?
- *Pain history:*
  Where is the pain located (neck, upper thoracic spine, lower thoracic spine, lumbar spine, lumbosacral spine)? When does it occur? Is it related to loading or movement, or does it also occur at rest (e.g. while sitting) or even at night? If so, does the pain occur only while changing position, or does the pain cause the patient to wake up at night? Does the pain occur on bending down or straightening up again? Does the pain also radiate to the legs? Does the pain occur on coughing or sneezing?
- *Sports history*
  What sports does the patient practice outside school? If spondylolysis is suspected ask specifically about the following activities: gymnastics, figure skating, ballet, javelin-throwing. If Scheuermann disease is suspected ask specifically whether the patient is involved in cycle racing or rowing.
- *Neurological symptoms*
  Is a leg weakness present and, if so, since when? Are there problems of micturition or defecation?

Inspection

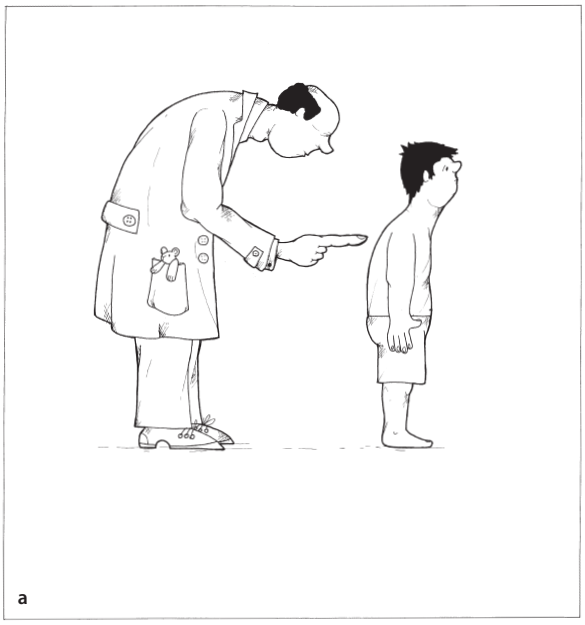
After the gait analysis (▶ Chapter 2.1.3), the standing patient's back is inspected from behind.

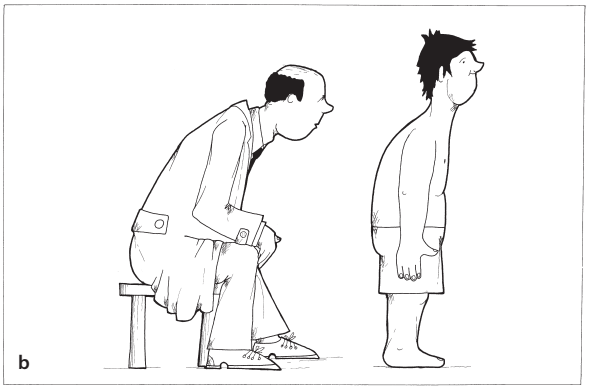
! To ensure that the patient's back is at eye-level, the examiner himself should not stand but preferably sit on a chair of the appropriate height (◘ Fig. 3.1).

- *Inspection from behind*
  We observe the position of the shoulders, the height of the scapulae and particularly the symmetry of the waist triangles. We look for pigmentation over the spinous processes, especially over the lumbar spine, as this can be an indication of (usually pathological) kyphosis in this area. A (hairy) nevus in this area can be a sign of an intraspinal anomaly.
- *Inspection from the side*
  We assess the sagittal curves and establish a postural type: normal (physiological) back, hollow back (increased thoracic kyphosis and lumbar lordosis), fully rounded back (kyphosis extending down to the lumbar area), hollow-flat back (hyperlordosis of the lumbar spine with reduced kyphosis of the thoracic spine, common in small children), flat back (reduced kyphosis of the thoracic spine and lordosis of the lumbar spine; ◘ Fig. 3.2).

! If the sagittal curves can be corrected by bending backwards or forwards, then postural variants are involved rather than (fixed) pathological changes. N.B.: beware of overdiagnosis and overtreatment!

We observe whether a ventral or dorsal overhang is present (◘ Fig. 3.3) and the extent of the pelvic tilt (◘ Fig. 3.4).





◘ **Fig. 3.1a.** *Not like this!* **b** During *examination in the standing position* the patient's back should be at the eye level of the examiner, who should therefore be seated. Small children may need to stand on a box so that the iliac crest is at the examiner's eye level. The child must be undressed down to the underpants. The dignity of the child or adolescent must be preserved. Girls who have reached puberty should also be allowed to wear their brassiere. Otherwise, all items of clothing, including socks, should be removed.

A vertical line from the center of the shoulders should pass through the center of the ankle. The forward and downward pelvic tilt is approx. 30° in relation to the horizontal. A reduction in this tilt is an indication of lumbar kyphosis (e.g. in lumbar Scheuermann disease) or of spondylolisthesis.

In order to assess posture-related muscle performance, Matthiass has proposed the arm-raising test. The child is asked to stand as straight as possible and raise his arms and keep them in a horizontal position. He should try and maintain this position for 30 seconds. A child or adolescent with normal postural capacity is able to maintain this position, in contrast with a child with postural weakness (Fig. 3.5).

We now ask the child to bend down as far as possible while keeping the knees perfectly straight. We now measure the finger-floor distance (FFD; Fig. 3.6). Normally, children and adolescents should be able to touch the floor with their fingertips or even place the whole palm of their hand on the floor. If this is not possible, we measure the distance from the fingertips to the floor in

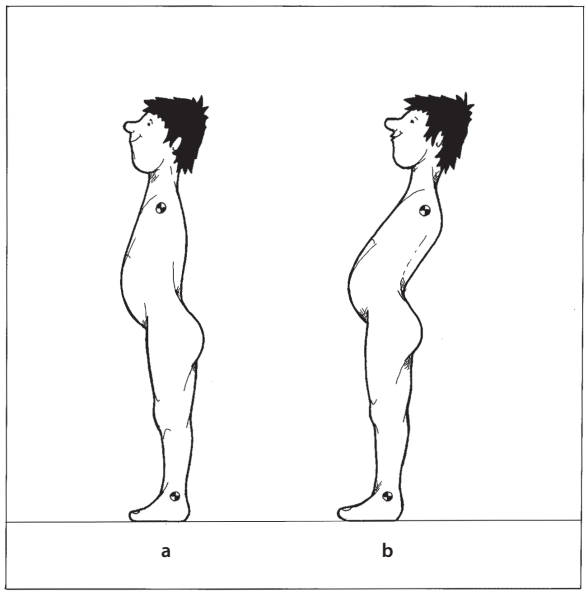


Fig. 3.3a. *Ventral* and **b** *dorsal overhang*: A vertical line from the center of the shoulders falls in front of or behind the center of the ankle

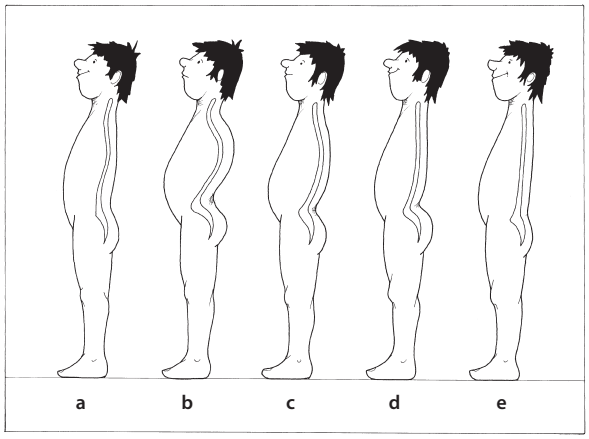


Fig. 3.2a–e. *Postural types:* **a** normal back, **b** hollow back, **c** rounded back, **d** hollow-flat back, **e** flat back

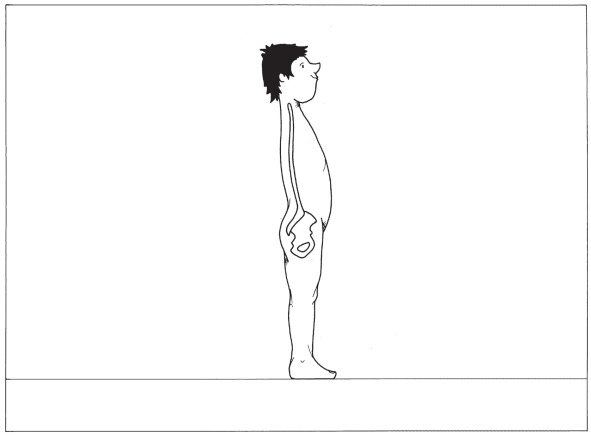


Fig. 3.4. *Pelvic tilt:* The forward and downward pelvic tilt in relation to the horizontal is normally approx. 20°–30°

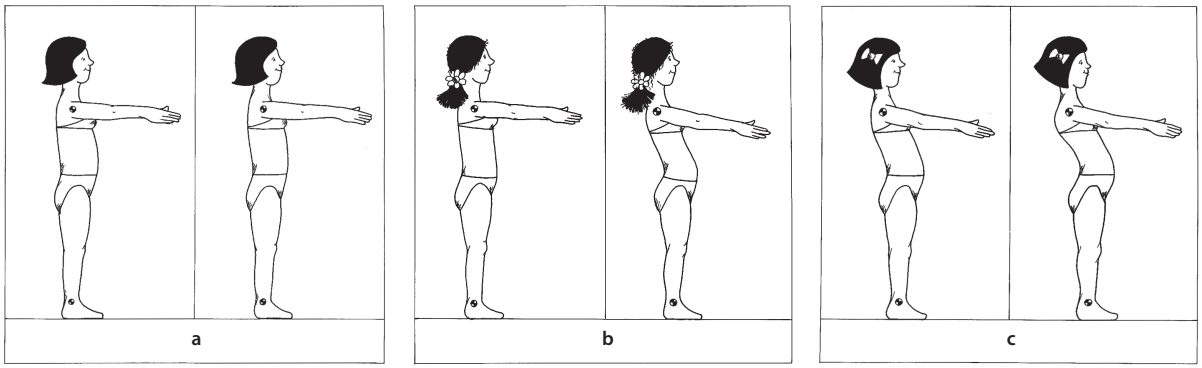


Fig. 3.5a–c. *Arm-raising test according to Matthiass:* The child is asked to stand as straight as possible and raise his arms and keep them in a horizontal position. He should try to maintain this position for 30 seconds. A child or adolescent with normal postural performance is able to maintain this position (a), in the case of a postural weakness this posture is lost (b), while a child with extremely weak muscles cannot even adopt the upright posture (c)

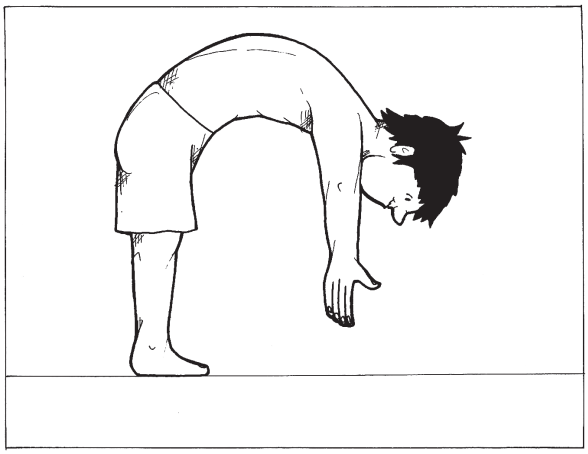


Fig. 3.6. *Finger-floor distance* (FFD): The patient bends down as far as possible without bending the knees. The distance between the floor and the fingertips is measured. Normal value = 0 cm

centimeters. However, this distance is less an indication of reduced mobility of the back than of contraction of the hamstrings. With the patient in a forward-bending position we observe whether the lumbar lordosis is corrected and whether the thoracic spine shows the right degree of kyphosis (correction of postural curvature in the case of a hollow or flat back). The patient is now asked to clasp his hands behind his neck (to prevent the shoulders from being pulled forward by the arms) and try to look up at the ceiling without changing the flexed position at the hip. Ideally, the patient is held in this position with a hand placed at the apex of the kyphosis and then asked to bend back (»look up at the ceiling«). We can then observe whether the thoracic kyphosis straightens out or whether a fixed kyphosis is present (e.g. as in a case of thoracic Scheuermann disease; Fig. 3.7). If the latter is suspected, the condition of the pectoral muscles must also be assessed at the same time. To this end, the shoulders of the erect patient are pushed backwards by hand. If the pectoral muscle is contracted, the shoulder remains in front of the thoracic plane.

- *Evaluation of the iliac crest*

  We place extended index fingers on both sides of the ilium and extend and abduct the thumbs at right angles, which then serve as pointers. We try to hold both thumbs horizontally (Fig. 3.8). If one iliac crest is lower than the other this will be reflected in the difference in the height of the thumbs. However, since it can be difficult to establish the precise difference, we place boards under the shorter leg until the iliac crests on both sides are at the same level and the two thumbs are likewise at the same height. The thickness of the boards corresponds to the leg length discrepancy in centimeters.

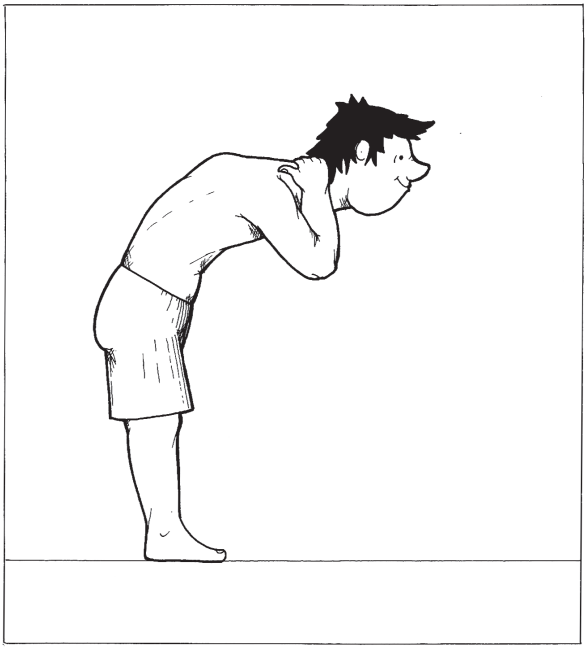


Fig. 3.7. *Straightening of the kyphosis:* While in a forward-bending position the patient clasps his hands behind his neck (to prevent the shoulders from being pulled forward by the arms) and tries to look up at the ceiling without changing this flexed position at the hip. Ideally, the patient is held in this position with a hand placed at the apex of the kyphosis and then asked to bend back (»look up at the ceiling«). We can then observe whether the thoracic kyphosis is straightened out or whether a fixed kyphosis is present

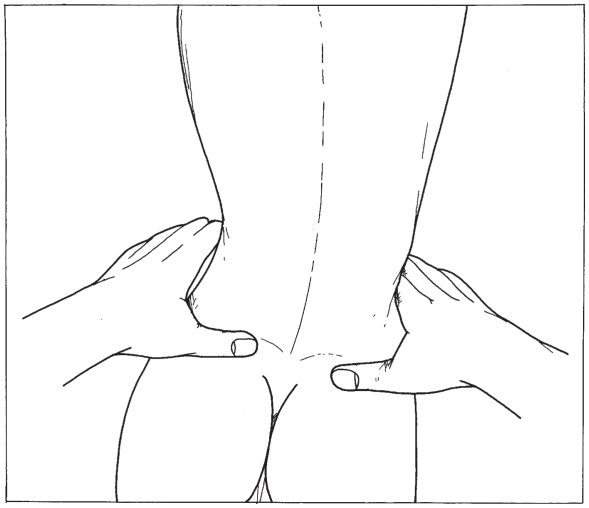


Fig. 3.8. *Height of the iliac crests:* Extended index fingers are positioned on both sides of the ilium. The thumbs are extended and abducted at right angles to serve as pointers. If one iliac crest is lower than the other this will be reflected in the difference in the height of the thumbs. Boards are placed under the shorter leg until the iliac crests on both sides are at the same level and the two thumbs are likewise at the same height.

When measuring leg length indirectly it is extremely important to ensure that both the knee and hip joints are fully extended, unless this is rendered impossible because of flexion contractures.

— *Vertical alignment*
A cord with a symmetrical weight is placed against the vertebra prominens, and we assess whether the weight is in line with the anal cleft or, if not, how many fingerwidths it deviates to the right or left (Fig. 3.9).

Examination of mobility

— *Examination of mobility from behind*
We examine the maximum lateral inclination of the standing patient's spine from behind (Fig. 3.10). We observe whether the whole spinal column curves harmoniously to the side or whether individual segments are fixed and do not move with the rest of the spine (indication of fixed scoliosis). The pelvis must be fixed in order to evaluate trunk rotation. The rotation of the shoulder girdle in relation to the frontal plane is measured in degrees and is best observed from above (Fig. 3.11).
The patient is now asked to bend forward until the thoracic spine forms the horizon. The symmetry of the thorax is assessed. Protrusion of the rib cage on one side is termed a rib prominence. Using a protractor (or – if available – a scoliometer or inclinometer) we measure the angle between the rib prominence and the horizontal (the latter can be determined parallel to a door or window frame in the examination room; Fig. 3.12).

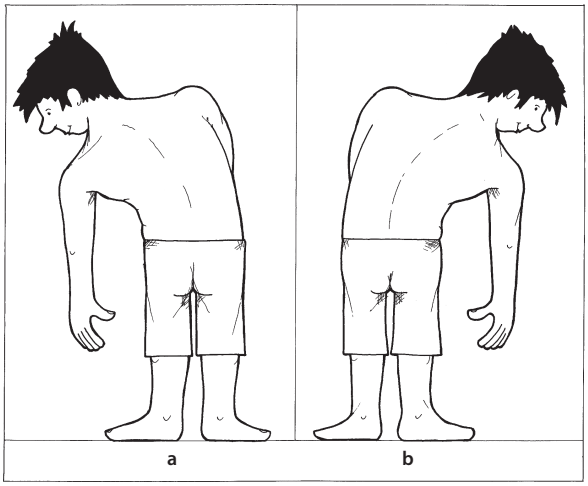
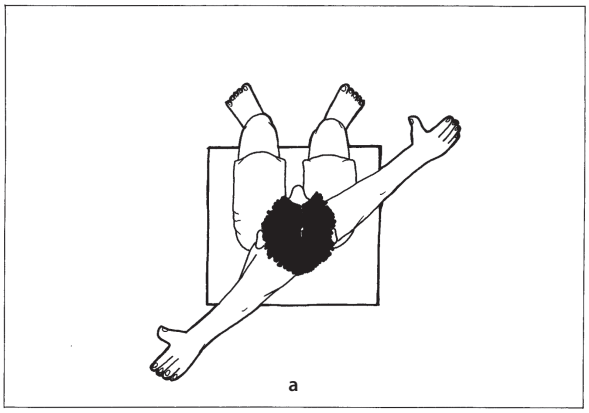


Fig. 3.10a, b. *Lateral inclination of the trunk:* The angle between the vertical and maximum lateral inclination of the spine is estimated in degrees from behind the standing patient (normal value: 30° –50°). We observe whether the whole spinal column bends harmoniously to the side or whether individual segments are fixed and do not move with the rest of the spine



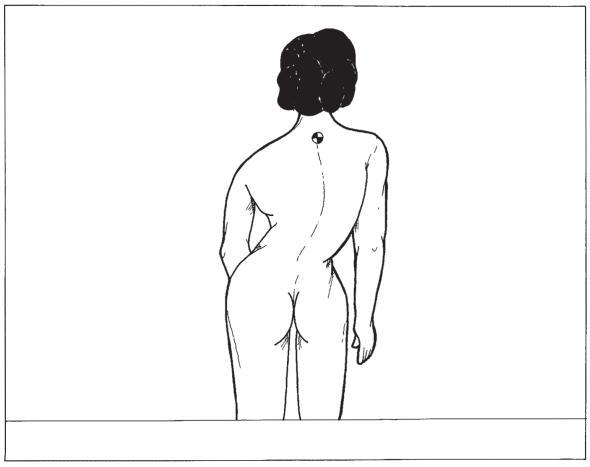


Fig. 3.9. *Vertical alignment:* A cord with a symmetrical weight is placed against the vertebra prominens and checked to see whether it is in line with the anal cleft or how many fingerwidths it deviates to the right or left

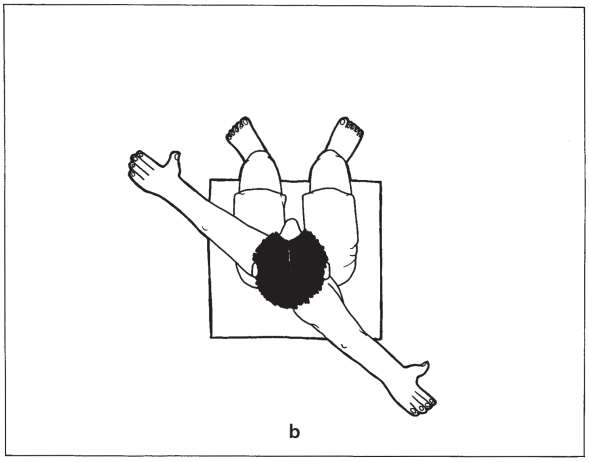


Fig. 3.11a, b. *Rotation of the trunk:* With the pelvis fixed, the rotation of the shoulder girdle in relation to the frontal plane is measured in degrees and is best observed from above. Normal value: 40° – 50°

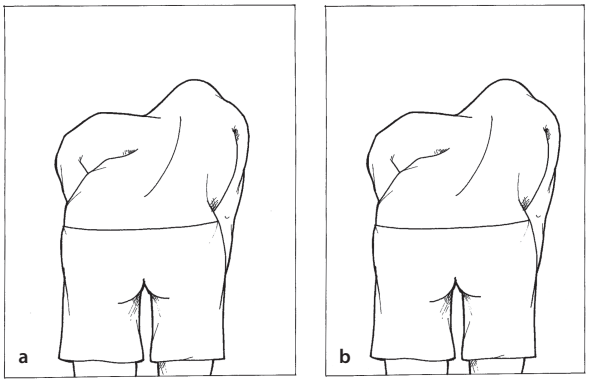


Fig. 3.12a, b. *Measurement of rib prominence:* The patient bends forward until the thoracic spine forms the horizon. **a** With a protractor, the angle between the horizontal (i.e. parallel to the door or window frame) and the surface of the back is measured. **b** A simpler and more accurate measurement is obtained with an inclinometer with integrated spirit level and a notch in the center to avoid any distortion of the measurement caused by the projecting spinous process

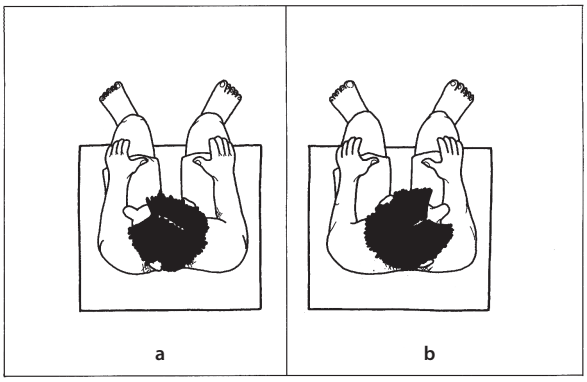


Fig. 3.13a, b. *Head rotation:* Head rotation to both sides is measured from above with the patient in a sitting position. The rotation is stated in degrees measured from the midline. It can be measured actively (by asking the patient to turn his head) or passively (by holding the sides of the head with both hands and turning to either side). Normal value: 60° – 80°. Observe any tensing of the sternocleidomastoid muscle at the same time

A rib prominence of more than 2° together with a horizontal pelvis is a reliable indication of a fixed rotation of the vertebral bodies. A rib prominence of 5° or more represents a serious case of scoliosis and requires radiographic investigation. The patient is now asked to continue bending forward until the lumbar spine forms the horizon so that we can then identify any lumbar prominence. Here, too, it is important that the pelvis is horizontal. If one leg is shorter than the other, the leg length discrepancy must be corrected using a board of appropriate thickness. The lumbar prominence is also measured with a protractor. An angle of 5° or more requires x-ray examination.

Examination of the mobility of the cervical spine

The head rotation to both sides is ideally measured from above with the patient in a sitting position (Fig. 3.13). The rotation can be actively (ask the patient to turn his head) or passively (hold the sides of the head with both hands and turn to either side). We can also observe any tensing of the sternocleidomastoid muscle during this maneuver. If a contracture due to muscular (congenital) torticollis is present, the muscle tenses on the side of the rotation movement.

We then check lateral inclination (Fig. 3.14), which can also be measured actively or passively. Here, too, the tensing of the sternocleidomastoid muscle is observed. If contracture is present, the muscle tenses when the head is inclined to the opposite side.

Finally, inclination and reclination are examined. With the head inclined forward the chin-sternum distance is measured. The patient then bends his head back and the angle with the axis of the body is estimated (Fig. 3.15).

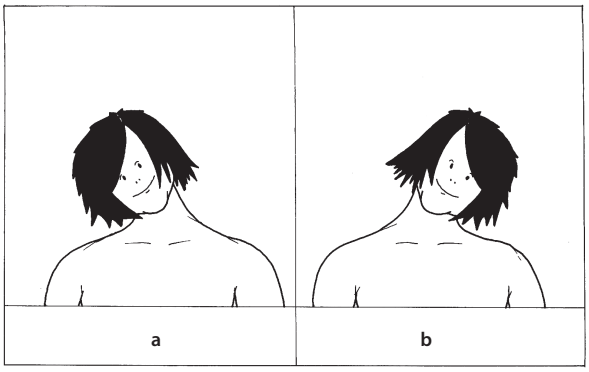


Fig. 3.14a, b. *Lateral inclination of the head:* This can be measured actively or passively. The deviation from the midline is stated in degrees. Normal value: 40° – 50°. Observe any tensing of the sternocleidomastoid muscle at the same time

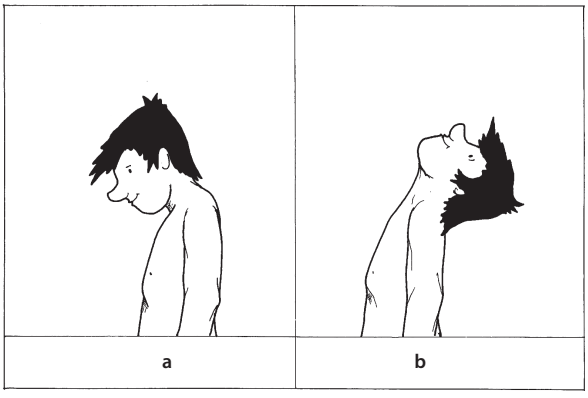


Fig. 3.15a. *Inclination of the head:* The chin-sternum distance is measured (in centimeters or fingerwidths; normal value: 0 cm). **b** *Reclination:* Estimate the angle in relation to the axis of the body in degrees. Normal value: 40° – 60°

- *Schober measurement*
  The Schober test is used to determine the mobility of the spine in the sagittal plane and involves measurement of the stretching of the skin over the thoracic and lumbar spine. An initial mark is made over spinous process S1 and a second mark 10 cm above the first. The distance between these skin marks increases as the patient bends forward, reaching a maximum of 15–17 cm. Thoracic spine: A mark is made over spinous process C7, and a second mark is made 30 cm below this. As the patient bends forward the distance between the two increases by 2–3 cm (Fig. 3.16).
  The maximum reclination of the spine is measured as shown in Fig. 3.17. We observe whether the patient complains of pain around the lumbosacral junction (indication of spondylolysis).

Palpation

We palpate the spinous processes and establish whether pain is elicited on pressure, percussion or vibration. To check pain on vibration we grasp the spinous processes between forefinger and thumb and move them back and forth. If the patient finds this painful, particularly around the lumbosacral junction, this is an important indication of possible spondylolysis.

We palpate the paravertebral muscles to assess whether these are strong, normal or weak, palpate any painful areas of muscle hardening (myogeloses) and check for tenderness over the muscle attachments. The transverse processes can also be felt by deep palpation.

During palpation, the skin moisture, temperature and elasticity of the skin are assessed and any dermographic urticaria noted.

- *Heel-drop test*
  The patient is asked to stand on tiptoe and the examiner rests his hands on the patient's shoulders. The patient is now asked to drop onto his heels while the examiner simultaneously presses down on the shoulders. This maneuver will elicit any vibration-related pain in the spine caused by inflammation, tumors or herniated disks.
- *Iliosacral joints*
  We check for pain on pressure or percussion and pain on compression from the side and sagittally. Mennell sign: In disorders of this joint, pain is elicited if the hip on the same side is overextended.

Neurological examination

A complete examination of the back (Table 3.1) also includes at least a cursory investigation of the neurological status. A very rough (and quick) indication of a motor disorder can be obtained by checking the patient's ability to walk on tiptoes or on heels. The most important aspects of the neurological examination from the orthopaedic standpoint are described in ▶ chapter 2.1.2.

Brief overview of spinal status (e.g. in mass screening or if the child is being seen specifically for a back problem):

- *Inspection from behind,*
- *Height of the iliac crests,*
- *Finger-floor distance,*
- *Rib prominence, lumbar prominence on forward bending?*
- *Walking on tiptoes and heels.*

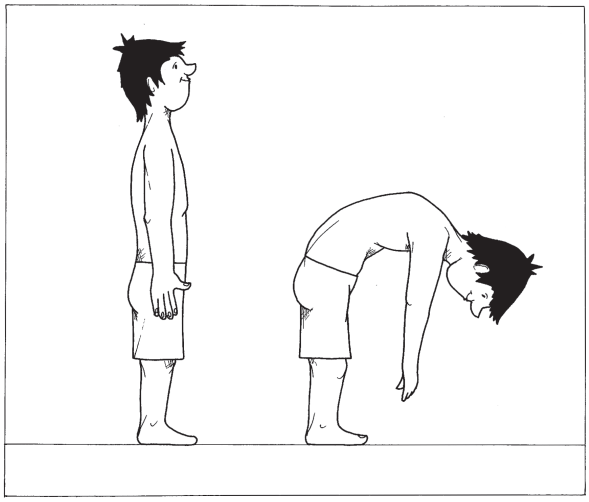


Fig. 3.16. *Schober sign.* Lumbar spine: Make an initial mark over spinous process S1 and a second mark 10 cm above this. The distance between these skin marks increases as the patient bends forward, reaching a maximum of 15–17 cm. Thoracic spine: A mark is made over spinous process C7, and a second mark is made 30 cm below this. As the patient bends forward the distance between the two increases by 2–3 cm

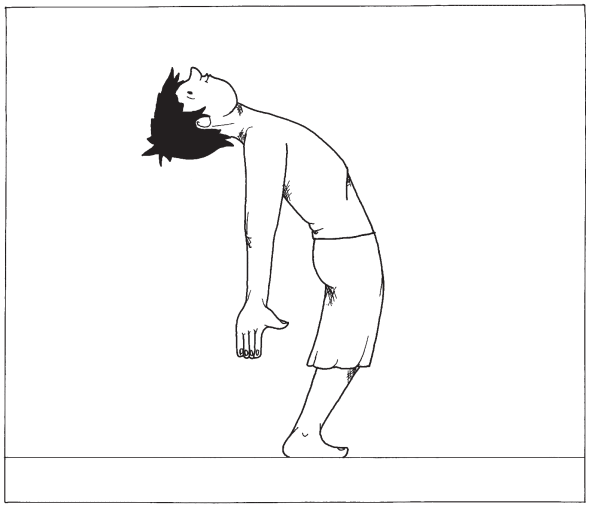


Fig. 3.17. *Reclination of the trunk:* The maximum reclination of the spine is measured as the angle between the upper body's vertical axis and the frontal plane. Normal value: 30°–60°

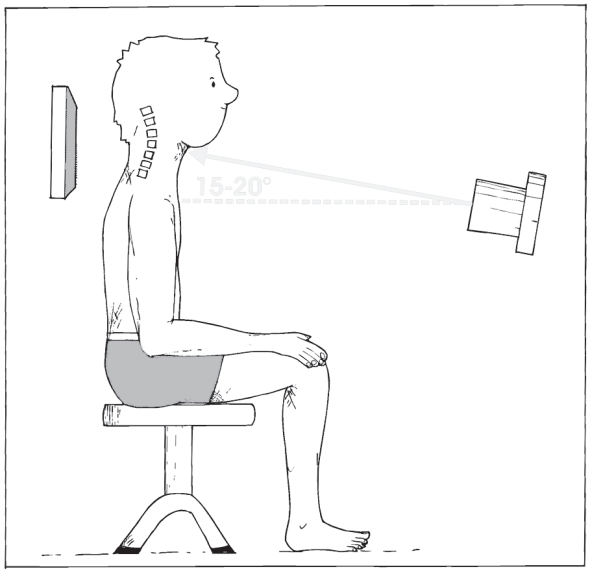
Table 3.1. Examination protocol for the back

Examination position	Examination	Questions
I. Walking	Movement pattern? Limping?	Ataxia? Neurological lesion?
II. Standing from behind	Position of the shoulders? Scapulae symmetrical? Spine straight? Iliac crests horizontal? Gluteal folds symmetrical? Waist triangles symmetrical? Plumbline in the center? Pigmentation over spinous processes? Hardening of paravertebral muscles? (if necessary examine on the lying patient as well) Pain on percussion/vibration of the vertebral bodies? (if necessary examine on the lying patient as well)	Scoliosis? Plexus paresis? Sprengel deformity? Winged scapula? Sprengel deformity? Scoliosis? Leg length discrepancy? Hip condition? Scoliosis? Severe scoliosis? Lumbar kyphosis? Myogelosis (muscle spasm)? Tumor? Infection? Spondylolysis?
III. Standing from the side	Shoulders pulled forward? Sagittal curves? Transition between front/back	Contracture of the pectoralis muscles? Scheuermann's disease? Contracture of psoas or hamstrings?
IV. Standing with flexed back from behind From the side	Spine straight? Rib hump >5° Lumbar prominence >5° FFD? Can the thoracic kyphosis be straightened out?	Scoliosis? Thoracic scoliosis? Lumbar scoliosis? Contracture of hamstrings? Thoracic Scheuermann's disease?
V. Mobility	Lateral inclination of the head? Head rotation? Reclination/Inclination of head? Lumbar pain on reclination? (if necessary examine on the lying patient as well)	Torticollis? Torticollis? Klippel-Feil syndrome? Spondylolysis?

3.1.2 Radiography of the spine

The following standard spinal x-rays are recorded:

- *Cervical spine, AP and lateral:*
  The patient can either stand or lie down for the AP x-ray of the cervical spine. The central x-ray beam is targeted on the 4th cervical vertebra (at the level of the Adam's apple) and is inclined towards the head at an angle of 15°–20°. (Fig. 3.18 left). For the lateral x-ray, the patient can either stand, sit or lie down, and hold his head up straight in a neutral position. The central beam is targeted horizontally on C4 (chin height; Fig. 3.18 right).
- *Transbuccal x-ray of the dens:*
  For the specialist dens x-ray the patient is placed on his back with the head in the neutral position. With the patient's mouth opened as wide as possible, the central beam is vertically aligned with the center of the open mouth (Fig. 3.19a). While the x-ray is recorded, the patient is asked to say »ah«, causing the tongue to press against the floor of the mouth thereby preventing its shadow from being projected onto vertebral bodies C1 and C2. The dens, axis, lateral masses of the atlas and the atlantoaxial joints will be clearly visible on the resulting x-ray.
- *Functional x-rays of the cervical spine from the side* during maximum inclination and reclination:
  If instability or a ligamentous injury is suspected, the cervical spine is x-rayed (on the awake patient) from the side, while the patient is sitting up and during maximum inclination and reclination (Fig. 3.19b).
- *Thoracic spine, AP and lateral:*
  The AP and lateral x-rays of the thoracic spine should, if possible, be recorded while the patient is standing. For the AP view, the central beam is targeted perpendicularly onto a point approx. 3 cm above the xiphoid process of the sternum. For the lateral x-ray of the thoracic spine, the patient is asked to raise his arms. The central beam is targeted horizontally at the level of the 6th thoracic vertebra and tilted towards the head at an angle of about 10°. The resulting x-ray shows the vertebral bodies and the intervertebral disks viewed from the side (Fig. 3.20).
- *Lumbar spine, AP and lateral*
  The AP and lateral x-rays of the lumbar spine should likewise be recorded while the patient is standing. For



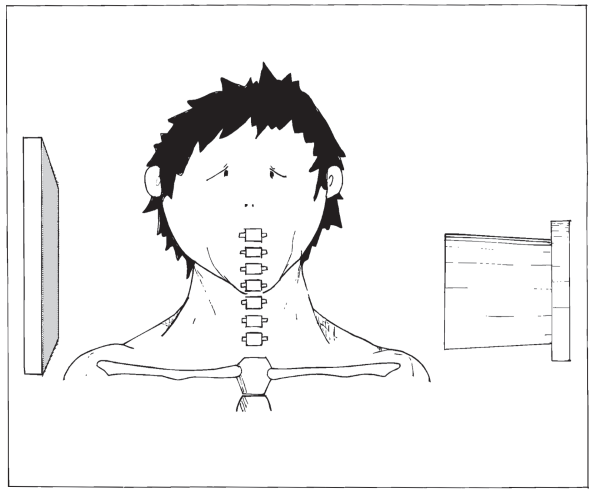


Fig. 3.18. Recording lateral and AP x-rays of the cervical spine. (after [1])

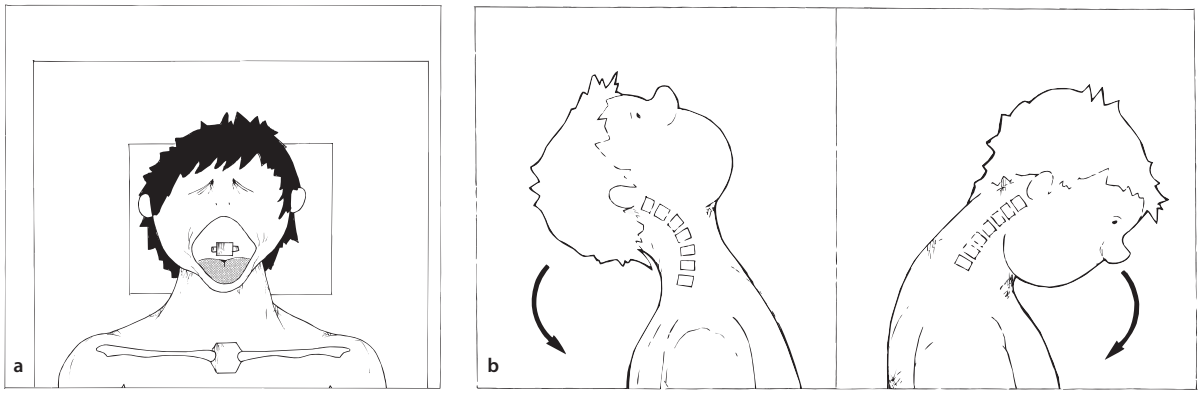


Fig. 3.19a, b. Recording cervical spine x-rays. **a** Radiographic technique for the transbuccal view of the dens, **b** Functional lateral x-rays of the cervical spine in maximum reclination *(left)* and inclination *(right)*

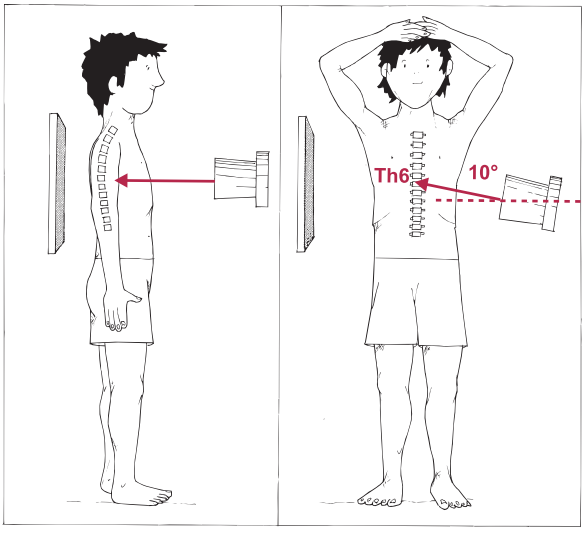


Fig. 3.20. Recording thoracic spine x-rays, lateral *(left)* and AP *(right)*. (after [1])

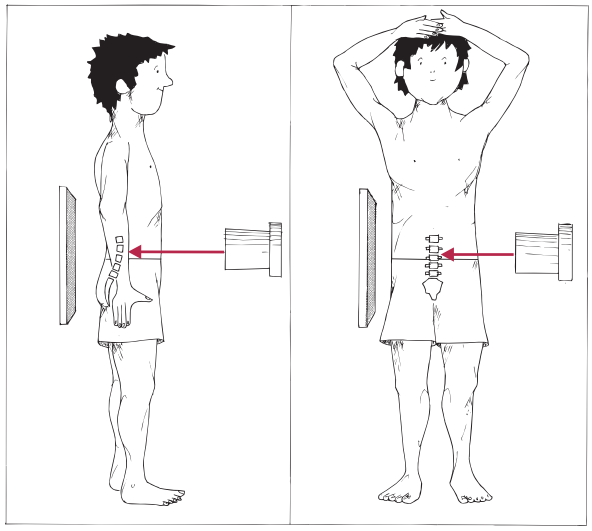


Fig. 3.21. Recording lumbar spine x-rays, lateral *(left)* and AP *(right)*. (after [1])

the AP view, the central beam points perpendicularly, at the level of the iliac crests, onto the center of the abdomen. For the lateral x-ray, the central beam is targeted on L3 at the patient's waist level (Fig. 3.21). In adolescents, wide cassettes should be used so that the iliac crest is included in the x-ray (so that the remaining growth potential can be assessed).

- *Thoracolumbar junction, lateral:*
  For this x-ray the central beam is targeted on T12.
- *Lumbosacral junction, lateral:*
  For this x-ray the lateral beam path is centered on L5.
- *Oblique x-rays of the lumbosacral junction:*
  For the oblique x-rays of the lumbar spine, the patient lies on his side on the examination table and then turns 45° to the right so that the small vertebral joints on the right are viewed (similarly, raising the left side will enable the facet joints on the left to be viewed). The central beam is targeted vertically onto the center of L3 (Fig. 3.22). See Fig. 3.68 and 3.69 for examples and explanations.
- *Whole spine, AP and lateral:*
  With children and younger adolescents it is possible to depict the whole spine on a single normal cassette. The central beam points to T12. If deformities are present, this overview is more useful for evaluating the statics of the spine than individual images of the thoracic and lumbar spine. Here, too, wide cassettes should be used so that the iliac crest is included in the x-ray. For full-grown patients the spine must be x-rayed using combined films in special cassettes. Since the distance from the x-ray tube is considerable, this not only has an adverse effect on image quality, but also involves a high dose of radioactivity. We only record such x-rays in exceptional cases.
- *CT of the spine:*
  CT is extremely useful in fractures for revealing fragments in the spinal canal. They are also effective for identifying intraosseous tumors.
- *Myelo-CT:*
  Myelo-CT has largely superseded the conventional myelogram when it comes to viewing any impediment in the spinal canal resulting from a neurological lesion.
- *Angiogram:*
  Angiograms can be recorded conventionally, as MR angiograms or, using a more recent technique, as CT angiograms, which produce the best view of the blood vessels. Such images are required in certain tumors or for depicting the artery of Adamkiewicz prior to vertebrectomies.
- *MRI of the spine:*
  The MRI scan is used for cases of inflammation and tumors (primarily for the imaging of the soft tissue components) and for revealing intraspinal anomalies before scoliosis operations (particularly for congenital scolioses).
- *Bone scan:*
  The technetium scan is useful for revealing small tumors that are not clearly depicted with conventional imaging techniques (e.g. osteoblastomas) or in the search for metastases.
- *Ultrasound scans:*
  Ultrasound scans are recorded in cases of a suspected spinal abscess or seroma.

Reference

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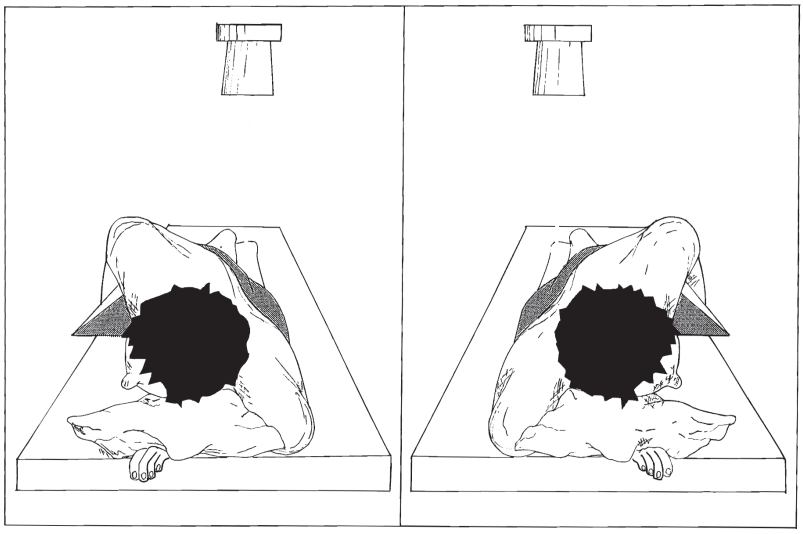
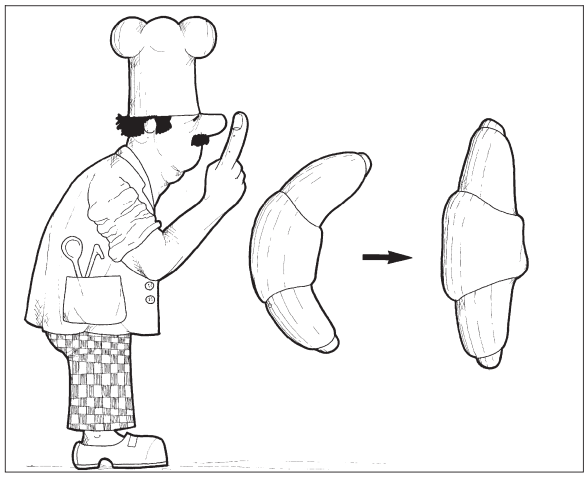


Fig. 3.22. Positioning of the patient and targeting of the central beam in oblique x-rays of the lumbosacral junction (after [1])

3.1.3 Can the »nut croissant«[1] be straightened out by admonitions? – or: To what extent is a bent back acceptable? – Postural problems in adolescents



» The body is the visible manifestation of the soul. (Christian Morgenstern, Steps) «

The back – a mirror of the soul?

Parents' concerns about the posture or the shape of the back of their offspring are one of the commonest reasons for a visit to the pediatrician or the orthopaedist. Their worries are essentially attributable to two main factors: On the one hand they are worried that an non-correctable deformity of the spine might result from the poor posture, as an expression of some sinister frame of mind. On the other hand, it is a generally known fact that back pain is one of the commonest conditions suffered in adulthood and one that might possibly be prevented by appropriate measures taken during childhood and adolescence.

But why are parents so worried about their child's appearance, particularly in relation to back problems, even though the back is usually covered by clothing and thus less exposed than, say, the face or the hands? – The back has special symbolic significance in linguistic usage and is, to a particularly great extent, the »visible manifestation of the soul«, as Christian Morgenstern puts it. A »good« posture for the spine is »upright«, just as a person's character can be described as »upright«. This also reflects the relationship between truth and dishonesty.

But terms associated with the back can also have other connotations. Politicians who adopt a particular standpoint and do not always change their opinion to match the prevailing mood are said to show »backbone«. But there are also others who are so thick-skinned that they can live without a backbone. Particularly strong-willed people are described as »unbending«. If their will is broken we say that it is »bent« to the will of another. People with a lot of problems are »weighed down by worries« until they eventually »collapse under the load«. Those who wish to ingratiate themselves with others »bow and scrape«. Those with huge debts are »laid low« and a person who refuses take responsibility for his own mistakes and accept the consequences may try and »place all the blame on someone else's shoulders«.

So we can see how terms connected with the back and spine can also be used to describe emotion-provoking activities and properties that are closely related to a person's state of mind. Linguists are unable to explain whether the language actually creates this link between physical posture and mental outlook. We also find »crooked« characters in literature. Victor Hugo, in particular, made a hunchback the lead character in two of his works: Quasimodo in *Notre-Dame de Paris* and the court jester in *Le Roi s'amuse.* The latter play was used as the basis for Giuseppe Verdi's famous opera *Rigoletto*. And the French poet Paul Féval has a hunchback as the main character in *Le Bossu*. But in these literary examples the hunched back does not represent the manifestation of a sinister soul. Quite the opposite, since they are kind-hearted sensitive individuals who have been disadvantaged by nature and brutally exploited by others because of their inability to defend themselves.

But while the body is indisputably an expression of the soul, the connections are much more multilayered and complex than suggested by the vernacular language. Viewed at a superficial level, nature can also be at variance with linguistic usage. Thus, parents always want their child to adopt as straight a posture as possible. But the drooping and loutish posture of the adolescent is precisely an expression of the desire not to »bend« to the will of his parents.

Economic significance of back pain

Lumbar back pain is one of the commonest conditions suffered by adults and the number one reason for lost productivity. Thus, according to one epidemiological study, 66% of employees stated that they had suffered back pain in the previous 12 months [5]. And even a group of individuals in their twenties (Swiss recruits and soldiers) showed a prevalence of 69% for lumbar back pain [7]. An American study showed that 11% of men and 9.5% of women visited a general practitioner because of lumbar back pain [3]. In the USA, the loss of earnings is estimated

[1] Nut croissant: term used in Switzerland for a croissant filled with nuts. The expression »nut croissant figure« is commonly used in Switzerland to refer to a particularly drooping, kyphotic posture.

at around 10 billion dollars [8]. In Switzerland, too, back pain is the second commonest cause of disability, after accidents. A high prevalence of lumbar back pain, at 48.2%, has been reported for industrial workers in Russia [9], indicating that back pain is not a specialty of the West, although it is clearly a much more serious problem in industrial nations than in the developing world. The significance of back pain evidently tends to parallel the degree of industrialization.

In Oman, the demand for back treatment has risen dramatically since the oil boom [2], a finding that is also of major economic significance. According to a Canadian statistical survey, approximately 30% of the total amount paid in 1981 as compensation for loss of earnings in the form of disability pensions was paid to back patients [1]. The pain frequently starts at a young age, and around half of adolescents complain of occasional back pain [10] (► Chapter 3.1.15).

For all of the reasons outlined above, it is perfectly understandable that parents are worried about what could happen to their children's backs in future.

Evolution of upright walking and posture

Humans are unique among all living creatures in exhibiting an erect posture. While primates evidently developed the mechanism for maintaining the trunk in an upright position at a very early stage, only humans are capable of standing and walking upright on two legs for prolonged periods. This species-specific bipedal, erect posture freed up the hands so that humans could use these for tasks other than locomotion. In fact, this discriminating use of the hand was probably the very first evolutionary step. A secondary consequence of the discovery that hands could be used not just for locomotion was the development of the brain and upright walking. The use of hands as tools and also the use of tools with the hands was therefore the first step in the evolution of man, some 5 million years ago, from primate to homo erectus, the precursor of today's homo sapiens.

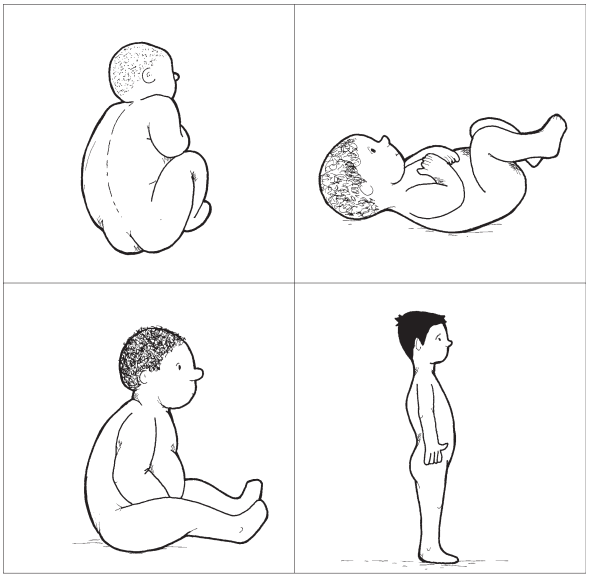
This upright posture caused the eyes to be shifted forwards, thereby widening the field of vision and eventually producing binocular, stereoscopic vision. Compared to quadrupeds and the climbing anthropoid ape, humans have better visual, acoustic and tactile spatial orientation. From the phylogenetic standpoint, the adoption of an erect posture in humans did not simply involve a rotation of 90° at the hip, but primarily around the lumbosacral junction as a result of the cuneiform shape of the 5th lumbar and 1st sacral vertebrae. The sacrum is the resting point about which this erect posture is achieved.

The development of the upright posture requires a specially-shaped spinal column. The double-S-shaped human spine differs from the single-S-shaped spine of the quadruped in its additional lumbar lordosis. Although this lumbar lordosis is not absolutely essential for an upright posture, it came about primarily for functional reasons. The S shape of the spine is the optimal design for the corresponding dynamic loads. The cervical and lumbar lordosis, and also the thoracic kyphosis, act like linked elastic springs. Any major deviations from these functionally-adapted curves in the spine are mechanically inappropriate and result in adverse loading conditions.

The upright posture also has implications for other organs as well as the spine. Thus the iliac wing in humans is much wider than in quadrupeds, since it has to help carry the internal organs. The detorsion of the femoral neck during growth is another phenomenon specific to humans. In fact, humans have paid very dearly for this unique advantage of an upright posture and have evidently not yet completely come to terms with this evolutionary step. Man's unique erect posture not only contributes to his special dominant role in nature, at the same time it has become a direct potential disease factor whose implications cannot yet be fully grasped.

Postural development in children

The phylogenetic development of the back is imitated during maturation from the fetus to the child and then from the child to the adult. In the uterus, the fetus is in a flexed position and the spinal column is completely kyphotic. The neonate also holds the shoulders, elbows, hips and knees in flexion, causing the spine, apart from the cervical section, to be held in kyphosis, as is also the case



Postural development from the fetus, via the infant and toddler, to the child

with quadrupeds. Flexion contractures of up to 30° are physiological. At a later stage, the neck, back and femoral extensors are the first to be strengthened, providing the infant with head control. After a few months the baby is also capable of sitting up, albeit with total kyphosis of the back. At this stage the lumbar lordosis is still lacking, which is a physiological finding during this period before the start of walking.

Once the baby starts walking, the lumbar lordosis itself starts to develop. But this process does not fully parallel the strengthening of the muscles, and a hyperlordosis usually forms at this stage as a result of gravity acting on the ventral side. In toddlers this hyperlordosis is often not compensated by a hyperkyphosis of the thoracic spine, resulting in the scenario of the »hollow back«. This type of posture in the toddler is characterized by the physiological weakness of the muscles and the general laxity of the ligaments that is typical of the constitution at this stage. The toddler's back shape only develops into the adult shape shortly before puberty, although this shape is still dependent on the state of the muscles. In the elderly, the spine again resembles the kyphotic picture of the infant (Fig. 3.23).

An important characteristic feature of the infant is the asymmetrical tonic neck reflex. The persistence of this reflex can lead to an asymmetrical development of the muscles and the condition known as *resolving infantile scoliosis*. Resolving infantile scoliosis is a single arc-shaped curvature of the whole spine resulting from the asymmetrical tone of the muscles. The curvature is associated with little rotation and occurs with a left- or right-sided convex curve with equal frequency. If the child is held by the head and feet, the opposite side can be made to curve. Resolving infantile scoliosis used to be much more common in the past, and is rarely encountered nowadays. This is possibly attributable to the trend (after 1970) of placing the infant in the prone position. More recently (since approximately 1992), the prone position is being abandoned following the discovery that sudden infant death syndrome occurs more frequently in the prone position than the supine position. We have, however, not seen an increase in resolving infantile scoliosis since then. Therefore there must be other etiological factors (e.g. genetic intermixture?).

The prognosis for resolving infantile scoliosis is very good, as almost all of these curvatures disappear during the first year of life. This did not always used to be the case. Some cases of apparently resolving infantile scoliosis persisted and developed into progressive idiopathic infantile scoliosis, a condition that used to be particularly common in Great Britain [6]. The observation that the difference between the angle made by the ribs and the spine when seen from the side is greater in the progressive forms than in cases that spontaneously resolve themselves means that the progressive forms can be detected at an early stage (▶ Chapter 3.1.4).

The condition of progressive infantile scoliosis has almost disappeared even in Scotland, where the condition was particularly common. While the progressive form of the disease has an extremely poor prognosis, resolving infantile scoliosis is not associated with any long-term sequelae. It is completely unrelated to idiopathic adolescent scoliosis, and patients with a history of resolving infantile scoliosis show no increased risk of developing idiopathic adolescent scoliosis in later life.

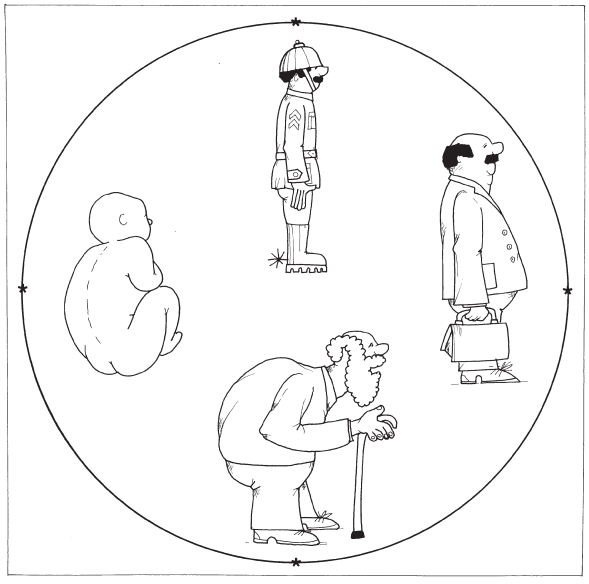


Fig. 3.23. Postural cycle (the old man returns to the kyphotic posture of the fetus)

Postural types in the adolescent

Posture is influenced by the following factors:

- *The shape of the bony skeleton*
  The shape is determined by genetic factors (the mother: *»His father has exactly the same crooked back«*). The position of the sacrum, which in turn is dependent on the pelvic tilt, also plays an important role. The steeper the sacrum, the less pronounced the sagittal curvatures (lordosis and kyphosis).
- *Ligamentous apparatus*
  Posture can be active or passive. If our muscles are not activated, then we simply »hang« from our ligaments. Such a posture can best be adopted by overstretching the hips, sticking out the tummy, positioning the lumbar spine in hyperlordosis and tilting the upper body backward to offset the forward shifting of the center of gravity. If the center of gravity is shifted forward or backward we talk of a ventral or dorsal overhang (▶ Chapter 3.1.1). This posture cannot be adopted passively, however, since it is unstable and must be compensated for by muscle activity.

- *Muscles*
  The state of the muscles has a considerable influence on our posture. Strong muscles with good tone can maintain an actively erect posture throughout the day. The condition of the muscles depends partly on constitutional factors and partly on the training status. But one other factor needs to be taken into account in relation to the growing body: The muscles, together with the skeleton, undergo substantial length growth but are unable to increase in width to the same extent. Consequently, a certain muscle weakness is physiological in the growing child. Only on completion of the growth phase can the »muscle corset« be trained and built up in the optimal way. Postural insufficiency is frequently associated with an intoeing gait and reduced hip flexion [4].
- *Pelvic tilt*
  The pelvic tilt is closely related to the steepness of the sacrum. Straightening the pelvis reduces the lumbar lordosis and thus the thoracic kyphosis as well (Fig. 3.24, 3.25).
- *Influence of the psyche*
  Posture is not a constant anatomical feature of an individual. Apart from constitutional factors, posture represents a snapshot that depends not only on muscular activity but, to a very great extent, on psychological status. As previously mentioned, linguistic usage also highlights this link. A state of mind characterized by joy, happiness, success, self-confidence, trust and optimism tends to affect the erect posture and the associated efficient postural pattern. By contrast, worries, conflicts, depression, failures and feelings of inferiority produce precisely the opposite effect and promote poor postural patterns.
  Another special factor comes into play in adolescents: Puberty is a stage of life marked by internal conflicts associated with finding one's own personality. Since an important element in this process is the loosening of the bond with the parents, a certain protesting posture in respect of the parents can be considered physiological.
  Since a straight posture is usually considered the ideal by parents, the internal protest against the parents' world manifests itself in the form of an – often ostentatiously – poor posture (particularly while sitting). The poor posture resulting from the physiological muscle weakness of the growing body is further emphasized by »casual« sitting. The more frequently the parents admonish their child with »sit up straight«, the quicker he or she resumes the »nut croissant« position. It is striking to observe how children with a very pronounced kyphotic posture are very frequently withdrawn and have one very dominating parent. When such adolescents are questioned about their symptoms or problems during the consultation, the mother or father will constantly reply on their behalf. It is noticeable that the child is clearly overwhelmed by the mother or father.
  But other problems can also cause adolescents to adopt a very kyphotic posture, e.g. if a female unconsciously tries to conceal her breasts by hunching her shoulders forward and folding her arms in front of her. Some girls are unable to accept the growth of

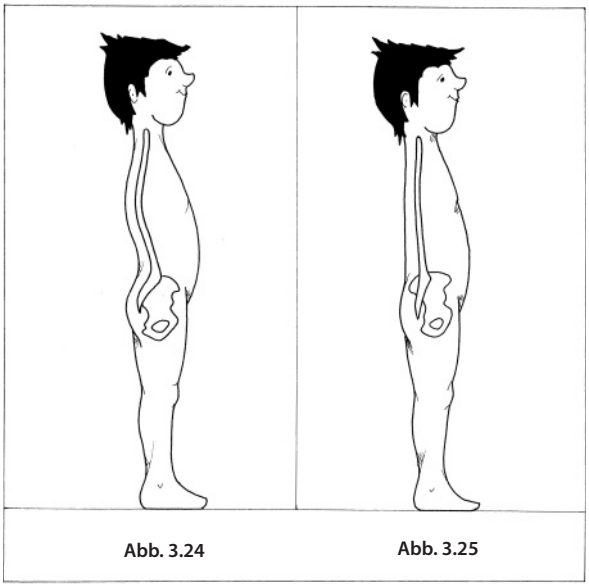


Fig. 3.24. Normal pelvic tilt with forward/caudal inclination of the pelvis by approx. 20°

Fig. 3.25. Cancellation of the pelvic tilt and consequent reduction of the lumbar lordosis and the thoracic kyphosis

Adolescents often deliberately adopt a seated posture that goes against their parents' ideas about good posture...

their own breasts. This is particularly apparent if the girl has a very dominant mother who herself has large breasts. But also a funnel or keeled chest can cause the girl to adopt a permanently kyphotic posture in the unconscious desire to conceal this part of her body.

- *Social aspects*
  Not every social class or era has the same conception of the ideal posture. Since ancient times, statues and paintings have tended to present the ideal of an upright posture. In European royal dynasties, a stiff posture was often promoted by constraining the individual in a brace. But the social notions of the ideal posture have changed since then, and the ideals of the modern age are frequently characterized by a markedly »casual« posture.

As already mentioned, posture represents a »*snapshot*«. Every individual can adopt a variety of postures.

The standing posture can be subdivided into the following *stages* (Fig. 3.26–3.28):

- habitual posture,
- passive posture,
- actively straightened posture.

We can also distinguish between *constitutional postural types* (normal back, hollow back, rounded back , flat back, hollow-flat back , ▶ chapter 3.1.1).

The classification of the first 4 back shapes dates back to the 19th century (Staffel 1889 [2]). These are physiological variants with essentially no pathological significance. We have added the 5th back shape since it is a relatively common physiological variant, particularly in children. Instead of a »normal back« perhaps we should rather refer to a harmonious back. Using the term »normal back« can easily give the impression that the other back shapes are abnormal, which is certainly not the case by definition, since these are, after all, types of posture. We only speak of a pathological shape if there is fixed hyperkyphosis of the thoracic spine, a permanent absence of lumbar lordosis or even a kyphosis in this area. The investigation of the correctability or fixation of individual segments is described in ▶ chapter 3.1.1.

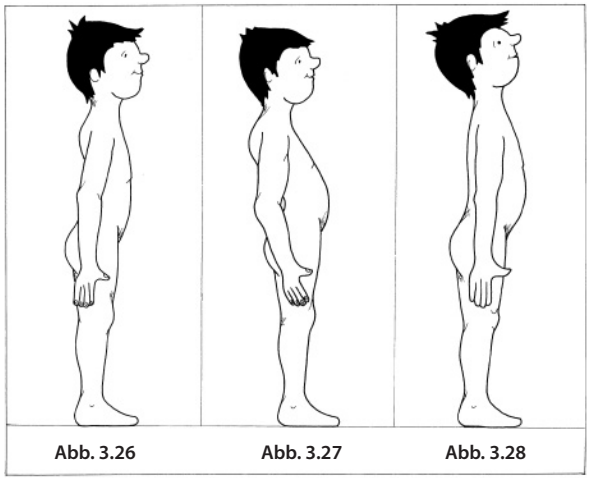


Fig. 3.26. Habitual posture posture

Fig. 3.27. Passive posture

Fig. 3.28. Actively straightened posture

Pathological significance of poor posture

Whether »postural damage« actually exists is a matter of considerable dispute. Since back symptoms are common in adults and have also increased over the past few decades, the discussion of this subject is highly topical. Unfortunately there is a scarcity of scientifically-established hard facts and, on the other hand, widely diverging opinions based on subjective impressions. However, a number of factors in recent years have thrown some light on the subject.

Various widely-held traditional views first need to be corrected somewhat:

- *The development of structural scoliosis has nothing to do with posture.* A poor posture cannot induce idiopathic adolescent scoliosis. Scoliosis is known to result from a discrepancy between the growth of the vertebral body anteriorly and the growth of the posterior elements, resulting primarily in lordosis. Adolescents with scoliosis are therefore conspicuously straight and erect, and also often very keen on sport. The lateral curvature develops as a result of the rotation of the vertebral bodies and has nothing to do with posture (▶ Chapter 3.1.4). A leg length discrepancy may possibly promote lumbar scoliosis. This is definitely the case with uncompensated differences of more than 2 cm. Whether it applies for differences of less than 2 cm is controversial, and it is possible that the leg length discrepancy only influences the direction of the scoliosis rather than its development.
- *Of the physiological postural types, apart from the harmonious posture, the hollow back has a much better prognosis than the flat back.* Although the flat back is the esthetic ideal, the future prospects in terms of subsequent symptoms are much worse for the flat back than for a back with markedly sagittal curves, given the poorer shock-absorbing properties of the former. Lumbar disk damage occurs more frequently with this back shape and is also often associated with pain. The problem arises primarily from the kyphosing of the lumbar spine. The lack of lordosis shifts the center of gravity forward, which means that the lumbar paravertebral muscles have to work harder to maintain posture. The kyphosing of the lumbar spine is also often very pronounced during sitting.

- *The development of a fixed kyphosis can be influenced by posture.* A permanent kyphotic posture can trigger Scheuermann disease during puberty. Although the prognosis in terms of symptoms is not bad in Scheuermann disease involving the thoracic region, it becomes increasingly worse the further down one goes, and lumbar Scheuermann disease is associated with a very high risk of subsequent chronic lumbar back pain. Usually the condition results in elimination of the lumbar lordosis, or even kyphosing in this area. This is extremely undesirable from the mechanical standpoint because of the forward-shifting of the center of gravity. It has to be offset by lordosing of the thoracic spine and considerable postural work by the paravertebral muscles in the lumbar area. The shock-absorbing properties of this type of spine are also poor.

Therapeutic options

Of the factors that determine posture, we can influence two in particular:

- the status of the muscles,
- possibly the psychological factors.

All other parameters are given and we have no way of influencing them.

As regards the *muscles*, we should always bear in mind that a certain amount of physiological muscle weakness is associated with growth.

Muscles can only be strengthened by activity. Such activity must be undertaken by the child or adolescent and cannot be imbued into the child from the outside. Consequently, the crucial factor in determining whether activity takes place or not is the *child's motivation*. The surest way of demotivating the child is to compel it to undertake an activity against its will.

Since physical therapy is not an attractive type of activity, it is pointless to prescribe months, or even years, of physical therapy, at the expense of health insurance funds, when the child is not remotely motivated. The outcome will be a complete lack of any effect on the muscles. Equally questionable in my view are the »postural physical education lessons« provided in many schools. Since all students attending such lessons are labeled as those with »poor posture« the participants are stigmatized from the outset. Since it is self evident that such lessons are unlikely to motivate the students to keep active, it would be much more useful to encourage the adolescent to exercise within the context of a sport that affords him or her a certain amount of pleasure. Although the type of sport selected is not ultimately important, activities in which the arms are also used are preferable. Swimming is best, of course, although other ball-based sports such as baseball, basketball or volleyball are extremely beneficial. Sports that exercise the muscles on one side of the body, e.g. tennis, are also perfectly appropriate since, as already mentioned, there is no need to worry at all about the possibility of scoliosis developing as a result of the unilateral muscle tension. Even scoliosis patients should be allowed to play tennis. The important thing is the pleasure gained from the sport. Passive and non-athletic children do not like taking part in ball-based sports because they invariably lose. However, perhaps such children can be motivated to take up swimming or possibly attend a fitness center on a regular basis. This avoids the problem of their having to constantly measure themselves against their peers.

One particular factor that promotes passivity is the considerable amount of time spent sitting at school or in the home. The lumbar spine tends to kyphose during passive sitting. Certain useful measures can be taken to counter this tendency, even though these are implemented in only a very small proportion of schools: An inclined writing surface reduces the kyphosing of the lumbar spine during writing; the writing surface should be positioned sufficiently high; a ball chair also promotes lordotic sitting and stimulates the sitter to constantly perform slight compensation movements; a kneeling chair with support for the lower leg also promotes lordotic sitting (Fig. 3.29). Such aids promote a habitual lordotic sitting posture that produces positive effects in the long term.

In theory, *psychological factors* can also be influenced, although this is much more difficult. Since fixed hyperkyphosis of the thoracic spine is often indicative of a conflict between the adolescent and a parent, the doctor must proceed very cautiously. Psychological counseling can prove worthwhile on occasion however. Another potentially fruitful strategy in motivating the adolescent to take up sport is for him or her to meet other relevant individuals who could serve as new positive models. In most cases, however, it can be very difficult to explore often deep-seated conflicts, particularly since both sides (parents and child) frequently adopt a highly defensive attitude. What is certain, however, is that constant admonitions to sit up straight are counterproductive.

In other words, the question posed at the start, i.e. whether the »nut croissant« posture can be straightened out by cajoling, can be answered resoundingly in the negative. A permanent improvement in posture will only be achieved if the adolescent is motivated to take part in enjoyable activities.

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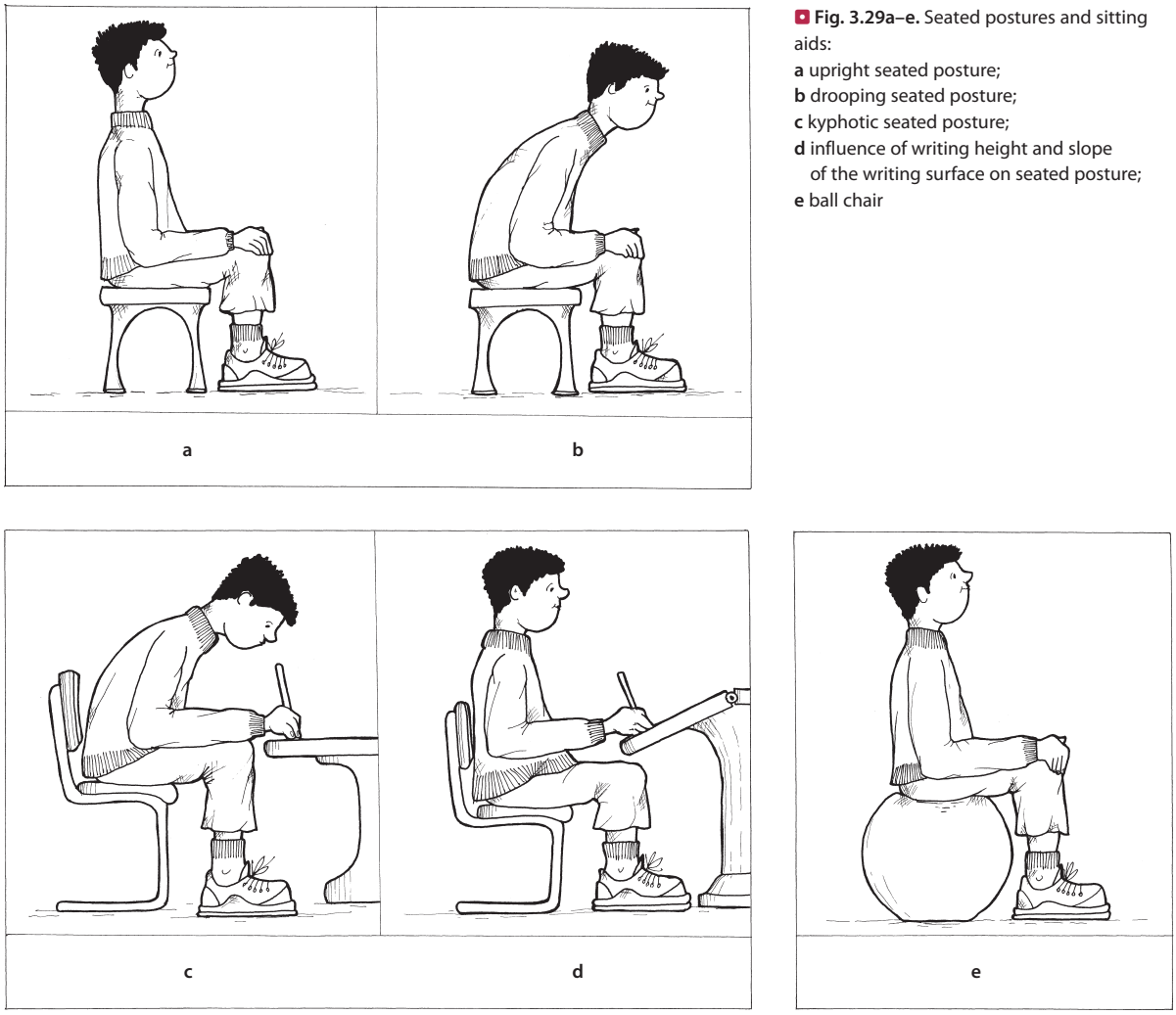

Fig. 3.29a–e. Seated postures and sitting aids:
a upright seated posture;
b drooping seated posture;
c kyphotic seated posture;
d influence of writing height and slope of the writing surface on seated posture;
e ball chair

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3.1.4 Idiopathic scolioses

» While her elegance in ballet may appeal, the risk of scoliosis is very real. «

Definition

Condition involving lateral bending of the spine of >10° of unknown origin. There are two basic clinical pictures of scoliosis:

- A rare form in which the deformity starts as early as infancy or childhood (*infantile* or *juvenile scoliosis*). Boys and girls are equally affected by this type. Scolioses at the thoracic level frequently have their convexity to the left and are associated with kyphosis.
- The more common *adolescent form* starts during puberty. Girls are mainly affected and the thoracic form is always right convex. This type of scoliosis is usually associated with lordosis.

Classification

Classification by age at onset (according to the American Scoliosis Research Society):
- Infantile: 0–3 years
- Juvenile: 4–10 years
- Adolescent over 10 years old

Because juvenile scolioses are extremely rare (and do not behave according to a typical pattern), the *British Scoliosis Society* classifies only two entities:
- Early onset: 0–7 years
- Late onset over 7 years old

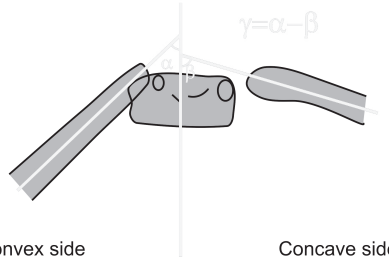
The condition known as *resolving infantile scoliosis* is not classed as an idiopathic scoliosis but is a special type of scoliotic posture. However, since it can progress to infantile idiopathic scoliosis it is discussed here.

Resolving infantile scoliosis

Resolving infantile scoliosis occurs at the age of a few months, but has become relatively rare in the west as a result of the frequent use of the prone position. Resolving infantile scoliosis is characterized by a long, usually left-convex, thoracolumbar, C-shaped arch with little rotation. The rib vertebral angle difference (RVAD) according to Mehta [68] is measured to distinguish it from progressive infantile scoliosis (see ◘ Fig. 3.30). The prognosis is good and a spontaneous recovery can be expected in over 96% of cases. Isolated cases can progress to infantile idiopathic scoliosis.

Infantile (early onset) scoliosis

This rare type is located in the thoracic area in 98% of cases and occurs 1.5 times more frequently in boys than in girls. In 76% of cases the scoliosis is left convex and often associated with a kyphosis. In the infant, an rib vertebral angle difference according to Mehta of more than 20° [68] indicates that the condition is not the benign resolving infantile scoliosis, but rather a progressive form of infantile idiopathic scoliosis (◘ Fig. 3.30). The characteristic features of infantile scoliosis differ from those of the adolescent form to such an extent that it can clearly be considered as a different disease. The prognosis for infantile scoliosis is very poor. Despite brace treatment, it will often undergo substantial progression, resulting in the need for surgery even at an early age in many cases.



◘ **Fig. 3.30.** *RVAD according to Mehta* [64]. In scolioses in the infant, the angle between a vertical line passing through the vertebral body and the axis of the rib is measured on both the convex and concave sides. If the difference *(γ)* between the two angles is 20° or more, the scoliosis is very likely to be the progressive form rather than a spontaneously correcting scoliosis

Juvenile scoliosis

If the scoliosis occurs between the ages of 4 and 10, the juvenile form is considered to be present. Girls are only slightly more frequently affected than boys. In addition to the thoracic location, lumbar and S-shaped curves also occur. The prognosis is poor. Only 5% of scolioses are non-progressive, while the rest increase annually by 1–3° up to aged 10, and by 5–10° a year during the pubertal growth spurt [88].

Adolescent (late onset) idiopathic scoliosis

This is by far the commonest form of scoliosis and is characterized by the following features:
- It is usually located at the *thoracic* level and almost without exception involves a *right-convex* curve.
- It occurs less commonly at the thoracolumbar and lumbar levels, and such cases show a marked tendency to go out of alignment. Sometimes these scolioses are not truly idiopathic but occur secondarily to leg length discrepancies or a lumbosacral junction anomaly.
- In around 10% of cases, adolescent scoliosis is *S-shaped*, i.e. there are 2 primary curves: Since the lumbar curve is usually more rotated than the thoracic curve, S-shaped scolioses are less conspicuous in cosmetic respects than *C-shaped* thoracic scolioses of the same severity.
- It is almost always associated with relative *lordosis* (for the thoracic level, an overall kyphotic angle of less than 20° is considered to be relative lordosis).
- It always involves *rotation* , whereby the posterior parts of the vertebral bodies are always *rotated* towards the concave side of the curve (if this is not the case then a structural idiopathic scoliosis is not present); for a given degree of curvature, the rotation is always more pronounced at the lumbar level than the thoracic level.
- Adolescent scoliosis probably develops as the result of a disparity between the *growth* of the posterior and anterior vertebral body sections; the diminished growth of the posterior sections forces the vertebral bodies to deviate laterally and to rotate. Instead of a scoliosis, one might describe this as a *rotational lordosis*.

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