Postural -Locomotion Function in the Diagnosis and Treatment of Movement Disorders

Summary for the lecture

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Postural Development

Dynamic Neuromuscular Stabilization (DNS) is a new and unique rehabilitation strategy based on the principles of developmental kinesiology and neurophysiological aspects of the maturing postural-locomotor system. Unlike anatomical norms, functional norms such as posture, pattern of core stabilization or respiration are not uniformly defined. DNS derives ideal quality of these functional stereotypes from central programs maturing during early postural ontogenesis. Humans are immature at birth, both in function and morphology. After birth, development continues in both function and morphology and is completed at the age of 4 years when gross motor function reaches full maturity. The shape of the hip joint, plantar arch, and spinal curve in a newborn matures during the course of normal development. Motor development during infancy is automatic and depends on the optical orientation and emotional needs of the child. Postural development is genetically determined, and motor functions develop on an automatic, subconscious level. The morphological development of the skeleton as well as joint positions and posture greatly depends on the stabilizing function of the muscles necessary for resultant dynamic movement. Each joint has a well-determined movement as part of a motor stereotype. The anatomical structure determines the biomechanical ideal joint movement. Each position that a joint adopts is dynamically controlled by specific parts of muscles that stabilize the joint at any given time. The muscle function that is encoded by motor programs develops as the CNS matures. Disturbance of this equilibrium due to CNS lesions, pain, trauma, habitual patterns, or repetitive overuse often results in the etiology or perpetuation of musculoskeletal pain dysfunctions.

Sagittal core stabilization matures during the first 4 ½ months of life (Fig.1,2). The position and shape of the spine, chest and pelvis reaches a neutral position as a result of coordinated muscle activity. This phase is followed by the development of purposeful phasic or dynamic function of the extremities, i.e. stepping forward (or grasping and reaching) and supporting (or taking off) function. Stepping forward extremities work in an open kinetic chain whereas the supporting extremities work in a closed kinetic chain. In addition, locomotor function matures simultaneously in two stereotypes i.e. in an ipsilateral pattern (turning) and contralateral pattern (creeping or crawling). The ipsilateral pattern involves turning from a supine position, where the ipsilateral arm and leg are activated in a stepping forward (reaching) function while the arm and leg on the opposite side serve as a supporting and taking off function (Fig.3). The contralateral pattern (creeping, crawling) develops from a prone position in which the stepping forward and supporting function occur on opposite arms and legs (Fig.4). Both stepping forward and supporting functions are dependent on intrinsic stabilization, allowing for purposeful extremity movement. Stabilization function is achieved by the coordinated activity of antagonistic muscle groups. As such, the quality of torso stabilization is essential for any phasic (dynamic) movement since each movement is preceded with the stabilization of body segments to provide balance, efficient coordination and stability to its participating elements. All afferent information, including orofacial function is involved in the postural-locomotion complex. The eyes and tongue automatically turn towards the reaching arm. The precise balance between antagoinistic muscles during physiological early development results in functionally centered position (neutral) of all the joints. Ideal posture and ideal functional stereotypes occur hand in hand with CNS maturation. When the CNS is compromised either structurally or does not mature in an ideal manner, abnormal postural development is often demonstrated in abnormal or dysfunctional joint position, e.g. anterior pelvic tilt, forward drawn head position, "inspiratory" position of the chest, abnormal spinal curves, etc.

Fig.1,2: Ideal pattern of sagittal stabilization matures at the age of 4,5 months

Fig.3: Ipsilateral motor pattern
Left arm and left leg- stepping forward,
right arm and right leg supporting

Fig.4: Contralateral motor pattern
Right arm, left leg stepping forward (reaching)
right leg, left arm supporting

Reflex postural and locomotion model

The development of spinal, chest and pelvic stabilization along with stepping forward and supporting function of the extremities is a CNS program. This inborn motor program can be evoked automatically through the stimulation of reflex zones. These evoked postural-locomotion pattern corresponds to the motor programs observed in the course of physiological ontogenesis (CNS maturation). The CNS is facilitated via specifically directed pressure on certain defined stimulation zones. Subsequently, muscle coordination involved in bracing the core forms the foundation for locomotion (stepping forward and supporting) function of the extremities and orofacial system activation. Stimulation also evokes balanced interplay between muscles with antagonistic function, maintaining all the joints in a functionally centered position throughout the entire movement. The global reflex postural-locomotion patterns can be evoked consistently on everyone, illustrating the interdependency between biomechanical and neurophysiological principles (Fig.5). Postural muscle function observed during ontogenesis and reflex stimulation demonstrates ideal postural and locomotion models. DNS diagnosis is based on comparing the patient's stabilizing pattern with the stabilization developmental pattern of a healthy baby and/or with the patterns evoked by reflex stimulation. The treatment approach emphasizes the training of these ideal patterns as defined by developmental kinesiology. The brain must be properly stimulated and conditioned to automatically activate optimal movement patterns that are necessary for the co-activation of the stabilizers. The ultimate goal is to teach the brain to maintain central control and stability of the movement restored during therapy sessions. This can be accomplished by activation of the stabilizers when placing the patient in the primal developmental positions.

Fig.5: Ideal pattern of core stabilization evoked by reflex stimulation

Definition of DNS ideal posture

Posture is a composite alignment of all the joints of the body against gravity or any external force at any given moment in time. Posture is not a synonym of upright stance, but is an essential component of any movement in any position of the body. Postural activity precedes and accompanies any purposeful movement. **Postural stabilization** requires the coordination of all muscles stabilizing the segments against gravity and any external force. Postural stabilization goes hand-in-hand with CNS maturation and this is often established during the first 4 ½ months of life. Well balanced activity between deep neck flexors and spinal extensors stabilizes the cervical and upper thoracic region. Stability of the lower thoracic and lumbar region is dependent on the proportional activity between the diaphragm, pelvic floor, all sections of the abdominal wall and spinal extensors. The above muscles constitute the integrated stabilizing system of the spine, chest and pelvis. Postural stabilization is an automatic function and is not entirely under our voluntary control. Postural insufficiency of a single muscle (deep intersegmental spinal muscles, deep neck flexors, diaphragm, pelvic floor, postero-lateral sections of the abdominal wall or serratus anterior are especially fragile in their postural function) will compromise the entire stabilization chain, resulting in muscular dysfunction and **postural instability**. Postural stability (or instability) can be evaluated via specific postural tests.

During any purposeful movement, the origin of the activated muscle must be stabilized. This is ensured by **"punctum fixum"** = a term describing a chain of all the muscles involved in stabilization. E.g. psoas muscle is activated during hip flexion. Its attachment executes the movement in the hip ("**punctum mobile**"), while its origin must be stabilized via the interplay of a chain of other muscles. The movement stereotype of hip flexion will be efficient, economical and biomechanically ideal only if spine, chest and pelvis are properly stabilized. Thus, during hip flexion (Fig.6), not only are hip flexors activated, but it involves simultaneous feed-forward mechanism of co-activation of muscles involved in the integrated spinal stabilizing system. The diaphragm, pelvic floor, deep neck flexors, and all the sections of the abdominal wall, including posterolateral abdominal sections, are proportionally activated, thus increasing intra-abdominal pressure (IAP) which in turn, stabilizes the lower thoracic segments and lumbar spine from front (Fig.7). This activity is balanced by spinal extensors (primarily the deep intrinsic spinal extensors). In this way, the torso is fully braced and hip flexion can be carried out with all lumbar segments in neutral, functionally centered position. The complex involvement and coordination of stabilizing muscle activation during a movement is called **postural reactivity.** The thorax, abdomen, shoulder and pelvic girdles provide a firm and stable base for any movement. Stabilization is never an isolated event of a single muscle; it always involves a whole muscle chain, which runs as far as the supporting segment. Since the stabilizing function is integrated in every movement, internal forces resulting from stabilization muscle activity occur repeatedly and stereotypically. Should the internal forces produce abnormal load pressures in a particular segment, it is only a matter of time before morphological changes (osteophytes, arthrosis, disc degeneration etc) and concomitant pain will ensue, as a consequence of the repeated overstress. In short, insufficient, subsconsicous and automatic stabilization is often the cause of muscular and movement dysfunctions and its evaluation should be included in a clinical evaluation.

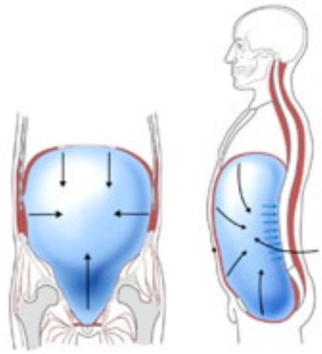


Fig.6: Postural activity precedes and accompanies any purposeful movement (ex/hip flexion)

Fig.7: Internal positive pressure creates functional strength and contributes to stability. Positive pressure is regulated by intra-abdominal pressure (IAP) which is generated and maintained by trunk and abdominal muscles

Pict. 6 Pict. 7

Postural abnormalities may result from the following conditions:

- anatomical abnormalities - genetic or acquired (e.g. hip joint anteversion, sacral dysplasia, any morphological changes due to trauma etc)
- neurological disturbances (e.g. cerebellar, vestibular, extrapyramidal etc)
- functional - disturbance of postural-stabilization muscle function

Primary reasons for functional postural disturbances

1. **Central coordination disturbance (CCD):** result of abnormal early postural development

Chronological development during the first year of life is often normal but the quality of postural function is not ideal. Although the baby is able to lift his head against gravity, turns, crawls etc. in his developmental age, the quality of the movement stereotypes is not ideal. A typical abnormal stereotype of head lifting in prone position during the first 3 months of life is inadequate arm support and excessive scapular adduction. The neck is often hyperextended with insufficient segmental movement in the mid-thoracic spine; the shoulder blades are elevated, shoulders are in protraction, and the pelvis is tilted anteriorly. Muscle coordination between serratus anterior, diaphragm and abdominal muscles is disturbed due to the lack of forearm support because of the position of elbows placed behind the shoulders. These babies will look like they have “wings” because of the prominence and protrusion of the scapulae (Fig.8). Another typical sign of CCD is fixed predilection: preferred head rotation to one side is physiological in the first 6 weeks of life after which, the head and neck becomes more neutral. However, in CCD, this predilection persists beyond 6 weeks. The motor stereotype of turning from supine to prone with hyperactivity of superficial spinal extensors due to insufficient oblique anterior muscle chains is another frequent abnormality (Fig.9). These abnormal postural patterns are then integrated all other ensuing motor stereotypes. Abnormal early development (CCD) is one of the most frequent etiologies of chronic back pain and movement disorders and can be recognized, even in adulthood (Fig.15). Typical morphological consequences are dysplastic short chest, diastasis recti, flat skull (due to long lasting head predilection), abnormal spinal curves, abnormal shape of lower ribs where the posterior angles are situated in front of the spine, etc.


Fig.8: Central coordination disturbance (CCD): Lack of arm support, C sine hyperextension, elevation of the shoulder blades, shoulder in protraction, laterodorsal sections of the abdominal wall insufficient in postural function, hyperactivity of superficial spinal extensors, the pelvis is tilted anteriorly
Fig.9: CCD: Abnormal stereotype of turning: hyperactivity of superficial spinal extensors due to insufficient oblique anterior muscle chains, lack of reciprocal movements of the extremities

2. **Habitual reasons:**

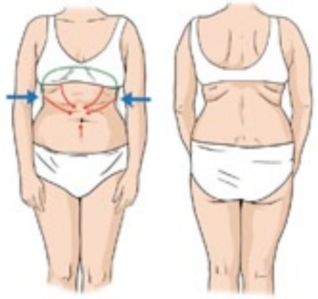
Poorly performed physical activity due to lack of proper training or repetitive movement stereotypes required for an occupation or sport may play a role in functional postural imbalances   Esthetic and cultural factors may influence the perpetuation of these postural imbalances e.g. females typically hollow the abdomen to look slimmer, wear high heels etc. Mentally challenging situations that may cause stress and especially chronic stress can also influence the limbic system, resulting in change of muscle tone distribution.

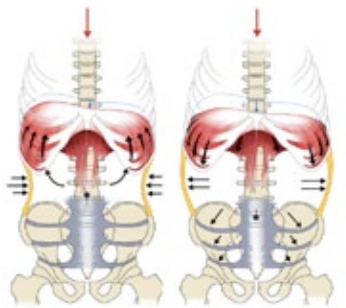
3. **Nociceptive reasons:**

Any pathological situation coupled with nociceptive irritation evokes the protective mechanisms in an effort to protect the structure from further damage. Changes in muscle function follow as a rule. Changes in muscle tone distribution may affect the whole muscle chain, single muscle or just few muscle fibers (trigger point).

DNS functional norms arising from developmental and reflex locomotion models
Stance and basic sagittal stabilization: Minimal muscle activity is necessary for normal standing posture. Any excessive isometric activity is a sign of abnormal posture, which is energy inefficient and may cause overloading on joint segments. To balance the stance most economically, proportional co-activation between anterior and posterior musculature is necessary. Activity of (mainly deep) spinal extensors must be balanced by the deep neck flexors and IAP regulators (diaphragm, abdominal and pelvic floor muscles) (Fig.7). This muscle coordination matures at the age of 4 ½ months (Fig.1,2) forming the foundation of any subsequent postural patterns (including stance and gait). Muscle hyper-tonus often appears in conjunction with energy inefficient stance as a compensation, and if sustained, may lead to overstress on certain segments causing pain and structural changes. In addition, these hypertonic and hyperactive muscles will also participate excessively during any other movements. When static disturbances becomes fixed in the CNS, patients often perceive such stance as natural. Hence, a postural exam is necessary. It is clinically useful to evaluate abdominal muscle tone distribution. Typical observed pathology is hyperacitvity of the upper abdominal sections with hollowing of the abdominal wall

as in the **"hour glass syndrome"** (Fig.10). Inversion (paradoxical) postural activity of the diaphragm follows as a rule. Physiologically, diaphragm fulfils a dual function - respiratory and postural functions. Under physiological conditions, the diaphragm descends caudally during any postural activities, i.e. the dome of the diaphragm flattens out while its centrum tendineum is stabilized in the caudal direction (Fig.11, right diagram). Contraction and flattening of the diaphragm should occur independently of breathing, i.e. during purely postural activities when the individual holds his/her breath. The flattening of the diaphragm presses on the internal organs which act as visco-elastic column, thus increasing IAP (Fig.7). Lower chest cavity and abdominal cavity widen. In the "hour glass" postures, the diaphragm descends and flattens significantly less and the centrum tendineum acts as a punctum fixum. The diaphragmatic attachments on the lower ribs are not stabilized well and are pulled towards the centrum tendineum, while the lower ribs are pulled cranially and intercostal spaces inward (Fig.11, left diagram). The diaphragm is not activated proportionally, its lumbar parts contract more then the rest. The superficial paraspinal muscles, especially in the T/L junction will compensate for insufficient postural diaphragmatic function. This postural dysfunction always goes hand in hand with abnormal respiratory stereotype.





Pict. 10 "hour glass syndrome"
Pict. 11:
left diagram: abnormal diaphragmatic and abdominal postural activity
right diagram: physiological postural activation

Basic postural stabilization and breathing stereotype form a functional unit and this is strongly influenced by the **chest position**. Physiologically, upper (scalenes, pectorales, SCM) and lower chest fixators (abdominals) work in balance, maintaining the chest in neutral position even during difficult postural tasks. The ventrodorsal axis connecting sternal and costophrenic diaphragmatic attachments should be almost horizontal (Fig.12). From a functional and biomechanical perspective, this is the most favorable chest position allowing for effective diaphragmatic contraction during any stabilization with or without simultaneous breathing. After the diaphragm flattens, abdominal muscles support its activity by eccentric or isometric contraction, the pelvic floor activates against the diaphragm and IAP increases - this establishes the stabilization phase. The intensity of contraction of these stabilizers and increase in IAP are dependent on demands from external forces. In the event of inadequate or disturbed postural muscle co-activation, excessive segmental loading and instability occurs. Compromised stabilization compounded by repetitive movements is most often the etiological factor of the patient's problems and anatomical ("degenerative") alterations.

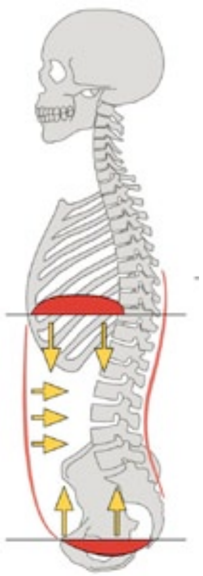


Fig. 12: Diagram of ideal postural stabilization, chest position and breathing stereotype

Ideal stereotype of breathing: During tidal breathing, auxiliary respiratory muscles should be silent. The upper ribs move in the frontal plane, the lower ribs move more in sagittal plane and their movement is more lateral. Vertebrocostal joints are free to rotate. Sternum is stable in horizontal plane, its lower part moves in AP direction. Rotational movement occurs at sternoclavicular joint. Clavicles are relatively still and do not move in cranio-caudal direction (Fig.13).

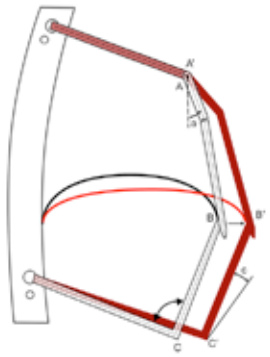


Fig. 13 - physiological stereotype of breathing

Frequent pathology associated with both stabilization and breathing is the **"inspiratory chest position"** with lack of movement in costovertebral joints, causing compensatory spinal movement during both breathing and postural activities. The spine extends with every inhalation and flexes with every exhalation causing an overuse of superficial paraspinal muscles. In addition, if the chest is rigid, then the rib cage is sustained in a cranial or "inspiratory" position.

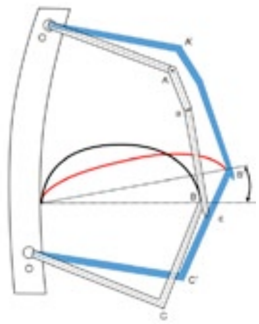
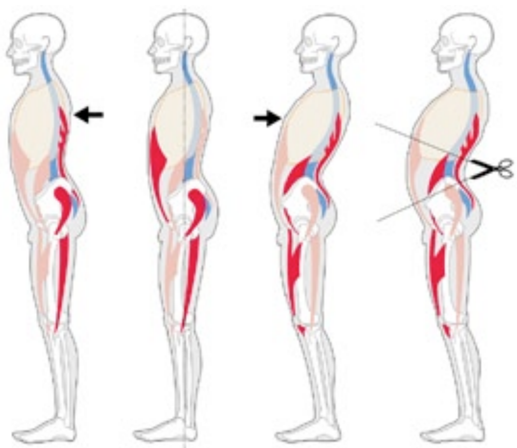


Fig. 14

Fig. 15

Fig. 14: Abnormal stereotype of breathing with cranio-caudal chest pathokinesis
Fig 15: Dysplastic chest (due to abnormal early development) in "inspiratory position", abnormal core stabilization with diastasis recti

Inspiratory chest position often occurs hand-in-hand with an anterior pelvic tilt. The axes of the chest and pelvis now become oblique instead of parallel. This crossing of these axes is called "**opening scissors syndrome**"(Fig.16d). For ideal stabilization and respiration, the chest must be stacked above the pelvis, with their axes almost horizontal and parallel to one another (Fig.12,16b). The forward drawn position of the chest (Fig. 16a) or apex of the T kyphosis situated behind the L/S junction (Fig.16c) present other abnormalities preventing ideal muscle balance and proper stabilization. Pelvic neutral position is also critical.



a **b** **c** **d**

Fig.16:
a) The forward drawn position of the chest
b) Ideal position between the chest and pelvis
c) the T kyphosis situated behind the L/S junction
d) "opening scissors syndrome"

Ideal pelvic position depends again on a balance between back extensors, diaphragm, pelvic floor and abdominal muscles regulating intra-abdominal and intra-pelvic pressure. Important also is balance among all the muscles attaching to pelvis. Anterior pelvic tilt is observed in a clinical picture of "opening scissors syndrome" (Fig.16d) with compensaotry mechanism of paravetebral muscles hypertonus. Posterior pelvic tilt is also not physiological, compromising stabilization of the low back and is often associated with lumbar kyphosis.

The position of the **shoulder blades** is another key link in stabilization. The medial edge of the scapulae should be parallel with the spine, with their angles adhering towards the rib cage. Retraction of the shoulder blades is frequently suggested as correct position, however it is not a neutral position . Excessive isometric activity of scapular adductors is uneconomical and overloads the spine. Predominance of the adductors over serratus anterior results in flat middle T-spine. External scapular rotation is another faulty position, resulting from dominance of the upper part of the trapezius, pectoralis major and shoulder adductors while lower scapular fixators especially serratus anterior are insufficient. Stabilizing activity of serratus anterior is very much dependent on chest position and coordination between the diaphragm and abdominal muscles which act as "punctum fixum" for serratus anterior.

In summary, many chronic pain patients demonstrate a compromised pattern of stabilization and abnormal initial chest, scapular and pelvic position. Evaluation of provoked postural activity (postural reactivity) helps in diagnosis. Kolar's approach to Dynamic Neuromuscular Stabilization (DNS) explains the importance of the above muscular interactions and their proper recruitment for dynamic stability of the spine and utilizes a series of systematic dynamic tests (Fig.17-22). DNS is a complex approach, encompassing principles of developmental kinesiology during the 1st year of human life, defining posture, breathing stereotype and functional joint centration from a "neurodevelopmental" paradigm. The treatment approach is based on reflex locomotion principles and ontogenetic postural locomotor patterns. The primary goal of this treatment approach is to optimize distribution of internal forces of the muscles acting on each segment of the spine and/or any other joint . Please see DNS workshop summary for more details.

Fig. 17-22: DNS **diagnosis** is based on **comparing** the patient's stabilizing pattern with the stabilization developmental pattern of a healthy baby. DNS trains ideal patterns as defined by developmental kinesiology

Workshop abstract

Kolar's approach to Dynamic Neuromuscular Stabilization (DNS) A Developmental Kinesiology Approach for Pain, Dysfunction and Optimal Performance

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Kolar's approach to Dynamic Neuromuscular Stabilization (DNS) is a complex approach that encompasses principles of developmental kinesiology during the 1st year of human life, and defining posture, breathing stereotype and functional joint centration from a "neurodevelopmental" paradigm (See summary: "Postural - Locomotion Function in the Diagnosis and Treatment of Movement Disorders" for details). DNS diagnosis is based on comparing the patient's stabilizing pattern with the stabilization developmental pattern of a healthy baby. The treatment approach is based on reflex locomotion principles and ontogenetic postural locomotor patterns. The primary goal of this treatment approach is to optimize distribution of internal forces of the muscles acting on each segment of the spine and/or any other joint.

Basic principles of DNS treatment techniques

1. The first step in treatment is to train basic intrinsic core stabilization i.e. activation of the integrated stabilizing system of the spine, chest and pelvis as well as to train proper respiratory pattern. Co-activation between deep neck flexors and extensors must be trained to adequately stabilize the C spine and upper T segments whilst the coordination between diaphragm, pelvic floor abdominal muscles and spinal extensors is necessary for lower T and L spine stability. Core stabilization is a prerequisite of any locomotion function. Abnormal stabilization compromises the quality of any dynamic movement.
2. Application of ontogenetic principles: quality of sagittal stabilization and respiratory stereotypes, ipsi and contralateral pattern of locomotion and supporting function of the extremities, functional joint centration, facilitation of muscle coordination via stimulation zones, resistance against anticipated stepping forward and supporting movement, integration of eyes, orofacial system and all afferent inputs within the postural-locomotion pattern.
3. Developmental postural-locomotion models are used to activate ideal muscle coordination and breathing stereotype. This can be achieved by positioning (and zone stimulation), where specific CNS programs are addressed and muscles are automatically activated in its postural function.
4. When training the stabilization function, one must respect that stabilization of any segment involves muscle chains which may involve muscle activity in distant areas from the area of focused stabilization. All supporting segments must be functionally centrated. Aproximation of girdle joints especially on supporting extremities is very strong facilitator of stabilization function.

5. Postural function must always correspond to phasic movement force. I.e. the strength which carries out the movement must not exceed the maximum stabilization strength. Otherwise faulty, substituting pattern will be trained.
6. Optimize dynamics of the trunk and mobilize the chest if stiff. Soft tissue mobilization is often required to train ideal stabilization and respiratory pattern.
7. Spine uprighting. Lack of segmental movement (frequently in middle T segments) often prevents ideal stabilization and respiration.
8. In active exercise (self-treatment techniques), progress from easier (lower, more stable) to more challenging (higher, unstable, exercise against resistance or external load) positions.
9. Refrain from using a position that a patient is unable to maintain or control. Exercising pathological pattern will reinforce patient's problems.
10. When the clinician guides the patient (manually, verbally) the patient must exercise with full attention and body awareness. The ultimate strategy is that he/she can activate the optimum patterns in self-treatment during ADL and sports activities.

DNS active exercise based on developmental positions automatically activates proper stereotype of stabilization and breathing:

3 months model 6 months 8 months

9 months developmental positions