Chapter 61

Dynamic neuromuscular stabilization: exercise in developmental positions to achieve spinal stability and functional joint centration

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Introduction to dynamic neuromuscular stabilization

Kolar's approach to dynamic neuromuscular stabilization (DNS) is a complex approach that encompasses principles of developmental kinesiology during the first year of human life (Kolar et al. 2010). Further, it includes defining posture, breathing pattern, and functional joint centration from a 'neurodevelopmental' perspective. DNS assessment is based upon the comparison of the patient's stabilizing pattern to the one of a healthy infant. The treatment approach is based on ontogenetic postural locomotor patterns. Optimizing the distribution of internal forces of muscles that act on each segment of the spine and/or any other joint is the primary goal of this treatment approach.

When assessing a patient with pain in the locomotor system and searching for its primary cause, the morphological aspects and external biomechanical impacts affecting the spine and the joint as well as the internal, stereotypically repeating forces developed by the patient's own musculature need to be considered. Current research literature addresses the importance of the deep spinal stabilizing muscle system (Bouche et al. 2011; Kim et al. 2010; Watanabe et al. 2010). However, not only 'deep muscles' provide spinal and extremity joint stability. Through postural-locomotion kinematic chains, nearly every muscle is involved in stabilization function. Muscle co-ordination is directly controlled by the central nervous system (CNS). Therefore, the quality of postural stabilization depends on the quality of sensorimotor control. Any phasic or purposeful movement is preceded by the automatic activation of the stabilizers (Borghuis et al. 2008; Hodges 2004; McGill et al. 2009). Therefore, body posture influences quality of purposeful movements and vice versa.

Postural stabilization is an automatic, subconscious function that is frequently compromised in patients with musculoskeletal pain and with various neurological diagnoses. Postural function is interdependent with respiratory function, which is an important aspect for consideration. Postural misalignment may result in an abnormal breathing pattern and vice versa. Since this coupled, automatic postural-respiratory function is not completely under voluntary control, it may be difficult to train and improve it with traditional rehabilitation approaches.

Assessment of sensorimotor central control and postural-locomotion function should be an integral part of clinical assessment in rehabilitation practice. Based on functional assessment, a 'key link' (or clinically most relevant dysfunction) should be identified and addressed by treatment. The goal of DNS is to improve or normalize quality of postural, respiratory, and locomotion patterns as defined by developmental kinesiology (early ontogenesis) and integrate the proper postural-locomotion and respiratory function within activities of daily living and sport performance.

Definition of an ideal body posture from a developmental perspective

Normal early progress during the first year of life usually leads to the development of an optimal stabilization pattern, meaning ideal co-ordination between the cervical and thoracic spinal flexors (longus colli, longus capitis, rectus capitis anterior, and lateralis muscles) and the extensors (semispinalis cervicis and capitis, splenius cervicis and capitis muscles). The lower thoracic and lumbar spine are stabilized via co-ordinated activity between the diaphragm, pelvic floor, and abdominal wall (i.e. muscles that regulate intra-abdominal pressure) (Figure 61.1a,b). Such muscle balance and optimal co-ordination can already be observed in a 3-month-old baby. At this age, the development of the stabilization function is completed in both prone (Figure 61.1a) and supine positions (Figure 61.1b), and is later utilized in more mature developmental postural positions such as side-lying, quadruped, tripod, bear position, squat, standing, and gait (see Chapter 8).

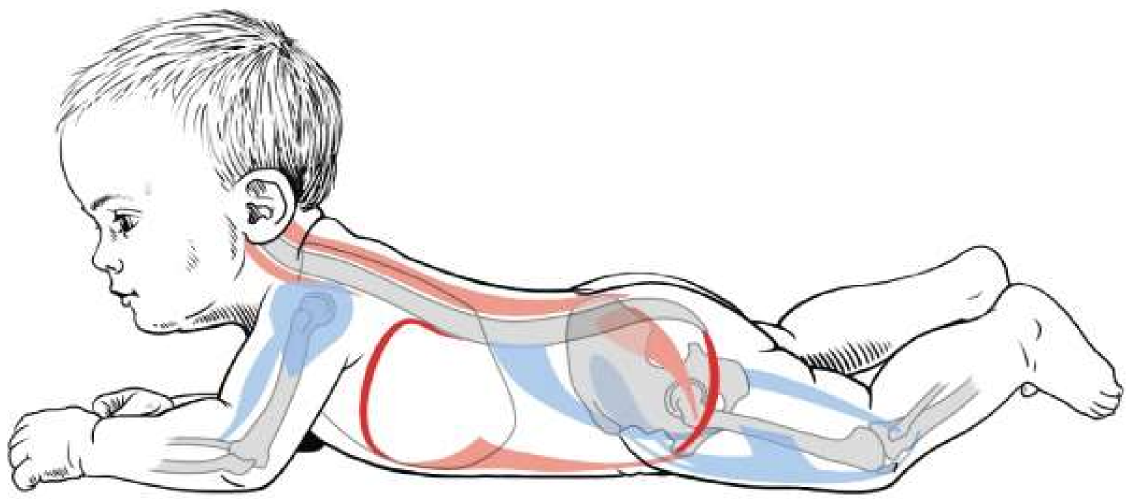

Figure 61.1 (a) A 3-month-old infant in prone position can hold its head against gravity, utilizing bilateral elbows and the pubic symphysis for support. To maintain this posture, the core must be stabilized via muscle synergy (muscles pictured in red). The cervical and upper thoracic spine are stabilized by balanced co-contraction between the deep neck flexors and extensors. The lower thoracic and lumbar spine are stabilized anteriorly by intra-abdominal pressure arising from co-ordinated activity of the diaphragm, pelvic floor, and abdominal wall musculature. This muscle synergy must be in balance with spinal extensors. Cervical extension, or uprighting, is initiated at the mid-thoracic spine (at the origin of the deep neck flexors).

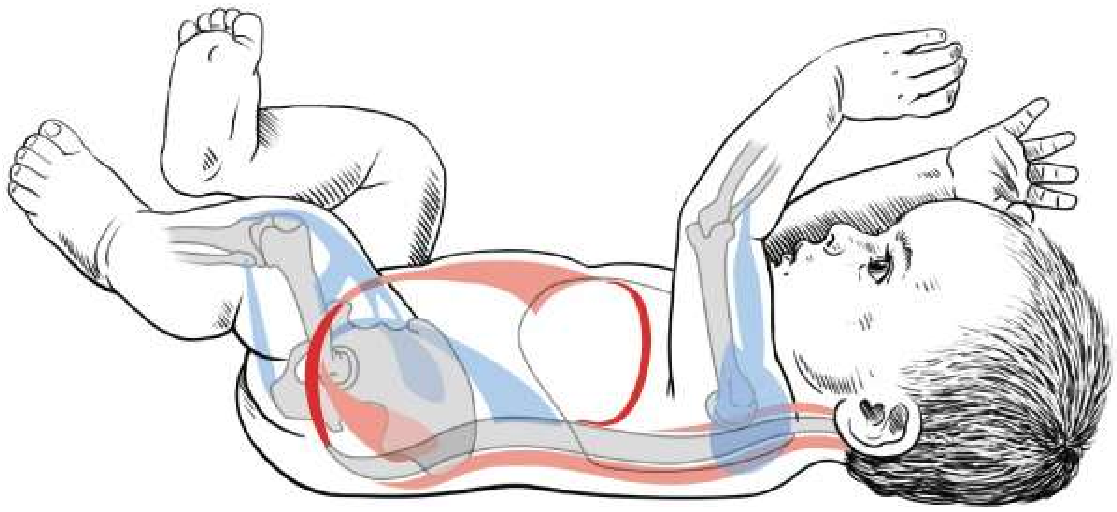

Figure 61.1 (b) A 3-month-old infant in supine position can hold its legs above the floor against gravity, utilizing the upper sections of the gluteal muscles, nuchal line, and back for support. The spine is stabilized using the same muscle synergy as described for prone position in Figure 61.1(a).

Aetiology of atypical posture

This optimal muscle synergy can be compromised by several mechanisms. Congenital skeletal dysplasia may prevent optimal stabilization. For example, pectus excavatum or carinatum, or congenitally fused vertebral bodies (Klippel-Feil syndrome) do not necessarily stand for atypical postural function, but may be inconvenient for ideal postural-locomotion muscle function. Such innate skeletal abnormalities usually do not respond well to any conservative treatment and may need to be corrected surgically.

Abnormal postural development during the first year of life is the second cause of atypical stabilization function (see Chapter 8) Depending on the type of developmental screening tests, developmental scales, and motor assessment instruments used during the evaluation of motor development of newborns and toddlers, various incidence of abnormal motor development is reported in literature (Zafeiriou 2004). Delayed or abnormal postural development classified as cerebral co-ordination disturbance (CCD) by Vojta (Imamura et al. 1983) is found in about 30% of infants and may result in a fixation of less than ideal co-ordination among stabilizers and may persist for the rest of life. Such abnormal postural muscle synergy may be even fostered by inadequate sports training or workload and potentially lead to pain syndromes.

The third common reason for faulty stabilization includes a habitual cause. For example, women, in order to look slim, constantly perform abdominal wall hollowing. In the end, a so- called ‘hourglass syndrome’ (Figure 61.2) becomes fixated as an abnormal stabilization pattern. Such abdominal wall imbalance keeps the diaphragm elevated, preventing it from maintaining a more neutral position and descending caudally during postural tasks. Lack of diaphragmatic postural function is then usually compensated for by paraspinal muscles, which become overloaded, develop trigger points, physiologically shorten, cause spinal joint dysfunction, and, finally, lead to degenerative spinal changes in an attempt to adjust for the permanent imbalance of stabilizing musculature. Similar consequences may occur as a result of incorrect weight training or erroneous methodology in sports training. For example, excessive strengthening of upper chest stabilizers (pectorales, upper trapezius) and paraspinal muscles may change the alignment between the chest and the pelvis, leading to an ‘open scissors syndrome’ and inefficient stabilization (Figure 61.3).

Figure 61.2 ‘Hourglass syndrome’: intentional hollowing, i.e. constant concentric activation of the abdominal wall muscles (blue arrows pointing towards the umbilicus, which moves upwards and inwards) pushes the diaphragm cranially, leading to limited excursions of the diaphragm during postural tasks (the difference between dotted and continuous red line indicating the upper contour of the diaphragm). During postural tasks, an ‘inverse’ diaphragm activation occurs (indicated by black arrows on the diaphragm, pointing towards the centrum tendineum).

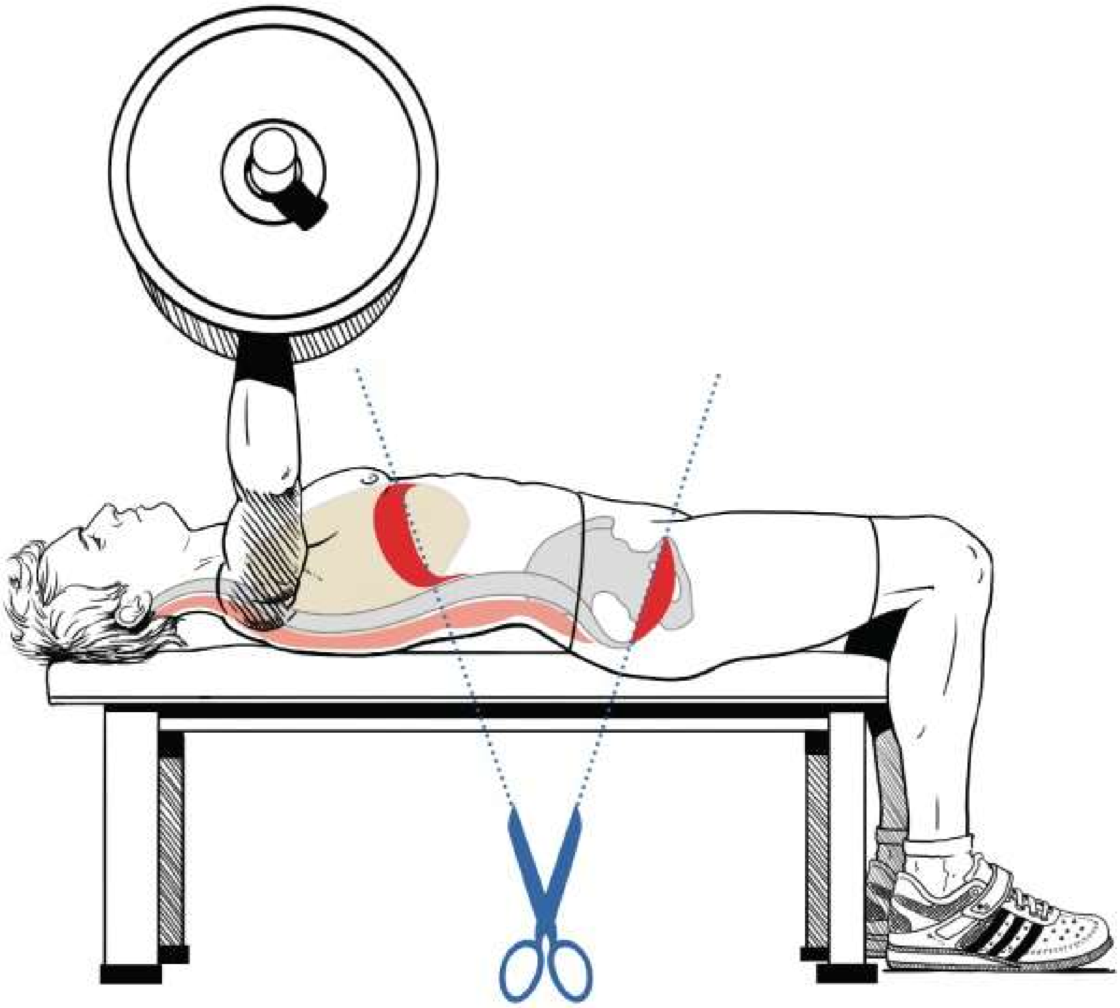

Figure 61.3 ‘Open scissors syndrome’: oblique alignment of the diaphragm and the pelvic floor during weightlifting does not allow for sufficient intra-abdominal pressure increase and it is compensated for by hypertrophic paraspinal muscles. Neck stabilization may also be compromised by this poor training strategy—note the position of the shoulders, neck extension, and atypical head support (should be nuchal line optimally).

The fourth cause of abnormal stabilization is a protective postural pattern. Janda (1980) already described, several decades ago, characteristic patterns of muscle hyper- and hypo-activity leading to predictable postural and gait disturbances and the stereotypical types of an ‘antalgic posture’ (Page et al.

2010). Also, Lewit describes ‘chain reactions’ that lead to abnormal postural patterns, such as ‘forward drawn posture’ and ‘pelvic shear dysfunction syndrome’, often originating from a pelvic girdle or a foot dysfunction (Lewit 2010). In other words, in case of any pathology (functional or structural, e.g., kidney stones, disc lesion, meniscus tear, respiratory disease), an individual’s posture automatically and subconsciously changes to protect the injured or affected body part. This protective postural pattern becomes consistent, sometimes clinically obvious, even in scenarios where the individual is still pain-free. Musculoskeletal pain is a protective signal leading to changes in movement patterns that serve to unload the painful tissue (Henriksen et al. 2011). This aspect is very important not only in a primary locomotor system dysfunction, but also in viscero-somatic patterns (Bitnar 2012). It is important for a clinician to remember that recurring muscle trigger points, joint restrictions, soft tissue dysfunction with a hyperalgic zone, and stereotypical changes in postural or stabilizing pattern may primarily originate from a visceral pathology that must be diagnosed and treated first.

Functional joint centration from a developmental perspective

When the CNS develops and functions optimally, in any postural situation, the joints are in the most suitable position for weightbearing (greatest possible stability at any angle) and are in the most favourable condition for further movement. During childhood, bone growth is linked to muscle activity. An optimal muscle pull will lead to a normal joint development. Furthermore, optimal joint position will be essential for both muscle pull and ligament orientation.

Traditionally, clinicians determine joint centration or decentration (‘subluxation’) by X-rays. Functional joint centration, however, is a broader term. It is not just the one position depicted on an X-ray. Functional joint centration is a dynamic neuromuscular strategy allowing for maximum interosseous contact and best biomechanical advantage in any joint position. Perfect muscular co-ordination, stabilizing the joint, is considered essential for therapeutic procedures. In a functionally centrated position, static loads are best tolerated based on the anatomical structures that can be found only in humans and, thus, making human locomotion unique and different from any animal (Lee at al. 2012; Ogihara et al. 2012; Sylvester and Pfisterer 2012; Zeinigner et al. 2011). During development, the principles controlling posture determine the formation of anatomical structures and are the expression of a centrally controlled programme. In DNS, clinical assessment is based on evaluation of muscle co-ordination related to a joint position (centration), with a therapeutic goal to restore such muscle co-ordination and joint centration as defined by developmental kinesiology.

Zones of support: their role in stabilization and locomotion

Zones of support form the basis for erect posture and any locomotion is initiated from these zones. They are stable points at which a muscle pull is anchored. Zones of support (i.e. supporting segments) play an important role in proprioception and exteroception and facilitate stabilization and locomotion functions (stepping and supporting function of extremities). In DNS, proper positioning, such as the functional centration of supporting segments, is critical. The CNS determines the zones of support based on the intended movement. Based on the developmental models, DNS describes functional joint centration for each exercise position in order to allow for ideal biomechanical loading with maximal congruence of articular surfaces. Starting an exercise by using functional centration in the supporting segment helps achieve centration in other joints as well. By contrast, incorrect position in the supporting segments may prevent ideal muscle co-ordination and joint centration elsewhere.

Functional assessment of dynamic neuromuscular stabilization

In addition to traditional musculoskeletal assessment, such as assessment of joint range of motion, soft tissue mobility, trigger points, or movement patterns (Janda 1980), DNS emphasizes functional assessment of core stabilization. DNS assessment is based on the comparison of the patient's stabilizing pattern to the developmental stabilization pattern of a healthy infant.

Functional stabilization is a global pattern. If one muscle (or even a part of it, such as the muscle section containing trigger points) is dysfunctional, then the entire stabilizing function is disturbed and the quality of purposeful movement is compromised. Compensatory mechanisms are developed in an attempt to provide some degree of segmental stability. These compensations typically involve certain muscle groups causing overload of joint and spinal discs, muscle overuse, and repetitive strain. Perpetuation of imbalance in the locomotor system and decreased spinal stability eventually result in painful conditions. The functional diagnostic system of DNS presents a set of functional tests to analyse the quality of functional stability and to define a 'key link' of dysfunction that should be primarily addressed by functional treatment.

1. Diaphragm test

Under normal conditions, the diaphragm fulfils combined respiratory, postural, and sphincter functions. Its function is challenging and often compromised. Disorders of breathing and continence have a stronger link to back pain than obesity and physical activity (Smith et al. 2006). Breathing and continence mechanisms may interfere with the physiology of spinal control and may provide a link to back pain. This relationship may be explained by physiological limitations in co-ordination of postural, respiratory, and continence functions of trunk muscles (Smith et al. 2006). Therefore, the diaphragm test is considered to be a key functional test in the DNS approach. It assesses the diaphragm's respiratory and postural functions as well as its co-ordination with other trunk stabilizers, i.e. the pelvic floor and all the muscles of the abdominal wall. These muscles regulate, or more precisely, increase the intra-abdominal pressure during postural tasks helping to stabilize the lower thoracic and lumbar spine.

During clinical assessment, the patient sits on the table, legs unsupported, arms relaxed on the table. First, the patient's breathing pattern is observed. The examiner places his/her fingers between and under the patient's lower ribs and asks the patient to take a deep breath in (Figure 61.4a). Optimally, the lower intercostal spaces widen as a result of external intercostal muscle activation. At the same time, as the diaphragm descends caudally with inspiration, the abdominal wall below the lower ribs expands proportionately in all directions (eccentric activity). Many individuals prefer to engage accessory respiratory muscles in their breathing, especially the sternocleidomastoid, scalenes, pectoralis major and minor, and the upper trapezius. In such case, the activation under the clinician's fingers is minimal and the patient's clavicles and shoulders are observed to elevate with each inhalation. This still does not indicate any real functional pathology or, at least, such a stereotype does not necessarily result in musculoskeletal pain conditions as long as the patient can modify it. To learn the patient's ability to modify their respiratory stereotype, the patient is instructed to relax their shoulders and take a deep breath under the examiner's palpating fingers (Figure 61.4a). Now, a significant and symmetrical expansion of the lower thoracic cavity in a lateral direction should be palpated and observed while the abdominal wall below the lower ribs should also expand in dorsolateral and anterior directions. Optimally, when observing the respiratory breathing from the front and palpating the lower abdominal wall, the inspiratory wave should go as far as the groin and the activation should also be felt under the examiner's fingers just above the hip joints (Figure 61.4b).

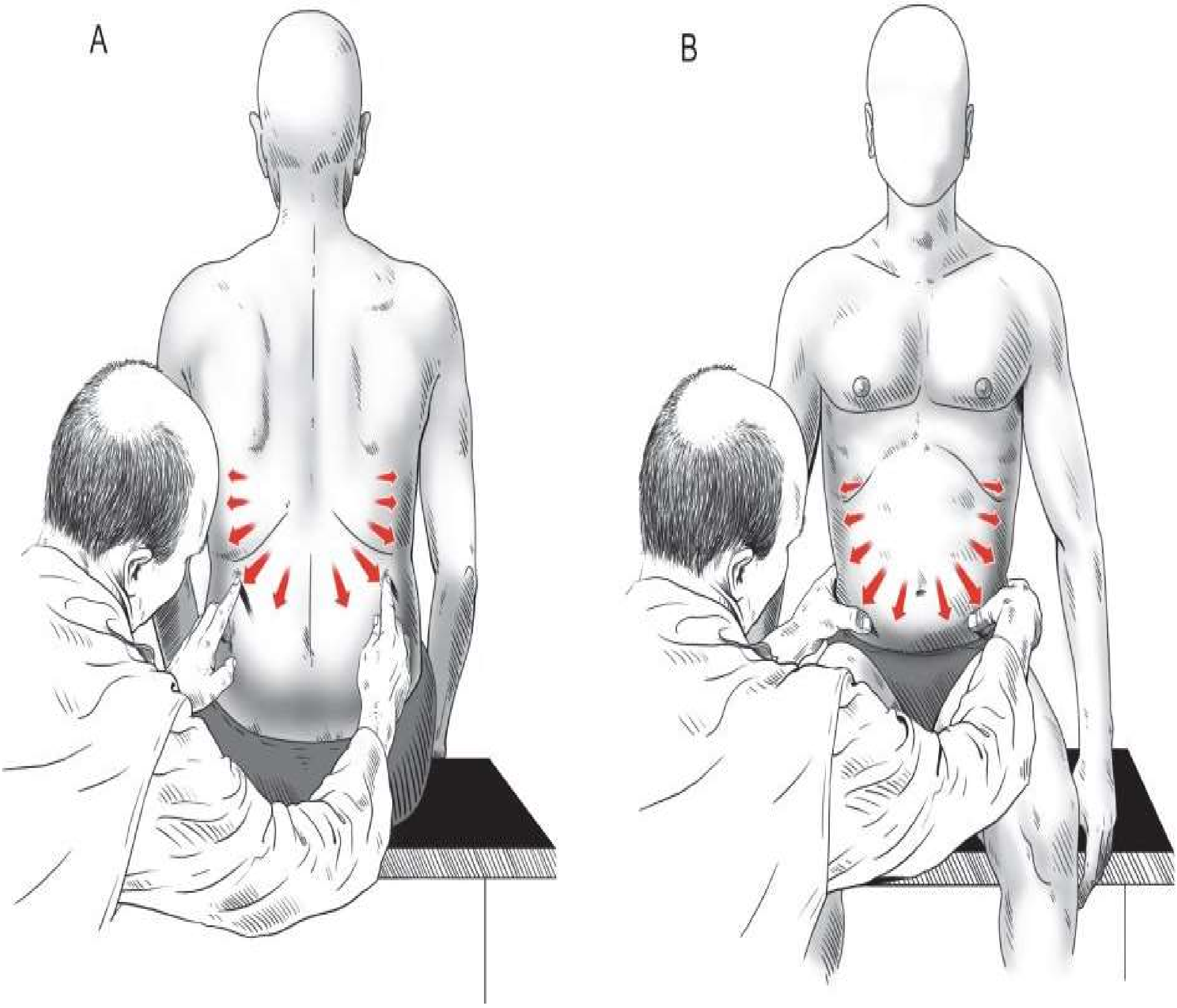

Figure 61.4 Diaphragm test: (**a**) optimal activation, assessment from behind; (**b**) optimal activation, assessment from the front.

To assess postural diaphragmatic function, the patient is instructed to exhale (diaphragm is in a cranial position) and then to expand actively the abdominal wall below the lower ribs in all the directions (the diaphragm descends caudally as a result of purely postural function, the person does not breathe). The amount of expansion correlates with postural function of the diaphragm (Kolar et al. 2010). In order to expand the abdominal wall, the eccentric activation of external and internal obliques along with the transversus and rectus abdominis are necessary. In addition, the concentric activation of the diaphragm (descends caudally during postural tasks) is needed to exert pressure on abdominal content from above and work in harmony with the pelvic floor muscles, which contract concentrically at the same time and provide pelvic support. Abdominal wall activation follows diaphragm and pelvic floor activation, modifying the amount of eccentric activation (expansion) to the activity of the diaphragm and the pelvic floor. From the front, the examiner can check if a person can actively expand the lower abdominal wall above the groin. Once again, this is possible only if the diaphragm properly fulfils its postural function, along with pelvic floor and subsequent abdominal wall activation (Figure 61.4b).

In reality, the diaphragm must fulfil respiratory and postural functions at the same time. In clinical assessment, however, it appears to be convenient to assess the respiratory and postural functions separately, as just described. It is more indicative of a person's ability to control the function of the diaphragm.

2. Intra-abdominal pressure test

The patient lies supine, with legs lifted above the table and flexed to 90° at the hips and knees. Knees are pelvic width apart. Initially, the examiner supports the patient's legs and then slowly removes the support. The patient's stabilizing pattern is observed during this postural task. Under normal conditions, posturally increased intra-abdominal pressure forces the patient's lower back towards the table and the chest remains aligned with the pelvis in such a way that the chest and pelvic axes remain parallel. Frequently, a descent of the diaphragm becomes evident, observed by a caudal movement of the umbilicus towards the pubic symphysis. Shoulders are relaxed. The entire abdominal wall activates eccentrically and proportionately in all directions. Co-ordinated activation between hip abductors and adductors and external and internal rotators keeps the hips in a neutral position (Figure 61.5a).

The following errors can be observed if postural function is compromised (Figure 61.5b):

(1) Insufficient intra-abdominal pressure increase is compensated for by excessive activation of paraspinal superficial muscles, leading to an open scissors syndrome.

(2) Patient's lumbar lordosis increases and the lower back does not adhere to the table; lack of intra-abdominal and intra-pelvic pressure causes hollowing above the groin.

(3) Diastasis recti can be observed and palpated.

(4) Patient elevates and protracts their shoulders (excessive activation of the upper trapezius and pectoralis).

(5) Poor trunk stabilization does not anchor hip flexors properly and the patient cannot maintain neutral hip position as a result; lower extremities become 'too heavy' and fall back on the table; hip abduction increases.

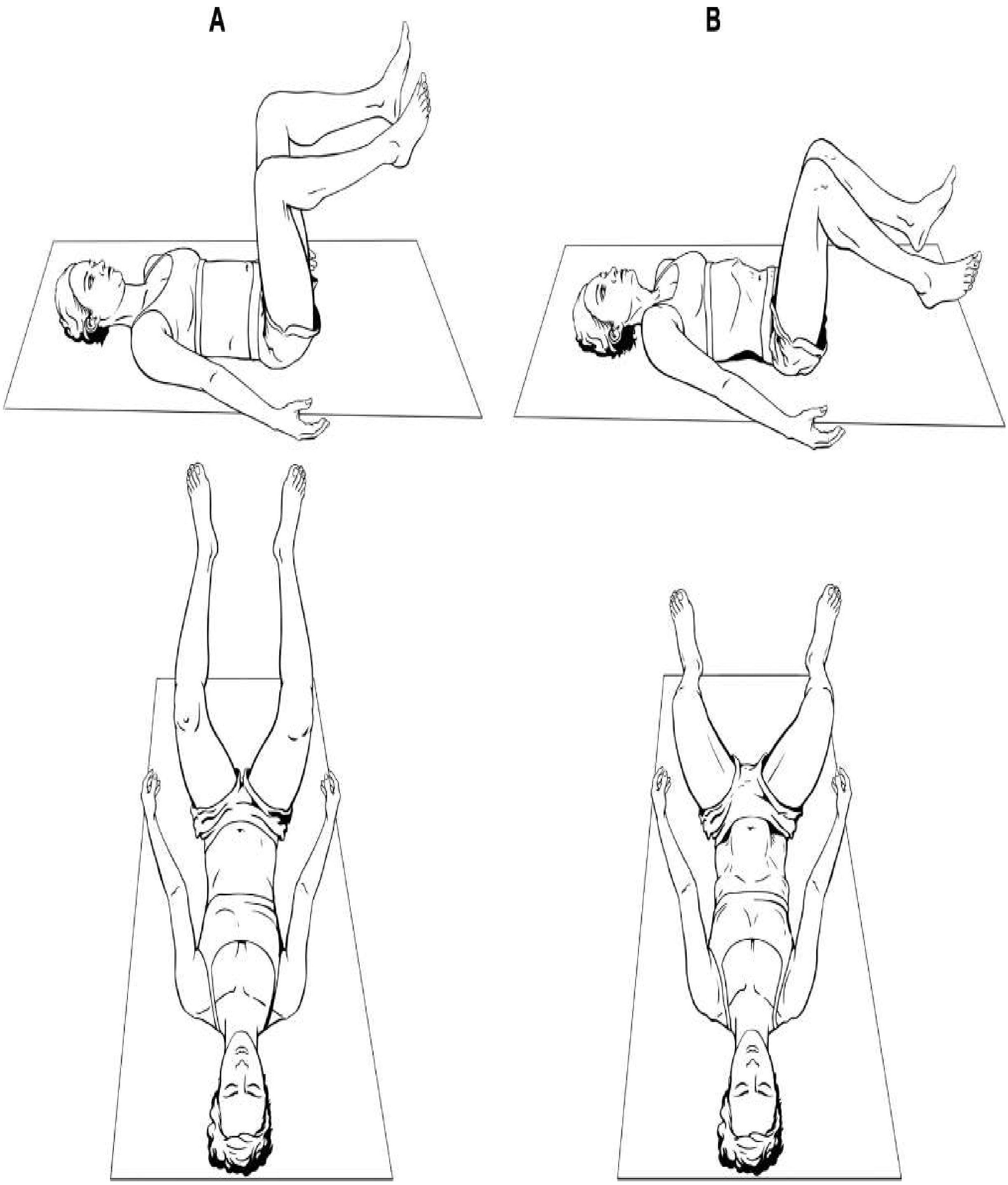

Figure 61.5 Intra-abdominal pressure test: (**a**) optimal activation; (**b**) abnormal activation.

3. Trunk and neck flexion test

The trunk flexion test is performed in supine position with arms positioned along the trunk. The patient slowly performs trunk flexion until the lower scapular angles come off the table. Ideally, the proportional eccentric activation of abdominal wall musculature in all directions is observed and palpated. Diastasis recti should not be observed. The thoracolumbar junction and lumbar spine adhere to the table as a result of an increased intra-abdominal pressure. Lower ribs are well stabilized via the oblique abdominal muscle slings (external and internal obliques, transversus abdominis) and do not flare out. The movement is smooth and effortless; the patient can maintain the end positions for at least 20 seconds (only lower scapular angles are in contact with the table). Lower extremities remain on the table during the testing (Figure 61.6a).

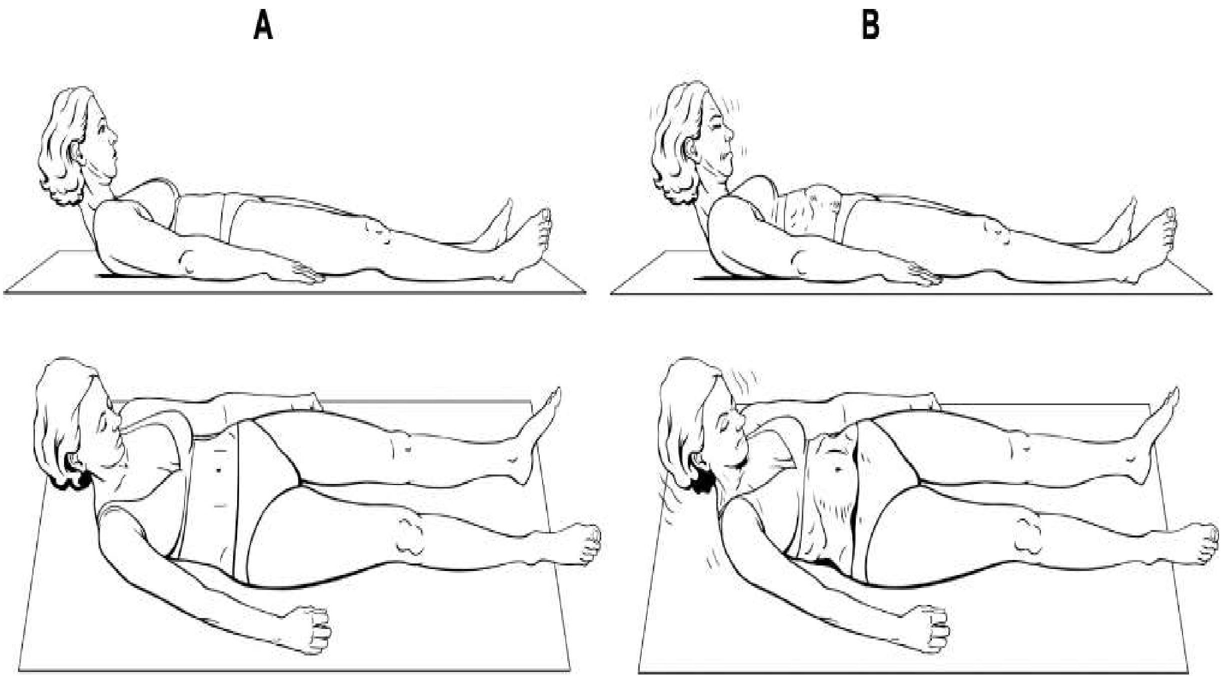

Figure 61.6 Trunk flexion test: (**a**) optimal activation; (**b**) abnormal activation.

Common signs of insufficiency (Figure 61.6b) include:

(1) Diastasis recti;

(2) Disproportional activation of abdominal wall with the upper section of the rectus abdominis predominant and the dorsolateral sections insufficient (bulging);

(3) Lower rib flaring;

(4) Hollowing above the groin;

(5) Trunk shaking (muscle weakness).

The neck flexion test is also performed in supine position. Ideally, the deep cervical flexors (longus capitis, longus colli, and rectus capitis anterior) are the primary muscles activated while the sternocleidomastoids and the scalenes assist. In a normal scenario, smooth, arc-shaped cervical flexion is observed, with the chin reaching as far as the jugular fossa at the end of the movement. This end position should be maintained for at least 20 seconds (Figure 61.7a).

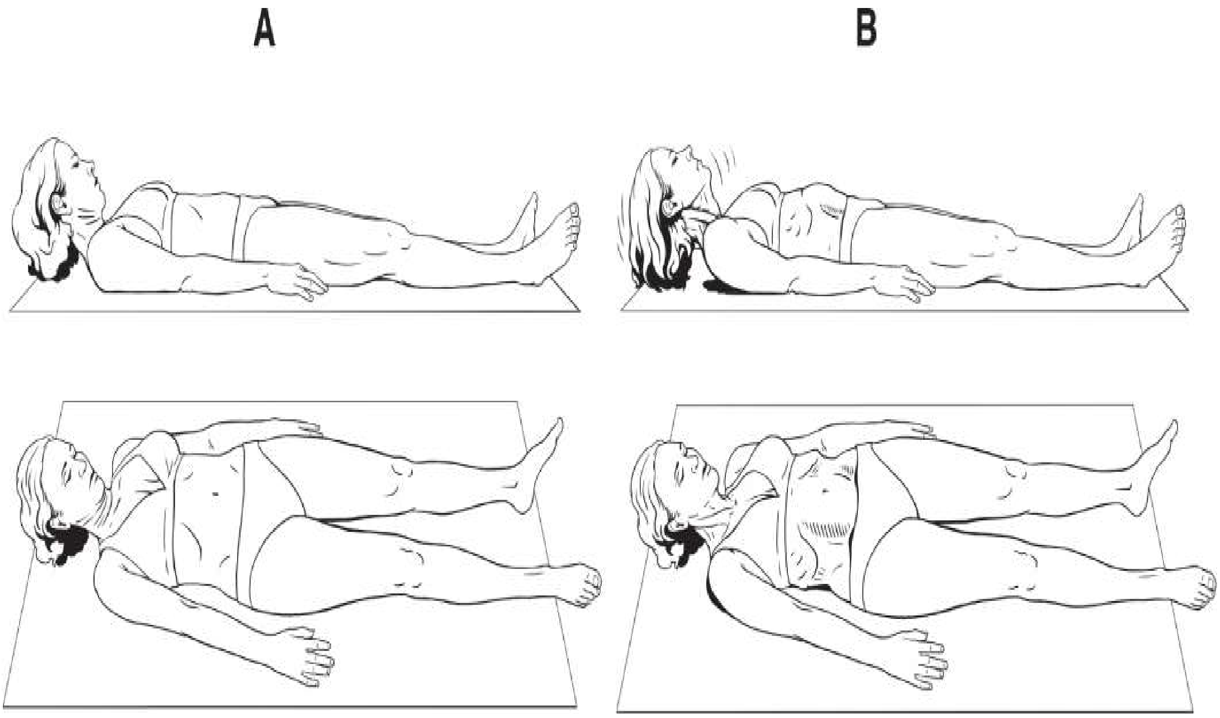

Figure 61.7 Neck flexion test: (**a**) optimal activation; (**b**) abnormal activation.

The deep neck flexors are often weak and substituted for by superficial muscles, mainly the sternocleidomastoid muscles. In such a case, the arc-shaped, proportionally segmental, cervical flexion pattern is altered and flexion takes place mainly in the lower cervical and upper thoracic segments while extension occurs in the upper cervical segments. At initiation of the movement, the chin juts forward. The movement is often shaky as a result of muscle weakness (Figure. 61.7b).

The test can also be enhanced by a slight resistance against the patient's forehead to confirm inadequate stabilization by the deep cervical flexors.

4. Trunk and neck extension test

The patient performs trunk extension in prone position with arms relaxed along the trunk. Ideally, gradual extension is observed in the cervical and thoracic segments. Shoulder blades remain in a neutral position with medial scapular borders being almost parallel to the spine. Eccentric activation of the dorsolateral sections of the abdominal wall occurs, counterbalancing the paraspinal muscle activity. The pelvis maintains its neutral position with the pubic symphysis and bilateral anterior superior ilias spine (ASIS) becoming zones of support. Lower extremities remain on the table with the gluteal muscles relaxed (Figure 61.8a).

Common signs of insufficiency (Figure 61.8b) include:

(1) Thoracic spine maintains a rigid kyphosis and gradual cervicothoracic segmental extension is replaced by extension at the cervicothoracic and thoracolumbar junctions only.

(2) Shoulder blades are elevated and externally rotated with protruding medial borders.

(3) Hyperactive superficial paraspinal muscles compensate for weak and bulging dorsolateral abdominal wall sections.

(4) Anterior pelvic tilt occurs as a result of insufficient frontal lumbar stability, which is often compensated for by superficial paraspinal muscles and hamstrings; patient may lift their legs off the table.

(5) Concentric activation of the gluteal muscles may also occur as a compensatory pattern assisting in pelvic stabilization with the patient squeezing their buttocks together.

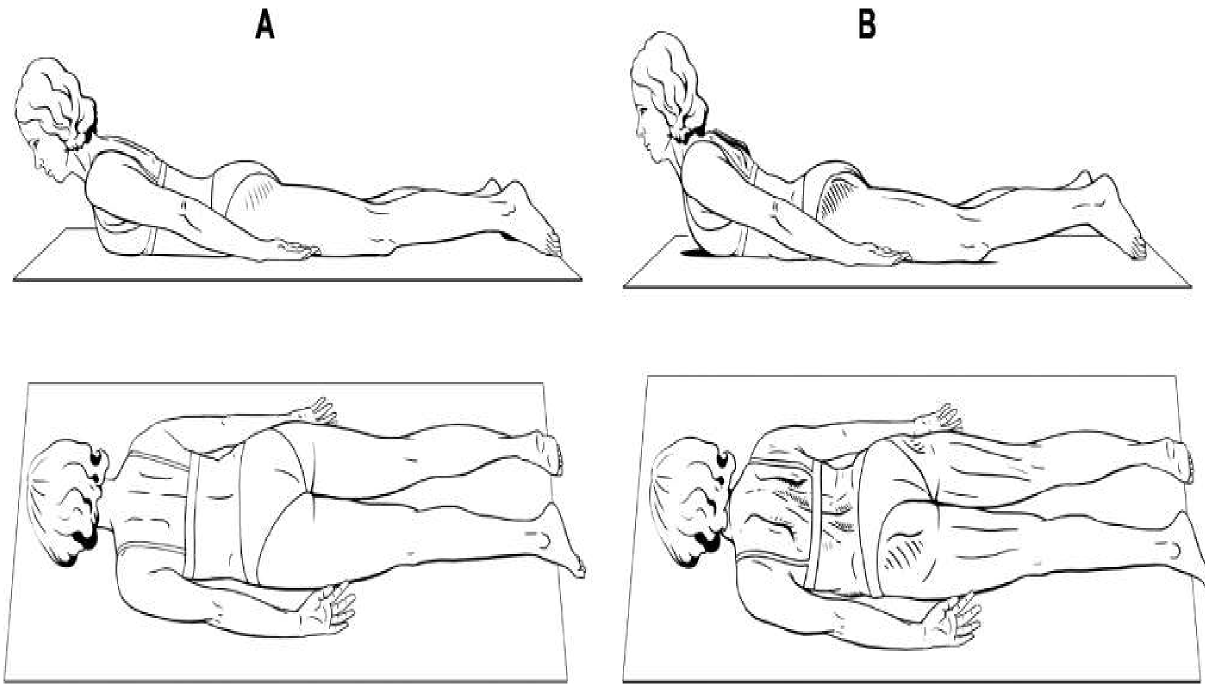

Figure 61.8 Trunk and neck extension test: (**a**) optimal activation; (**b**) abnormal activation.

5. Quadruped rock forward test

The patient is in a quadruped position using hands and knees for support. Then, slowly, the patient shifts their head and trunk forward and stays in this position for approximately 30 seconds. The hand position (supporting function) and the trunk stabilization pattern are observed.

Ideally, both hands provide support while maintaining functionally centrated position; i.e. the thenar and hypothenar areas are equally loaded, fingers are ‘freely’ extended rather than hyperextended or flexed, both hands are ‘grasping’ the floor providing support. Shoulder blades are in a neutral position, adhering to the rib cage, medial borders nearly parallel to the spine. The spine elongates, the thoracolumbar junction is firm and stable, proportionate activation of the muscles of the abdominal wall occurs (Figure 61.9a).

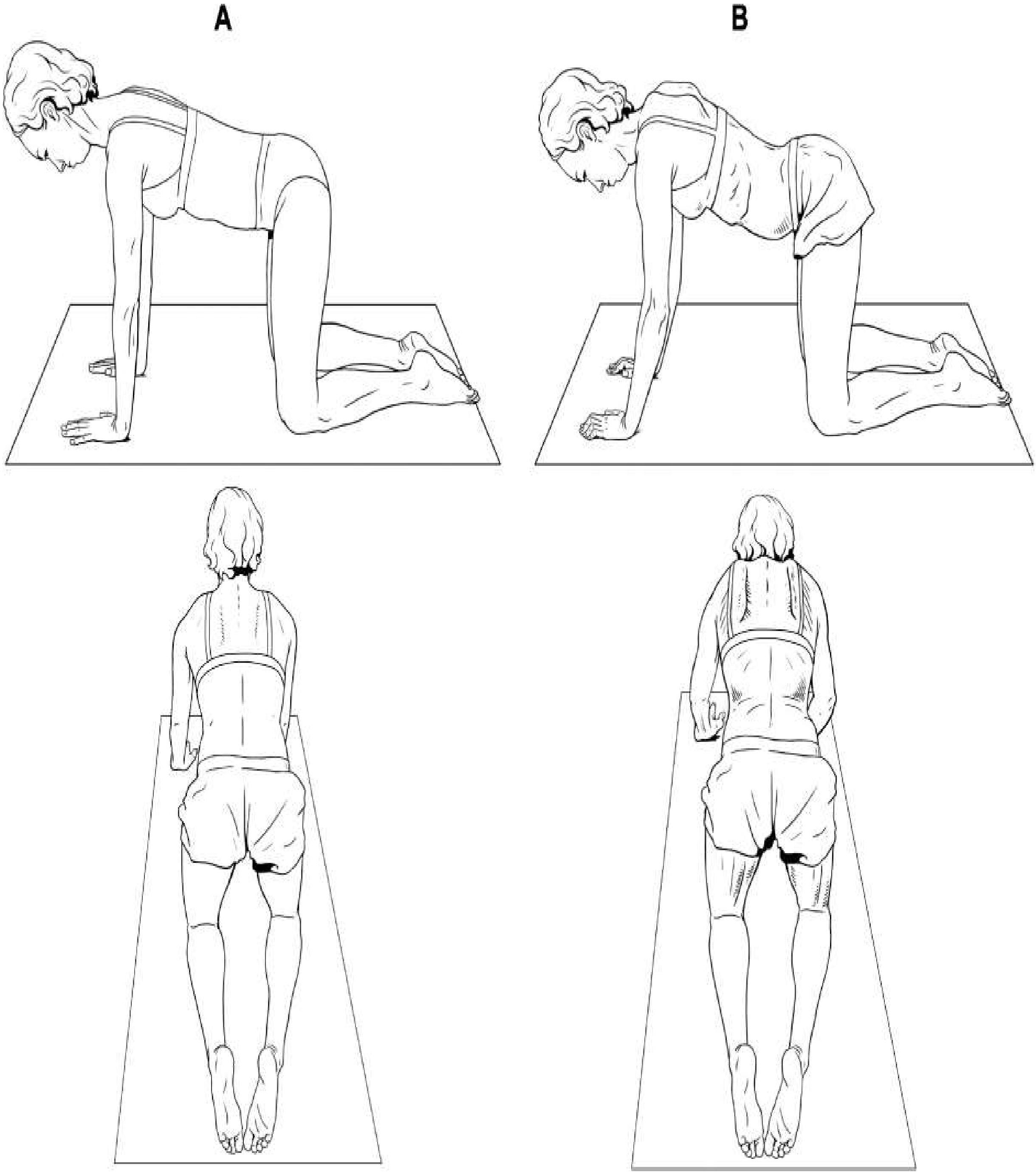

Figure 61.9 Quadruped rock forward test: (**a**) optimal activation; (**b**) abnormal activation.

Under pathological conditions, a decentration of the hands occurs. Usually, the hypothenar area is weightbearing more while the thenar section loses contact with the table. As a result, flexion at the elbow occurs. Often, the scapula on the ipsilateral slide loses its neutral position; it is pulled cranially, its lower angle rotating externally and the medial border protruding. A collapse at the thoracolumbar junction is often related to an anterior pelvic tilt (Figure 61.9b).

6. Squat test

The patient performs a squat. The pattern of trunk stabilization, head position, and the support function of the feet are evaluated. Ideally, the cervical spine is elongated, proportional co-ordination between the neck flexors and extensors keeps the head in a neutral position. During the squat, shoulders and knees are aligned, the chest is not pulled forward in front of the knees, and the knees are not moving over the big toes. Proportional eccentric activation of all the sections of the abdominal wall can be palpated. The chest axis is parallel to the pelvic axis. Gluteal muscles are activated eccentrically demonstrating a hemispheric shape. Knees are pelvic width apart. Feet are functionally centrated, the longitudinal arch does not collapse, the first and fifth metatarsophalangeal regions and the heel form a supporting tripod. The toes are ‘grasping’ the floor and assisting in stabilization (Figure 61.10a).

A B

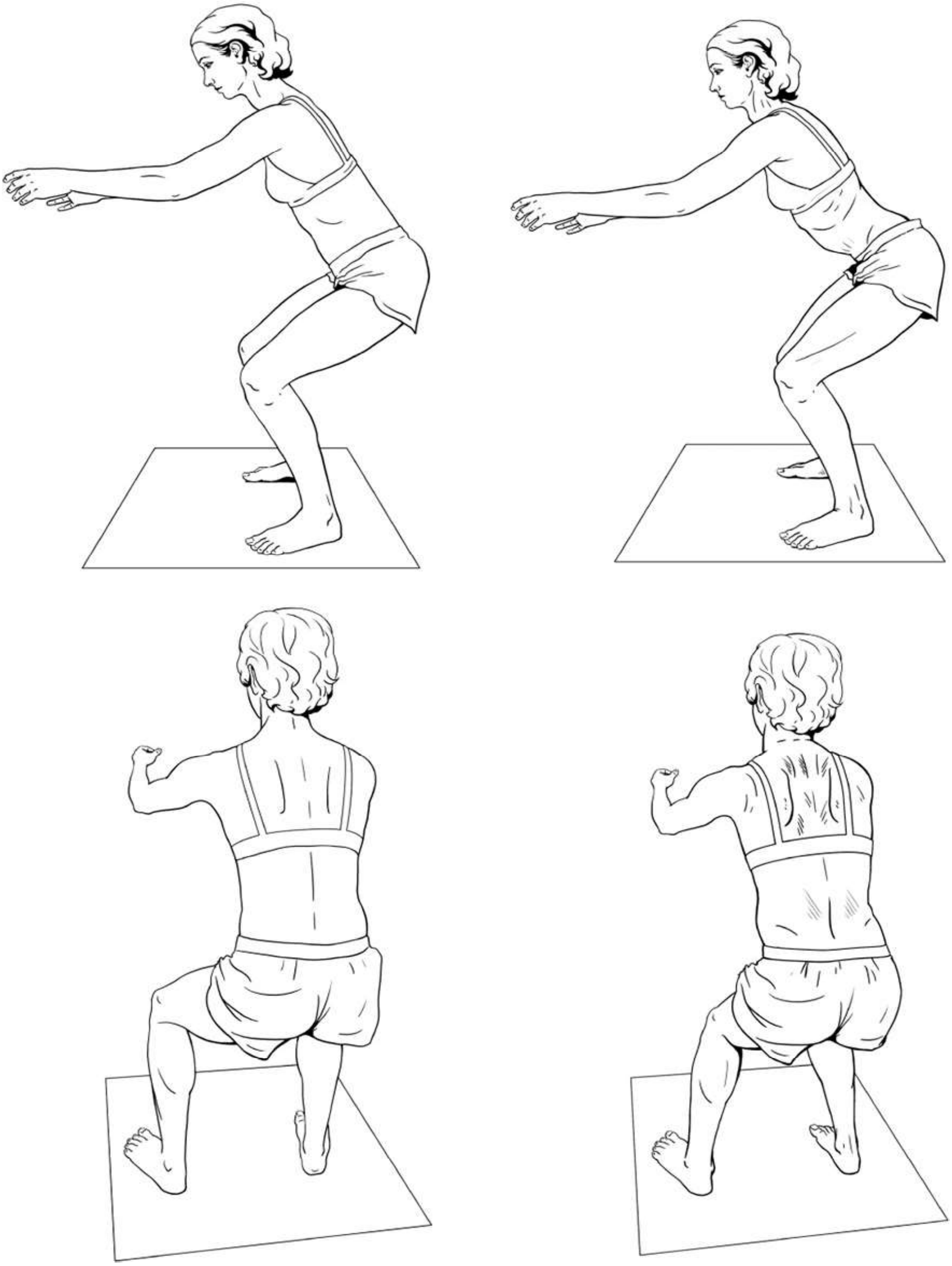

Figure 61.10 Squat test: (**a**) optimal activation; (**b**) abnormal activation.

Signs of insufficiency (Figure 61.10b) include the following:

(1) Hyperextension at the cervicocranial junction (deep neck flexor insufficiency);

(2) Hyperactivity of paraspinal muscles;

(3) Chest moves forward and the chest axis is not properly aligned with the pelvic axis;

(4) Pelvis tilts anteriorly leading to open scissors syndrome;

(5) Insufficient activation of lower abdominal wall;

(6) Disproportional or insufficient activation of the gluteal muscles is manifested by flattening of the gluteal region, hip internal rotation, and knees collapsing inward;

(7) Decentrated supporting foot function manifests itself by longitudinal arch collapse; insufficient supporting function of the first toe is common; the patient lifts the first toe or all the toes from the ground or, on the contrary, grasps the floor with the toes too forcefully.

The functional tests described here are just examples. In DNS, any positions can be used for both functional assessment and exercise positions. Each position is a snapshot of a partial pattern of the entire locomotor pattern. Ideally, muscle co-ordination has to be balanced at each snapshot, stabilizing the core properly and allowing for the most efficient pattern of stepping, grasping, and supporting extremity function as well as head movement.

Dynamic neuromuscular stabilization training based on developmental positions

In addition to traditional manual techniques, such as joint mobilization, soft tissue mobilization, and muscle stretching, patient's education in exercise and self-treatment procedures form a critical component of the DNS concept. Active exercise needs to address CNS control to alter and correct motor patterns. Hence, patient participation and compliance are important. A patient is expected to exercise on a daily basis. 'Brain education' is the ultimate goal to achieve ideal muscle balance and functional joint centration in an attempt to avoid overloading and to control movement patterns in a more efficient way. Patient's exercise needs to be fully 'conscious': the patient must be aware of movement quality, which is much more important than quantity. The patient must feel both the correct and incorrect movement pattern and be able to differentiate them. This depends on adequate body awareness. Only then can the patient exercise independently at home.

Movement should be slow and the patient should pay full attention to it, always looking for functional joint centration. Supporting segments form the basis for posture, and locomotion is initiated from these segments. If the supporting segment is decentrated, the decentration will reflect throughout the entire system, and the exercise may promote further pathology instead of correcting the problem.

Every patient is unique and DNS training must always be modified for each individual. The progression is from simple and basic to more advanced or challenging positions and exercises. Finally, the patient should be able to activate correct movement patterns not only during DNS exercise but also during activities of daily living and sports performance. The greater the number of modifications of the movement pattern the patient can execute with good control, the better the prognosis and success of the programme, i.e. the greater the variety of motor programmes available to the patient.

In DNS, any developmental position (physiological) can be used in self-treatment. More mature positions (i.e. ontogenetically younger) are always based on the less mature ones (i.e. ontogenetically older). Usually, ontogenetically younger positions are more difficult than the older ones, but this is not a rule. Since DNS is mostly an educational programme focusing on the improvement of the stabilizing system, its therapeutic effect can usually be observed after 6 or more weeks. It requires discipline and patience from both the clinician and the patient. However, the final effect can be quite remarkable and long-lasting.

Since stabilization function is inseparable from respiratory function, training of a proper breathing pattern is an essential part of DNS. Often, the first step is to release soft tissues of the trunk and the fasciae of the back, mobilize the thoracic spine and vertebrocostal joints to achieve neutral position of the chest. The neutral position consists of balance between the upper chest stabilizers (pectorales, upper trapezius, sternocleidomastoid muscle (SCM), scalenes), which are often short and overloaded, and the lower chest stabilizers (abdominal muscles, diaphragm), which may be posturally insufficient in some sections. Chest and pelvic axes need to be in parallel alignment in such a way that the lower thoracic cavity is positioned just above the pelvis.

The following positions described can be used in stabilization training, but the entire DNS system offers much more. If one videos a healthy infant, older than 3 months, in any position, any snapshot from the video can be used as an exercise position. If the baby is developing normally, any position demonstrates ideal core stabilization, joint centration, and an ideal locomotion pattern as a result of a genetically determined CNS programme. In DNS, the patient's position and movement are compared to the physiological developmental positions and movements.

Initially, just holding the position and focusing on proper breathing can be quite challenging and serve as a sufficient exercise for a patient. Once the patient masters the position easily, it can be progressed by moving extremities against resistance bands (resistance against stepping, reaching, or supporting extremity function; see Chapter 8). When exercising against resistance, the resistance must be adequate; in other words, the amount of resistance must correlate to the strength of the weakest part of the stabilizing system. Resistance training should not be performed before correct stabilization and breathing are mastered. Also, the transitions from one position to another can be trained (e.g. supine to side-lying, side-lying to side-sitting or prone). The exercise can be performed on unstable surfaces or with weights (barbells, dumb-bells). Any modification and progression can be used as long as the patient maintains ideal stabilization co-ordination and breathing pattern. Only as many repetitions should be performed as for which the patient can demonstrate perfect stabilization and a high-quality locomotion pattern.

1. Supine position equivalent to 3 months of age (Figure 61.11)

Initial position: Supine, legs above the table, approximately 90°Flexion at hips and knees, slight hip external rotation. Initially, the legs may be supported.
Zones of support: Nuchal line, thoracolumbar junction, upper gluteal muscles.
Instructions: Relax the shoulders, maintain neutral (caudal) position of the chest throughout the entire respiratory cycle, breathe into your groin, and breathe into the dorsolateral sections of your abdominal wall.
Modification and progression: Legs unsupported; exercise against resistance band; holding a heavy ball in both hands, moving it few centimetres to each side and/or up and down; the clinician gives unexpected perturbations as the patient resists while maintaining proper trunk position and abdominal wall co-ordination; exercise cervical flexion (deep neck flexor activation).

Figure 61.11 Exercise in supine position equivalent to 3 months of age. The clinician helps the patient maintain neutral (caudal) position of the chest by slightly pushing the chest caudally (while avoiding pressing it towards the table); the other hand, placed on the lower abdominal wall, cues the patient to activate the lower abdominal wall with inhalation and/or a postural task.

2. Prone position equivalent to 3 months of age (Figure 61.12)

Initial position: Prone, elbow support, approximately 125–135° angle between the trunk and the arm.

Zones of support: Medial epicondyles of bilateral elbows, bilateral ASIS, and pubic symphysis.

Instructions: Focus on elbow support, spine elongation, pulling down the shoulder blades, chin tuck, breathing into the groin, and breathing into dorsolateral sections of the abdominal wall.

Modification and progression: Exercise segmental extension in the mid-thoracic spine, initiating the movement at T4–5 and then extending the spine in a cranial direction, segment by segment at a time; exercise rotation of the cervical and upper thoracic spine, imagine that neck rotation initiates at the mid-thoracic segments.

Figure 61.12 Exercise in prone position equivalent to 3 months of age. The clinician helps elongate the spine and align the neck in a neutral position by placing one hand on the nuchal line and the other hand on the mid-thoracic spine. The clinician guides the patient to initiate cervical extension from this specific area.

3. Side-lying position equivalent to 5 months of age (Figure 61.13)

Initial position: Side-lying, head may be supported, pillow height correlating with the distance between the patient's bottom shoulder and the neck, 90°Flexion at shoulder and elbow of the bottom arm, top leg placed in front of the bottom leg.
Zones of support: Deltoid and greater trochanter areas (mastoid, lateral nuchal line if head supported).
Instructions: Spine elongation, weightbearing through the deltoid and greater trochanter area, pulling the bottom shoulder blade caudally (Figure 61.13a), breathing into the groin and dorsolateral sections of the abdominal wall.
Modification and progression: Exercise against resistance band—top arm is reaching against resistance, bottom forearm is pronating against resistance (Figure 61.13b); holding barbell or dumb-bell in each hand, focusing on a breathing pattern and spinal elongation; initiating rolling by shifting the support from the deltoid area towards the elbow of the bottom arm; clinician gives unexpected perturbations rolling the patient forwards and backwards, the patient resists while maintaining proper core stabilization.

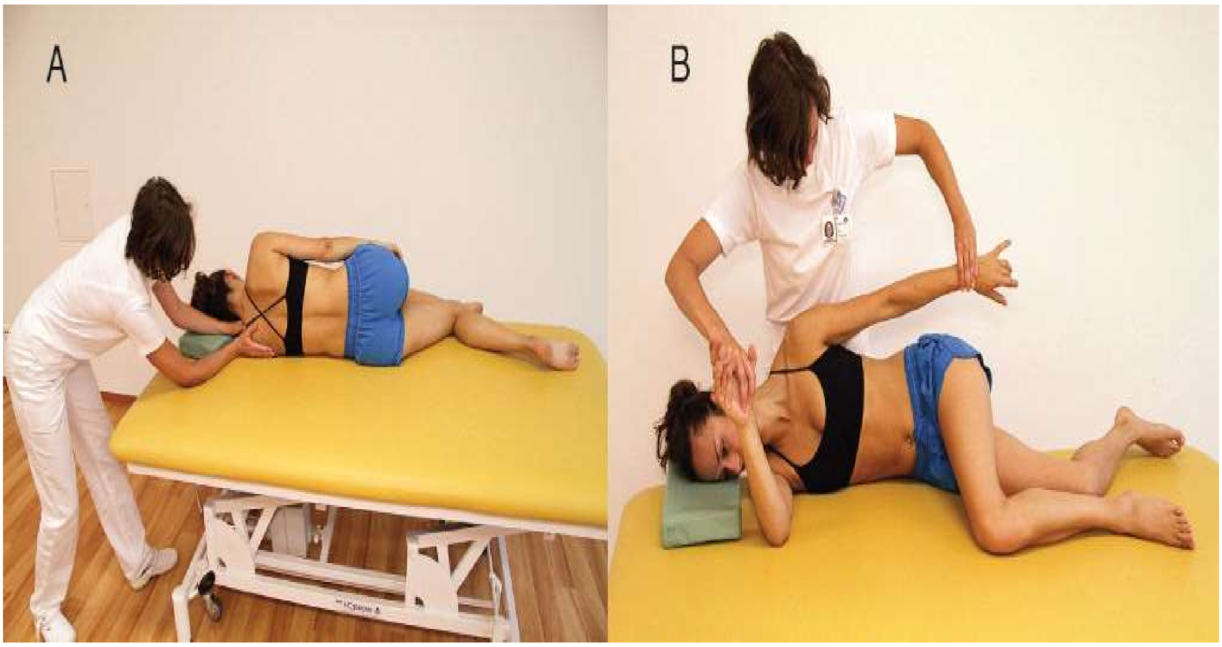

Figure 61.13 Exercise in side-lying position equivalent to 5 months of age: (**a**) the clinician facilitates a neutral position of the bottom supporting shoulder blade, which the patient then attempts to maintain by him/herself throughout the exercise; (**b**) the clinician resists

reaching movement of the patient’s top arm (forearm supination) and the supporting movement of the bottom arm (forearm pronation).

4. Supine position equivalent to 6 months of age (Figure 61.14)

Initial position: Supine, legs lifted, hands grasping the feet. If uncomfortable, patient's buttocks are supported with a towel.

Zones of support: Nuchal line, upper sections of the gluteal muscles, and thoracolumbar junction.

Instructions: Spine elongation, pulling shoulder blades caudally, breathing into the groin and dorsolateral sections of the abdominal wall.

Modification and progression: Shifting support from the gluteal region towards the thoracolumbar junction; trying to lift the pelvis and low back as one unit towards the ceiling; rolling the entire body from one side to the other side; bracing the entire core; exercising cervical flexion (deep neck flexor activation).

Figure 61.14 Exercise in supine position equivalent to 6 months of age. The clinician instructs the patient to lift the buttocks and lumbar spine, shifting support from the upper gluteal sections towards the thoracolumbar junction, while guiding the patient's breathing into the dorsolateral sections of the abdominal wall.

5. Side-sitting position equivalent to 8 months of age (Figure 61.15)

Initial position: Side-sitting, supporting hand is in line with the bottom greater trochanter, top leg in front of or behind the bottom leg, slight hip and knee flexion of the bottom leg.

Zones of support: bottom palm with weightbearing throughout the entire palm, bottom greater trochanter.

Instructions: Focusing on proportional support of the hand and weightbearing throughout the trochanter area, pulling the bottom shoulder blade caudally, elongating the spine, tucking in the chin, breathing into the groin and dorsolateral sections of the abdominal wall.

Modification and progression: Reaching with the top arm against band resistance; holding a weight in the top hand; moving forward towards quadruped position and back; resisting the clinician's unexpected perturbations.

Figure 61.15 Exercise in side-sitting position equivalent to 8 months of age. The clinician's

one hand assists the patient in maintaining a neutral chest position and guides proper breathing pattern, while the other hand resists the patient's reaching movement with the top arm.

6. Tripod position equivalent to 9 months of age (Figure 61.16)

Initial position: Modified kneeling.
Zones of support: Knee, ipsilateral hand, and contralateral foot.
Instructions: Focusing on proportional foot support, distributing the weight between the first and fifth metatarsophalangeal joints and the heel, focusing on proportional support through the hand, pulling both shoulder blades caudally, spine elongation, chin tuck, breathing into the groin and dorsolateral sections of the abdominal wall.
Modification and progression: Reaching with the free arm against band resistance; holding a weight in the free hand; moving forward (initiating movement up towards standing) and moving back towards side-sitting position. The range of movement can be small, only initiating the change in the position, but maintain proper core stabilization at all times.

Figure 61.16 Exercise in tripod position equivalent to 9 months of age. The clinician helps to centrate the knee, pushing through the knee towards the supporting foot and resisting the patient's reaching arm.

7. Squat position equivalent to 10 months of age (Figure 61.17)

Initial position: Unsupported squat or, initially, buttock support (upper gluteal sections leaning on the edge of a table), arms in front of trunk.
Zones of support: Centrated feet (and upper gluteal muscles).
Instructions: Focusing on centration of both feet, maintaining longitudinal arch on bilateral feet, weightbearing through the first and fifth metatarsophalangeal joints and the heel, keeping knees above the forefeet, spine elongation, pulling the shoulder blades caudally, breathing into the groin and dorsolateral sections of the abdominal wall.
Modification and progression: Arm movement against band resistance; holding heavy ball, moving the ball up and down and/or sideways; moving the body up and down several centimetres (moving between deeper and higher squat) while maintaining proper foot centration, knee position, and core bracing; squatting on a soft or unstable surface.

Figure 61.17 Exercise in squat position equivalent to 10 months of age. The clinician provides support and helps stabilize the patient's posture while guiding their breathing pattern. Gradually, the support may be removed and the patient may move lower to a deeper squat.

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