3 Problems Associated with the Loss of Selective Trunk Activity in Hemiplegia

Hemiplegia, whatever its cause, is characterised by the loss of motor control on one side of the body. The typical inability to move the arm and leg, the development of spasticity in mass patterns and movement in stereotyped synergies have been clearly documented (B. Bobath 1978, Brunstrom 1970; Charness 1986, Davies 1985; Perry 1969). In addition, however, there is a most significant loss of selective activity in the muscles controlling the trunk, particularly in those muscles responsible for flexion, rotation and lateral flexion.

After onset of hemiplegia, the patient experiences difficulty in moving his trunk in relation to the pull of gravity, regardless of which type of muscle action is required. The abdominal muscles demonstrate a remarkable loss of activity and tone. In supine lying, the ribcage is drawn upwards and outwards and the shoulder girdle lies in an elevated position bilaterally, causing the neck to appear shortened (Fig. 3.1). The umbilicus is drawn towards the non-affected side. The entire abdominal wall has a hypotonic appearance, and the hypotonia is confirmed by the total lack of resistance to stretch on palpation (Fig. 3.2). In a sitting position, the lateral wall bulges loosely above the pelvis on the hemiplegic side with a loss of the normal contour of the waist to a greater or lesser degree (Fig. 3.3). In both sitting and standing positions, viewed from behind, the distance from the vertebral column to the lateral border of the trunk is greater on the affected side than on the sound side (Fig. 3.4). The resultant loss

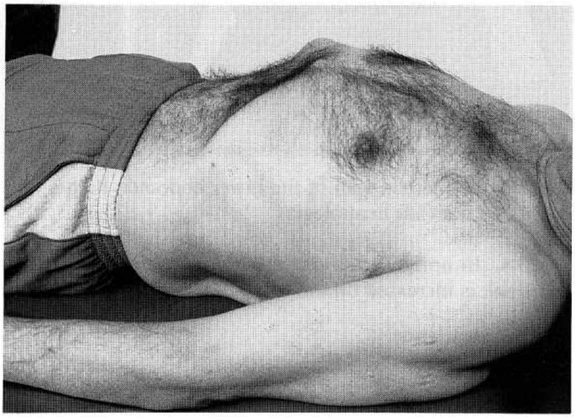
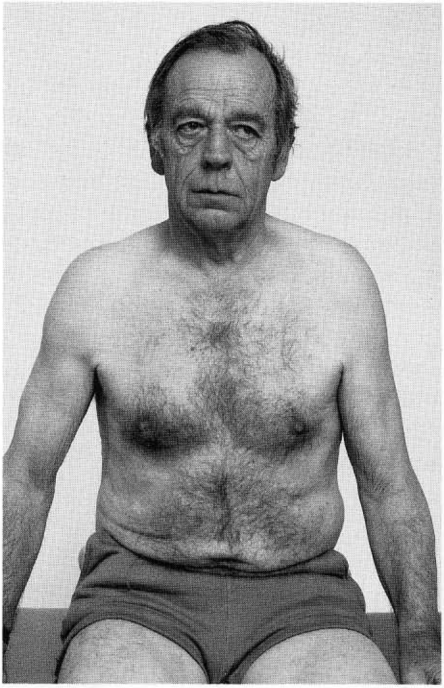
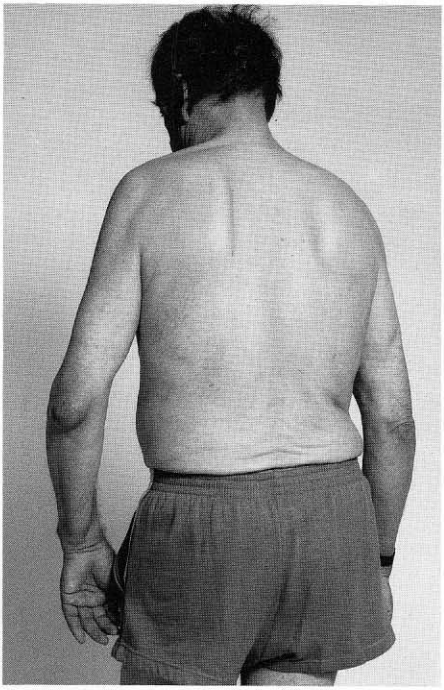


Fig. 3.1. In supine the rib cage is drawn upwards and outwards. The shoulder girdle lies in an elevated position, giving the neck a shortened appearance (left hemiplegia)

Fig. 3.2. Bilateral hypotonus of the abdominal muscles with lack of resistance to stretch (left hemiplegia)

3.3





3.4

Fig. 3.3. The lateral wall of the lower abdomen bulges on the affected side with a loss of the waist contour (left hemiplegia)

Fig. 3.4. In upright positions the distance from the vertebral column to the lateral border of the trunk is increased on the affected side (left hemiplegia)

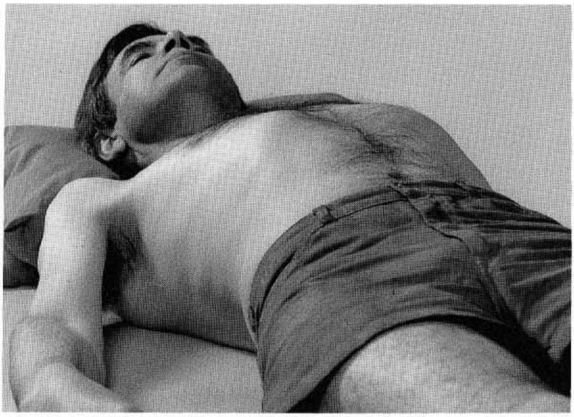


Fig. 3.5. Patient still demonstrates elevation of the rib cage with hyperactivity of the back extensors in supine 14 years after stroke (right hemiplegia)

of trunk control has far-reaching effects and is to a certain extent more disabling than the involvement of the arm and leg musculature, as the agility of children with extremity paralysis following polio demonstrates. The lack of proximal stabilisation influences the limbs profoundly in that the arm and leg can only be moved in spastic synergies. Distal spasticity is further increased as the patient tries to compensate for the loss of fixation when he attempts to move against gravity.

It is interesting to note that the patient's inability to control his trunk selectively closely resembles the stages of trunk control observed during the motor development of the normal baby and young child. It would seem that as a result of the hemiplegia the patient has been thrust back on to an earlier developmental level of motor function.

During normal development, extensor control of the trunk precedes flexor control, and the patient will likewise be able to extend his trunk actively at an early stage following the onset of hemiplegia. If he is not carefully treated, however, he will continue to use the more primitive extensor activity for all movements, and flexor control will not be attained. Such a situation is self-reinforcing in that the more the patient uses extension, the less will abdominal muscle activity be stimulated. The loss of flexor control can often still be observed even 10 or more years following stroke (Fig. 3.5).

3.1 Possible Reasons for the Bilateral Loss of Abdominal Muscle Activity and Tone

1. With the exception of the rectus abdominis, all the other muscles of the abdominal wall are attached by more than half to the central aponeurosis which is connected to the linea alba, and so each side is dependent upon the other for efficient action. The muscles on both sides are therefore im-

paired, and at an early stage of his disablement the patient begins to use compensatory muscles in order to move at all. He usually compensates by activating his back extensors and changing the position of his hips accordingly.

"The alienation of paretic muscles from an activity pattern occurs frequently. Only through specific training of control and co-ordination do those muscles again become incorporated as part of the normal activity pattern" (Kottke 1982 a, b). Without such specific training the muscles remain inactive, and recurrent inhibition may well set in and produce a "self-monitoring inhibition of motor neurons".

Usually, the abdominal muscles on the nonparetic side are affected as well, although not so drastically, due to the fact that no stable insertion is provided by the aponeuroses. As Perkins and Kent (1986), explaining the action of the transverse abdominals and obliques, write: "Because all of these muscles are paired, when contracted they pull in a tug-of-war fashion on opposite sides of the abdominal aponeurosis".

When activity is attempted, the contralateral side of the abdominal wall elongates, offering no anchorage for the contracting muscles. The patient may be able to contract the rectus abdominis as a whole in a mass pattern of flexion, such as when sitting up from lying, as both origin and insertion are more stable, being attached to bone, i. e. to the pubis below, to fixed rib cartilages and even to the xiphoid process of the sternum above.

2. In the early stages of hemiplegia the patient is obliged to use the more primitive extension of his trunk in order to be able to move his body at all. The back extensors are therefore in a constant state of activity, or even over-activity, which could well lead to reciprocal inhibition of the antagonists (Kottke 1975 a, b). Brooks (1986), referring to the lower limb in hemiplegia, explains how "the hyperactive extensors (deprived of supraspinal controls) tonically inhibit the physiological flexors which consequently are less spastic and more paralysed". The same mechanism could well apply to the flexors of the trunk.
3. The hemiplegic patient usually sits with his hips in some degree of extension and his thoracic spine flexed passively to compensate for his weight being behind his centre of gravity. In such a position the abdominal muscles cannot function effectively as their origin and insertion are already too closely approximated (s. Klein-Vogelbach 1989, personal communication). When standing or walking the kyphotic position of the spine is also adopted by the patient to prevent his falling backwards.

3.2 Loss of Selective Activity

3.2.1 Muscles of the Trunk

Loss of selective activity in the various muscle groups of the trunk means that the patient is unable to stabilise his thoracic spine in extension while using his lower abdominal muscles (flexors) in isolation, as in walking, for example. Neither can he maintain the extension when using the abdominal muscles unilaterally for side flexion of the trunk or to rotate the side forwards.

3.2.2 Muscles of the Trunk and Limbs Acting Simultaneously

The patient is also unable to move his limbs in isolation without the activity occurring in a similar pattern in his trunk or move his trunk without movement taking place in his limbs. For example, when he sits up from lying, the legs will flex as well, making the movement difficult, if not impossible. In standing when the patient lifts one of his legs actively in front of him, his trunk will flex as well, and when he extends he leg behind him, his back extends.

3.3 Inability to Move in Normal Patterns

Due to the hemiplegia, and depending upon its severity, the adult patient's ability to move retrogresses to an earlier developmental level. Certainly in the first days following stroke, he feels "as helpless as a baby", as many a patient verbalises. He is unable to turn himself over in bed, come up to a sitting position unaided, and walking is frequently impossible for him. The regression refers only to motor function and in no way should the patient be considered or treated as a child. He is a thinking, feeling adult with a host of stored experiences and achievements and should be treated as such at all times. The comparison between the motor ability of the patient and that of the normal child will, however, help the rehabilitation team to analyse and treat the motor problems with more understanding and greater success.

3.4 The Most Commonly Observed Problems Seen in Relation to Normal Motor Development

As a result of the loss of trunk control, patients with hemiplegia will have difficulties, to a greater or lesser degree, with regard to the activities described below during their rehabilitation. The difficulties are more easily seen in certain positions or during specific movement sequences and will be described under headings referring to these. A difficulty observed in one movement or position will, however affect the performance of other normal activities as well. Breathing difficulties experienced will naturally restrict the patient's active participation in the entire rehabilitation programme.

3.4.1 Difficulties with Breathing and Speaking

With the rib cage held in a position of inspiration and the abdominal muscles flaccid and inactive, it is clear that the muscles of respiration cannot function efficiently (Fig. 3.6). Due to hyperactive extension of the spine, the patient's ribs with their long lever arm anteriorly are elevated together with the sternum. The elevation is accentuated further by the early development of hypertonus in the pectoralis muscle groups and by the patient activating these muscles as he attempts to move his hemiplegic arm by using the total mass pattern of extension.

The ribs are not held down from below by the abdominal muscles, and the configuration of the thorax is distorted. The movements of the rib cage will also be abnormal. Kolb and Kleyntyens (1937) recorded the movements of the chest with a kymograph and found, without being able to explain the findings, that "during hyperpnoea the movements on the affected side are increased out of proportion to those on the normal side. This increase persists longer than on the normal side and is noted in both spastic and flaccid hemiplegia". The difference between the two sides almost certainly can be explained by the insufficient activity in the abdominal muscles to "hold the ribs down", which Spaltenholz (1901) describes as being their main function.

The patient is not able to breathe out passively during quiet breathing as the elevated rib cage opposes the normal elastic recoil. When asked to breathe out he will usually press his lips together and blow the air out actively between them against resistance. Fugl-Meyer et al. (1983) found that "decreased expiratory force was a common denominator in stroke with hemiplegia or hemiparesis", and in a later study (Fugl-Meyer and Griemby 1984) that "abdominal electromyographic activity during forced expiratory manoeuvres appears constantly to be decreased".

Even patients who were known to have had extremely good respiratory function prior to stroke, with no previous history of lung disease, are short of breath during comparatively light activities. All the investigated patients in the study by Haas et al. (1967) had impaired respiratory function, and it is postulat-

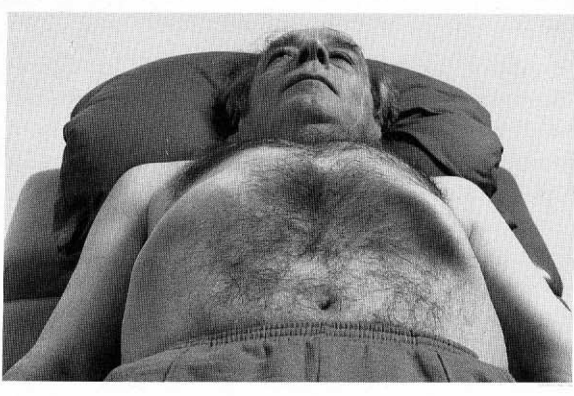


Fig. 3.6. The rib cage is held in a position of inspiration, preventing efficient respiratory muscle function (left hemiplegia)

ed that this impairment contributes to the fatigue which so often hampers the rehabilitation of hemiplegic patients.

Inspiration is also affected by the loss of stabilising activity on the part of the abdominal muscles. Due to abdominal wall laxness "respiratory mechanics are also interfered with by paradoxic inward motion of the upper thorax during upper intercostal contraction during inspiration" (Luce et al. 1982). The diaphragm cannot function efficiently, nor can the external intercostals as the ribs are already pulled upwards and approximated. "After the diaphragm the external intercostals are the next most important muscles of inspiration". They "function as if they were in a single sheet of muscle pulling all the lower ribs towards the first rib" (Perkins and Kent 1986).

In tests carried out on 20 patients with early flaccid hemiplegia, De Troyer et al. (1981) found that "in most patients a striking reduction in activity was observed during voluntary inspiration in both the intercostal muscles and the diaphragm on the side of the paresis". "In hemiplegia, moreover, forced inspiratory and expiratory volumes and maximum breathing capacity are also significantly reduced (Fugl-Meyer and Griemby 1984).

Not only does the patient tire easily during physical activity as a result of the reduced respiratory function, but he may have difficulty in speaking normally as well. The volume of his voice is reduced, and he is only able to use very short sentences, in a type of telegraphic speech. He may even rebreathe after each word as, for example, when counting or naming the days of the week. In order to use sentences of normal length it is necessary to be able to maintain a sound easily for about 12–15 s. The patient will often only achieve 5 s when tested.

3.4.1.1 Distorted Configuration of the Rib Cage

The fixed position of the ribs, or even rib cage contracture, has far-reaching effects on movements of the trunk itself, particularly flexion/rotation of the upper trunk. Flexion with rotation of the thoracic spine is a combination of movements which frequently occurs during functional activities, e. g. when lifting or placing objects to one side or in front and to one side. The ribs would block the movement, but they "possess the property of elasticity which allows them to distort during rotation of a vertebra" (Blair 1986).

With the ribs held in a fixed position from above, the instrinsic flexibility of their shafts as described by Schultz et al. (1974) is prevented from allowing the changes in the shape of the chest wall which are necessary for flexion, rotation and lateral flexion of the thoracic spine. Both active and passive movements feel blocked in all starting positions during therapy.

3.4.2 Difficulties Observed in Lying

In supine lying, because the rib cage is in a position of inspiration, the shoulder girdle is elevated, causing the neck to appear shortened. The umbilicus is drawn towards the sound side (Fig. 3.7 a). When the patient flexes his leg up towards him or his leg is placed in flexion by the therapist, the hip adopts a position of lateral rotation with abduction, the knee flexes and the foot supinates (Fig. 3.7 b).

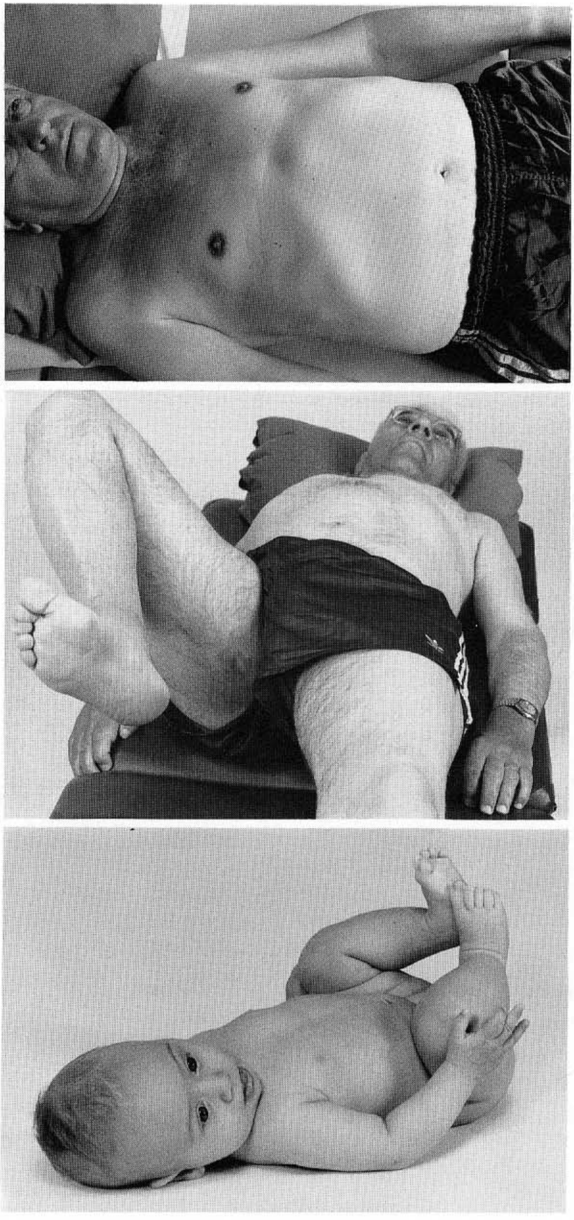


Fig. 3.7. **a** The umbilicus is drawn towards the sound side (right hemiplegia). **b** The hip laterally rotates and abducts when the hemiplegic leg is flexed. The foot supinates (right hemiplegia). **c** A normal 3-month-old baby shows a similar mass pattern of flexion of the legs. Typically the lower ribs are expanded, the shoulder girdle elevated and the neck very short

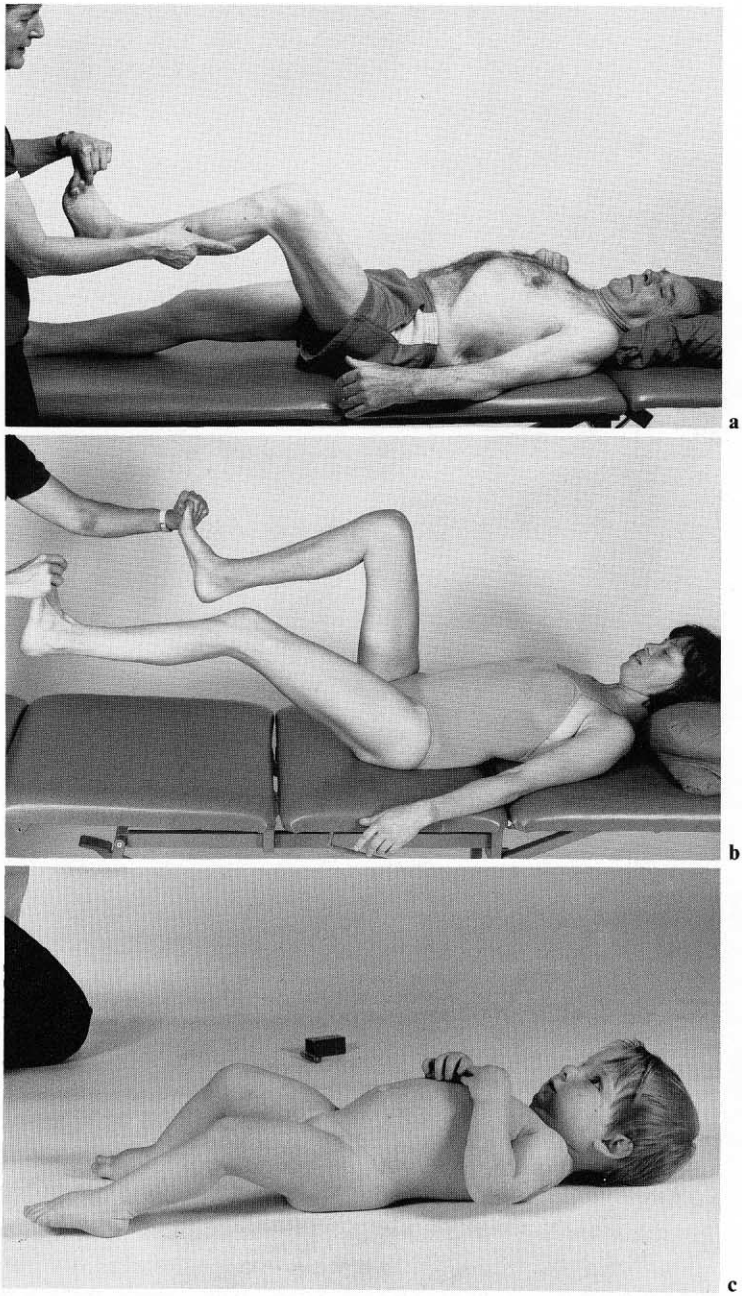
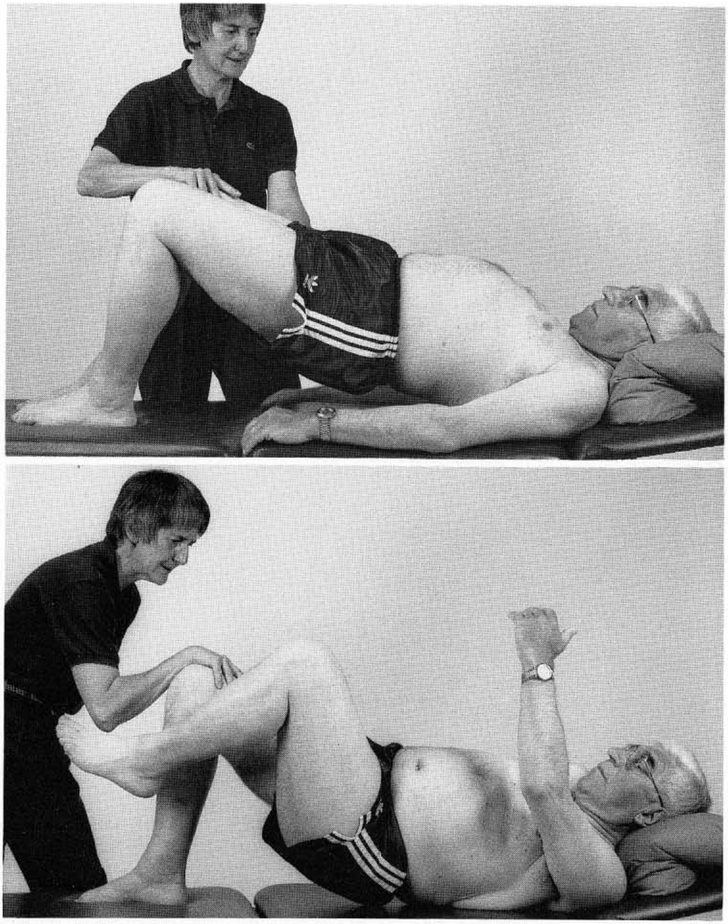


Fig. 3.8 a–c. Hip flexion accompanied by extension of the lumbar spine. **a** When flexing the hip actively, the patient attempts to stabilise his pelvis by pressing the sound leg down on the supporting surface (left hemiplegia). **b** When flexing both hips actively, lordosis increases and the abdomen protrudes (right hemiplegia). **c** A 9-month-old normal baby demonstrates a similar posture



a

b

Fig. 3.9. **a** Forming a bridge by extending the hips and spine. **b** When the sound foot is lifted, the pelvis drops down on the ipsilateral side due to inadequate abdominal muscle activity (right hemiplegia)

As the Bobaths (K. Bobath and B. Bobath 1977) explain, the patient with hemiplegia is only able to activate his muscles on the affected side in one or two mass synergies, and these synergies, as seen for example in the young baby, are inadequate for functional activities. The patient is unable to adduct his flexed hip, or to move other parts of the leg selectively while the hip is flexed. Adduction of the hip in supine lying would require activity from the abdominal muscles to stabilise the pelvis. The young baby typically has a very short neck, his lower ribs are expanded and he flexes his legs in a similar pattern (Fig. 3.7 c).

When the patient holds his hemiplegic leg in flexion, the lumbar spine extends and he attempts to stabilise his pelvis by forcibly extending the leg on the

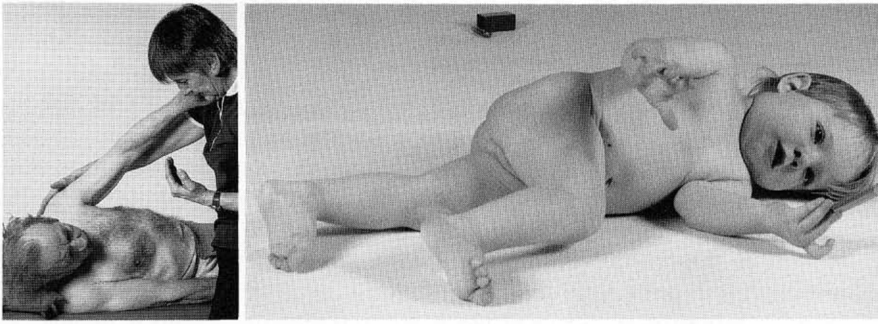


Fig. 3.10. **a** Turning towards the sound side. Without fixation by the abdominal muscles the ribs are pulled upwards instead of the head being raised (left hemiplegia). **b** A 9-month-old baby rests its head on the floor when rolling over to reach for an object

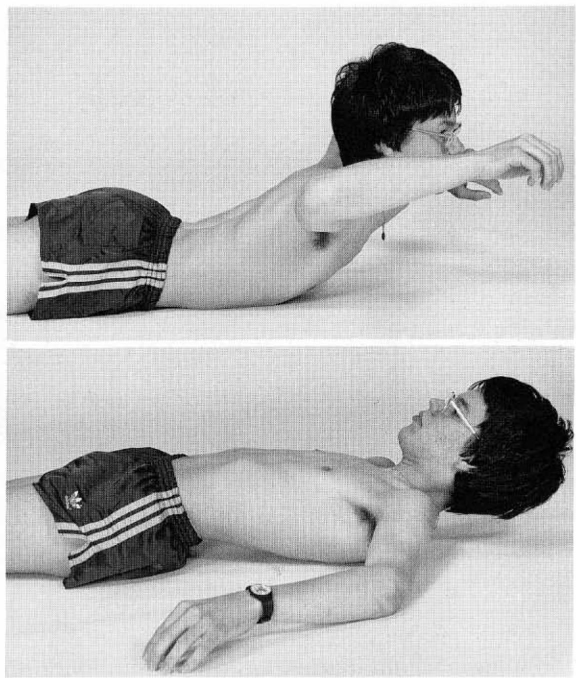
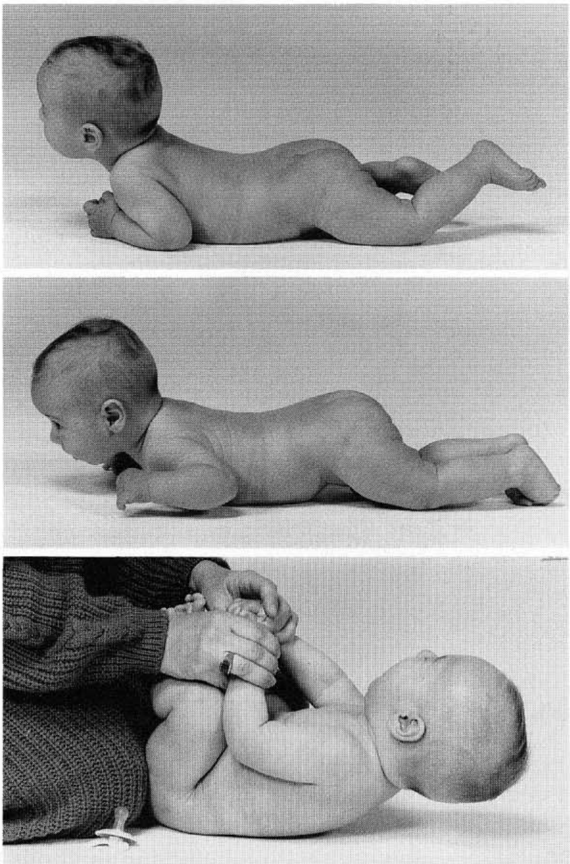


Fig. 3.11. **a** In prone lying, the patient is able to lift his head and shoulders using extensor activity (left hemiplegia). **b** From a supine position he is unable to flex his trunk to come up to sitting (left hemiplegia)

sound side, pressing the heel down against the supporting surface (Fig. 3.8 a). If both lower limbs are moved simultaneously the lumbar spine extends and the abdomen protrudes (Fig. 3.8 b). A baby 9–10 months old has the same posture (Fig. 3.8 c). Some patients blow out their abdomen forcibly in an attempt to compensate for the loss of stabilising abdominal muscle activity.

At an early stage the patient is able to extend his spine and hips and raise his buttocks off the supporting surface when lying with his knees and hips flexed to form a "bridge" (Fig. 3.9 a). At about 6 months a baby can often be observed making the same movement as it bounces its bottom up and down while lying on the floor. When, however, the patient lifts his sound foot into the air, the leg becomes a "tentacle" requiring activity from the abdominals to support it. The pelvis cannot be held level and sinks down on the sound side (Fig. 3.9 b). With insufficient tone and activity the oblique abdominal muscles are unable to suspend the bridge from above.

Rolling over on to his side the patient is unable to lift his head sufficiently against gravity, and the head righting reaction is inadequate. Lateral flexion of the neck to support the weight of the head and allow it to right is dependent upon a stable anchorage from the thorax. Without fixation from the abdominal muscles, the ribs are pulled upwards instead of the head being raised (Fig. 3.10 a). When the young baby starts to roll over on to its side to reach for an object, it will frequently rest its head on the floor for the same reason (Fig. 3.10 b).



a b c

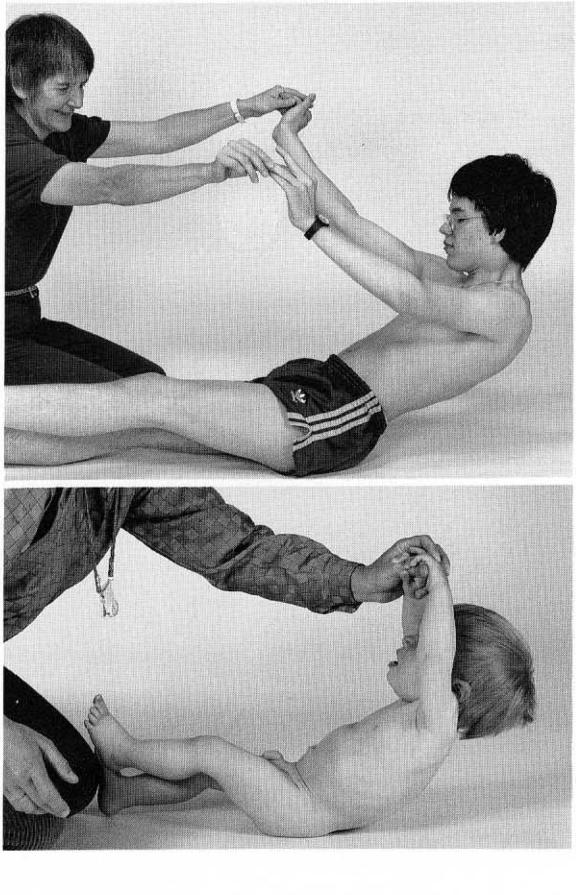
Fig. 3.12 a–c. In normal development active control of extension of the trunk precedes active flexion by far. **a** A 3-month-old baby raises his head in prone lying. **b** He can lift his head and shoulders without the support of his arms. **c** He is unable to flex his trunk to sit up, and his legs cannot extend selectively

3.4.3 Difficulties in Moving Between Lying and Sitting

In prone lying, the activity of the more primitive extensor muscles allows the patient to raise his head and shoulders from the floor without the support of his arms (Fig. 3.11 a). From a supine position, however, many patients are unable to come up to a sitting position unaided (Fig. 3.11 b).

Despite the size and weight of his head in proportion to his body, a baby can raise his head and shoulders from an early age (Fig. 3.12 a). He can even do so without pushing on his elbows (Fig. 3.12 b). Even with help, though, he is unable to come up to sitting, and holding his head flexed against gravity presents problems (Fig. 3.12 c). It will take a few years for him to achieve an adult pattern.

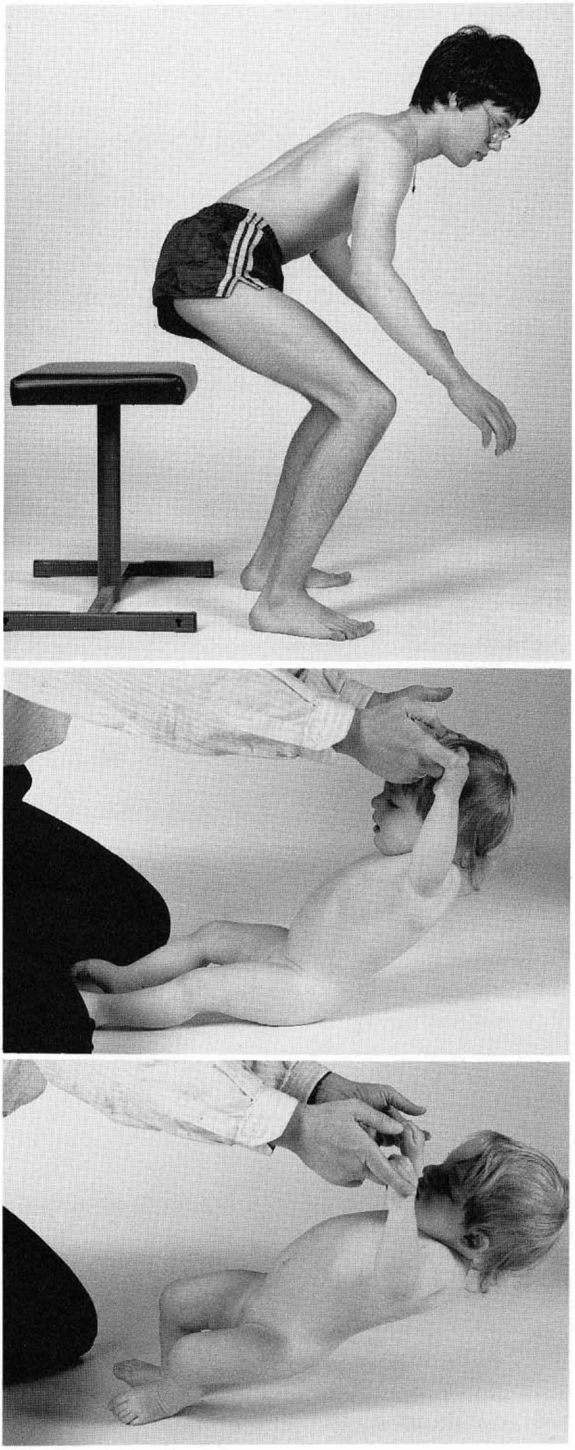
When the patient sits up with the therapist helping by holding his hands, he raises his arms to be able to use his more effective back extensors (Fig. 3.13 a). He has difficulty in keeping his affected leg extended on the floor to provide an anchor. A 10-month-old baby will also lift his arms as he too has more trunk



a

b

Fig. 3.13 a, b. Sitting up from lying with some help. **a** The therapist holds the patient's hands lightly to give support. The arms lift because the patient uses his extensors. His affected leg leaves the floor (left hemiplegia). **b** A 10-month-old baby also lifts his arms when his mother assists, and he cannot hold his legs down on the floor



a

b

c

Fig. 3.14 a–c. Ability to use extension, but not flexion. **a** The patient can stand up from sitting using mainly his trunk and leg extensors (compare with Fig. 3.11 b; left hemiplegia). **b** A 9-month-old baby tries unsuccessfully to sit up using flexion. **c** The baby quickly brings her feet back and pushes up to standing using her extensors

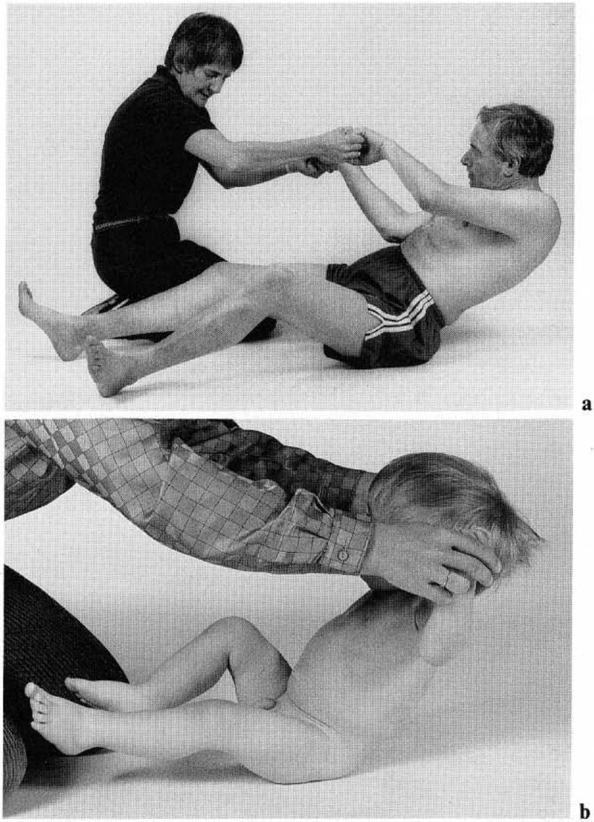


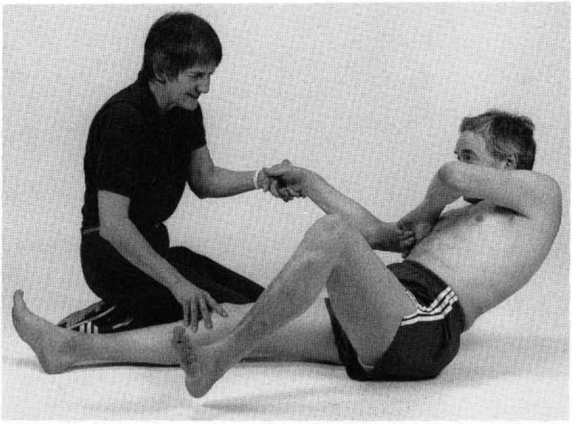
Fig. 3.15. **a** The patient has difficulty in coming up to sitting, even when the therapist pulls on his arms. He cannot extend his hemiplegic leg selectively when his trunk is flexing (left hemiplegia). **b** A 10-month-old baby has the same difficulty

extension control than flexion. His legs leave the floor, too, due to loss of selective activity between trunk and limbs (Fig. 3.13 b).

The patient finds it easier to stand up from sitting on a chair using the more effective extensor activity in both his trunk and his lower limbs, than to sit up from lying, which calls for flexion of the trunk (Fig. 3.14 a). A 9-month-old baby, finding the flexion tedious when pulled to sitting, often brings his feet back towards him and uses extension to come upright instead (Fig. 3.14 b, c).

Without selective activity between the trunk which is trying to flex and the legs which have to extend actively in order to remain on the floor, the patient cannot come up to sitting from lying even with help (Fig. 3.15 a). At 10 months the child can control the position of his head against gravity, but his legs flex and leave the floor too (Fig. 3.15 b).

When attempting to sit up with rotation with the hemiplegic side coming forwards, the arm flexes strongly in the spastic pattern of flexion with scapula retraction opposing the rotation. The patient's affected leg pulls into flexion as well, sometimes leaving the supporting surface altogether (Fig. 3.16 a). At 20 months, the child usually does not attempt to sit up with rotation, but if he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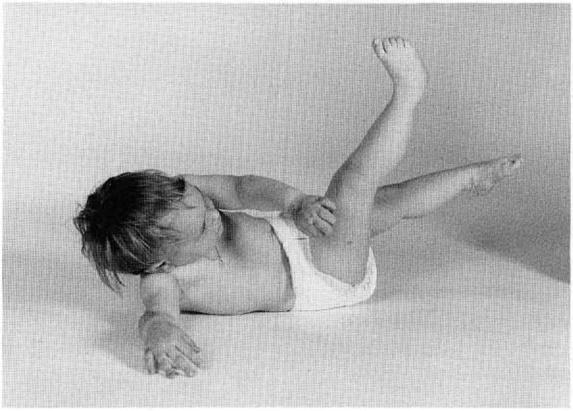
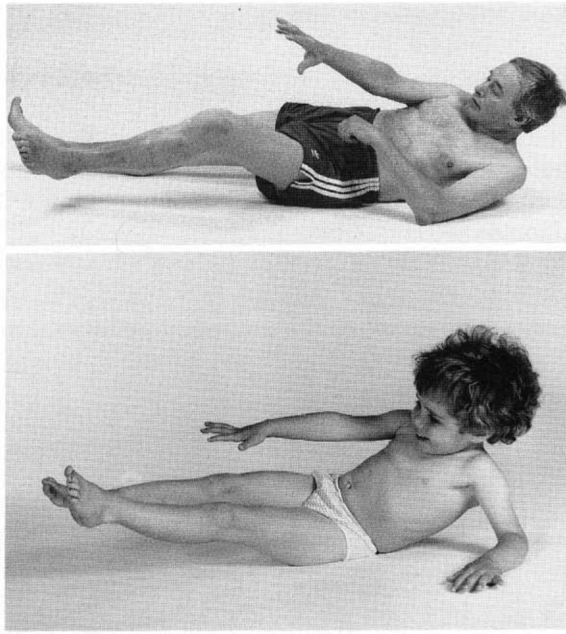

b

Fig. 3.16 a, b. Flexion of the trunk with rotation is even more advanced. **a** The patient is unable to flex his trunk and rotate towards the sound side when trying to sit up from lying. Both the hemiplegic arm and leg pull strongly into flexion (left hemiplegia). **b** A normal 20-month-old child attempts the movement, but fails. Her legs show total patterns of movement

does, his legs leave the floor as well and sometimes adopt a position very similar to the mass spastic synergies (Fig. 3.16 b). The arm also flexes, and the child is unable to bring his shoulder forwards with oblique abdominal control not yet sufficiently developed.

Even when sitting up with the sound side rotating forwards, the hemiplegic leg tends to flex despite the patient's conscious effort to maintain knee extension and keep the foot on the supporting surface (Fig. 3.17 a). The difficulty persists even when the patient is able to walk independently, but the gait pattern still shows abnormalities. At 3 years of age the child is not able to keep his legs extended and flat on the floor when sitting up with rotation either (Fig. 3.17 b). It must be remembered that even though he is already able to run around freely at this stage, the child's actual walking pattern is not the same as an adult's until he is seven years old (Okamoto 1973).

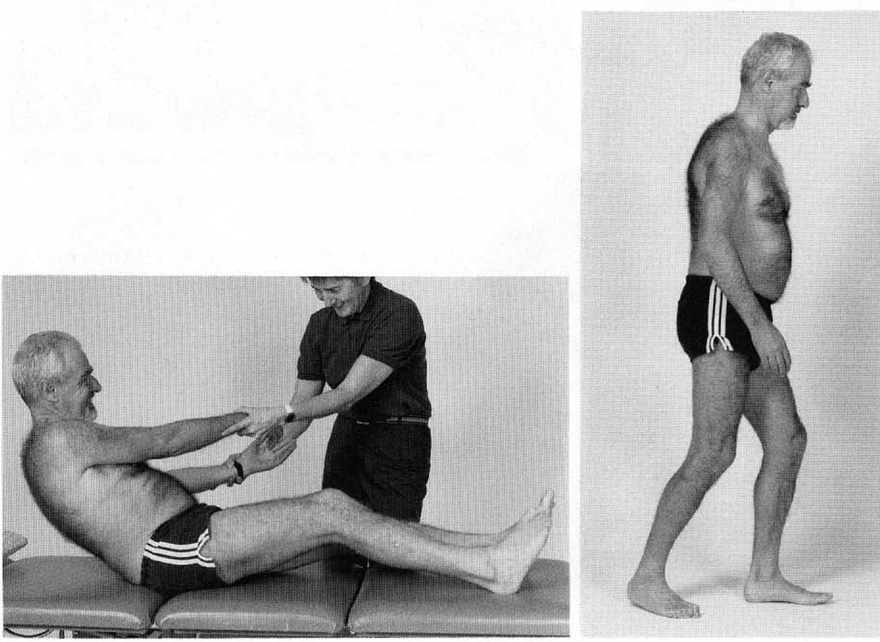
The patient who has difficulty in sitting up with rotation of his trunk, while at the same time extending his leg selectively will certainly still reveal problems of a similar nature when walking (Fig. 3.18 a, b).



a

b

Fig. 3.17. **a** Even when rotating towards the hemiplegic side the patient is unable to sit up, and he cannot extend his hemiplegic leg while the trunk is flexing (left hemiplegia). **b** A normal 3-year-old child cannot sit up with rotation without using her arms for support



a

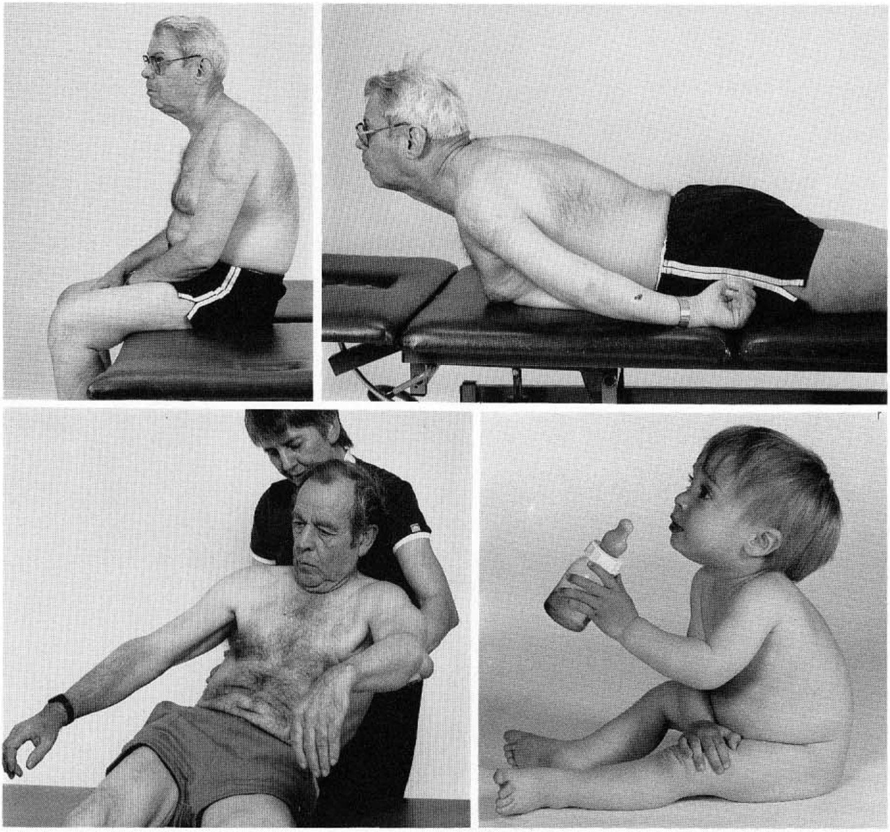
b

Fig. 3.18. **a** A patient who is able to walk long distances without aids still has difficulty in flexing and rotating his trunk towards the sound side (right hemiplegia). **b** His walking reveals similar problems

3.4.4 Difficulties in Sitting

The patient usually sits with his spine flexed and his neck extended, to a greater or lesser degree (Fig. 3.19 a). Such a posture is not due to weakness in his trunk extensors as is often mistakenly supposed (Fig. 3.19 b), rather the patient without adequate abdominal muscles and with his hip extended when he sits upright adopts the posture to prevent falling over backwards, which he would otherwise do (Fig. 3.19 c).

At 10 months a child also sits with his back rounded although he has excellent trunk extensors at this age (Fig. 3.19 d). He does so to keep his weight well forwards as he has neither sufficient abdominal muscle activity to prevent his falling backwards nor protective extension of his arms behind him should he



a b c d

Fig. 3.19 a–d. Typical sitting posture. **a** The hemiplegic patient sits with his hips extended, his spine kyphotic and his neck extended (left hemiplegia). **b** It is erroneous to think that his trunk extensors are weak. **c** The kyphotic posture prevents his falling over backwards. **d** A 10-month-old baby adopts the same posture to avoid falling back as he also has too little abdominal muscle control

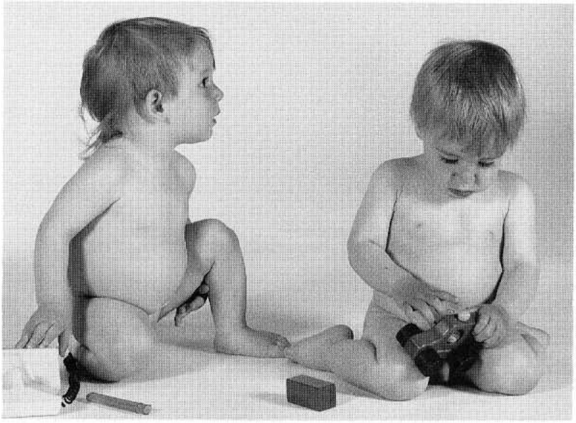


Fig. 3.20. Babies 9 and 10 months old adopt postures which allow them to extend their trunks without falling backwards

do so. Alternatively, he sits with his legs positioned in such a way as to provide a stable base, allowing him to extend his spine without being in danger of falling over (Fig. 3.20).

All balance reactions in sitting are adversely affected by the loss of selective trunk control. When the patient's weight is shifted sideways, his head cannot right if the abdominals cannot hold the ribs down. His trunk cannot shorten on the uppermost side away from gravity as lateral flexion involves all the abdominal muscles. His hemiplegic leg cannot abduct and extend to act as a counterweight as the pelvis is not able to provide a stable anchorage for the necessary muscles without the abdominals acting as fixators.

3.4.5 Difficulties in Standing Up from Sitting

The patient is unable to stand up normally from a sitting position because of inadequate selective activity in his legs and in his trunk (see Figs. 7.4, 7.5 and 7.9). If he stands up in an abnormal way, then his first steps when walking are automatically abnormal too (Davies 1985).

3.4.6 Difficulties in Standing

The patient with no abdominal control or insufficient activity in the abdominal muscles to support the long lever of his trunk against gravity would fall over backwards if he extended his spine and his hips simultaneously without support (Fig. 3.21 a). A 9-month-old baby, therefore, only stands when holding on to something (Fig. 3.21 b) or someone. It is interesting to note that the knees are hyperextended at this stage in his development. The abdominal muscles are required to tilt the pelvis up in the front and bring the hips into extension. The child's very lordotic lumbar spine ensures that his weight is kept well forward.