

Importance of Developmental Kinesiology for Manual Medicine

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(Czech Journal of Rehabilitation and Physical Therapy)

Summary

Developmental kinesiology is the basis for all current treatment approaches for children suffering from neurological lesions. The genetically determined relationship between the sensory-motor systems occurs on multiple levels of the CNS. Although the exact neurophysiological relationship between the sensory and motor systems has not been clearly defined, it plays a crucial role during postural ontogenesis. Developmental kinesiology offers a new neurophysiological explanation of this relationship and its role in postural functions. Understanding the genetically determined functional synergies allows us to apply a new diagnostic and therapeutic approach that utilizes peripheral structures to achieve a reflex response of muscle activation and improved postural control.

Key words: developmental kinesiology, postural function, reflex locomotion

Developmental kinesiology is an essential part of physiotherapy, which can be used for children suffering from any neurological lesion. Most of the neurophysiological techniques used in physiotherapy do not make use of the genetically determined multi-level sensory-motor relationships, which are directly responsible for optimal postural ontogenesis.

In physiotherapy, motor patterns organized at the spinal or brain stem level are used quite frequently (the deep neck tonic reflexes, vestibular reflexes etc.). These sensory-motor connections are well defined as afferent inputs, which elicit a specific efferent reaction. For example it is common knowledge that afferent stimuli at the region of C1-C3 (head rotation) is processed as afferent information at the brain stem level, which then evokes the following reactions: the arm on the facial side of the head (the side that the head is turned towards) moves into shoulder internal rotation and adduction with scapular protraction, elbow extension, forearm pronation, with palmar and ulnar flexion of the hand. Similarly a very well defined reaction can be observed in the occipital arm and in both legs and trunk musculature. The brain stem is the highest level of reflex organization with well-established kinesiological reactions in response to specific afferent stimuli. These well-described reflexes at the spinal and brain stem level are used in both the diagnosis and treatment of individuals with movement dysfunction.

It is extremely important for diagnosis and treatment to also consider the higher levels of the CNS, which store motor programs essential for postural control. These programs are developed during normal postural ontogenesis. In these genetically inherited motor programs there is a very well-defined relationship between afferent stimuli and efferent reactions in the higher centers of the CNS, as in programs processed on the spinal and brain stem level. However, the kinesiological pathway of the efferent reactions is not well defined which may contribute to the lack of diagnostic tools and treatment procedures that make use of these reflex pathways. Although the exact neurological pathways are not well defined, it does not diminish the significance of their role in rehabilitation. Currently chiropractic and osteopathic methods use these reflex reactions, which can significantly improve treatment outcomes.

Postural functions from the sensory-motor point of view

In neurophysiology the kinesiological aspect of postural function is attributed to unconditioned reflex mechanisms at spinal and brain stem levels. Kinesiological postural function is usually defined as the normal reflex postural reactions that occur with a subject standing erect. The reflexes ensuring erect posture are then explained by mechanisms that control:

1. **Muscle tonus:** (again at spinal and brain stem level of control)
2. **Local static reactions:** “Standing reactions” controlled at the spinal level including tactile and proprioceptive (in interosseous muscles) receptors that are stimulated as the foot touches the floor. The reflex reaction results in increased tonus in the muscles of that foot, which then creates a point of support.
3. **Segmental static reactions:** Coordinated muscular activity of the two legs: A typical example is the crossed extension reflex.
4. **Global static reactions:**
 - a: tonic neck reflexes
 - b: tonic labyrinth reflexes
 - c: phasic labyrinth reflexes

It follows from the kinesiological course of postural development that we must broaden our point of view to include the special sensory-motor relationships, which come into play as the baby develops postural control and straightening of the spine occurs, usually between the 4th and 6th week of life. At this time the CNS centers responsible for maintaining posture against gravity become activated. It is obvious from analyzing the kinesiological course of postural function that the highest levels of the CNS are responsible for controlling body posture. The complex sensory motor interactions required for normal posture control cannot be at the spinal or brain stem level.

Automatic body posture control from the neurophysiological point of view

1. Inherited genetically determined CNS programs are crucial.

As the CNS matures automatic body postural control programs become activated. Postural activity and postural re-activity reflects the kinesiological development of the postural control programs and the maturity of the CNS.

If the position of the baby's body is changed passively, the whole locomotor system reacts to the change in position. This reaction is not haphazard but follows a specific pattern that is dependent on afferent stimuli resulting from the position change of the body and the new support zones created.

The body's reaction to a passive change of position (postural re-activity) and its kinesiological course depends on the developmental stage of postural activity. The motor reaction to the passive change of body position is a reflection of the exact maturity level of the balance, posture, and phasic functions the baby has reached. These functions develop during postural ontogenesis and are dependent on the maturation of sensory orientation mechanisms (visual, auditory, and tactile systems). As the child orients itself in space it triggers these CNS mechanisms, which automatically control body posture and movements (locomotion). Body posture changes can be seen at the age of 6 weeks when orientation first starts in the development of postural control. In this way motor programs become activated, resulting in a global motor pattern. It can be said that global motor

patterns are stored in the brain as “a finished matrix” which is composed of very well defined, highly differentiated muscular functions. The process of functional muscular differentiation in the course of postural ontogenesis can be illustrated by the pectoralis major muscle.

Example of functional muscle differentiation

At the neonatal stage, there is no support function of the extremities where the infant is unable to weight bear in any position. The baby holds his arms in protraction and internal rotation. The first event that must occur in order for the child to weight bear and straighten the trunk is retraction of the arms. This is accomplished by the long head of the triceps brachii. Activation of the external rotators occurs simultaneously with relaxation of the pectoralis major. From the 6th week of life, the baby automatically starts to move his arms into the sagittal plane and the first support on the elbows is established. When the body is supported on the elbows, the pull of the pectoralis major will be directed distally. During locomotion, if this muscle is activated on the support side, it will work against gravity, moving the trunk towards the fixed point (“punctum fixum”) in a ventral, dorsal or lateral direction. The pectoralis major thus works against gravity and at the same time allows stable posture during movement in cooperation with its antagonists. This function ensures good balance in the course of movement. This preprogrammed function of the pectoralis major against gravity comes into play when the shoulder angle is between 120 and 135 degrees of flexion. This can be observed in partial movement patterns throughout ontogenesis.

We know that the child who cannot flex his arm at the shoulder to more than 120 degrees when sitting (or in kneeling) cannot stand because the function of the pectoralis major against gravity has not yet matured enough to provide the global postural control necessary for standing.

The pectoralis major also works in as an integral part of reaching and grasping. The preprogrammed phasic function of the pectoralis major occurs in supine at the end of the first trimester and in prone during the second half of the second trimester. It is important for the grasping function of the arm for the fixed point (“punctum fixum”) to be located proximally and the moving point (“punctum mobile”) distally to allow the child to reach to manipulate objects.

The differentiated muscular function of the pectoralis major described above occurs in the course of postural ontogenesis in other muscles as well. Activation of one muscle during preprogrammed functions is always coordinated with the activity of other muscles. In this way exact coordination between individual muscles within the whole global movement pattern can be defined.

2. Automatic control of body posture depends on integration of many afferent stimuli:

Proprioceptive, interoceptive, and exteroceptive (tactile and telereception) afferent stimuli influence automatic postural control along with the spinal level reflexes. The spinal level integration of asymmetrical tonic neck reflexes (ATNR), symmetrical tonic neck reflexes (STNR) and vestibular reflexes are examples of some of the other afferent stimuli, which can also influence automatic control of body posture. The ATNR, STNR, vestibular reflexes and other spinal level reflexes are usually identified as the most important contributors to body posture control. However, the proprioceptive, interoceptive and exteroceptive stimuli resulting from momentary body posture also follows a kinesiology very well defined motor response, as the reflexes processed at spinal or brain stem level and should be considered of equal importance.

It is important to understand that every mechanical or nociceptive stimulus is processed at the highest levels of the CNS and is followed by a specific motor and postural response. Any afferent input will influence the total motor pattern. For example, if we tap the patellar tendon to evoke the patellar reflex, we activate muscle spindles resulting in contraction of the quadriceps femoris and movement of the knee into extension. At the same time, however, higher levels of the CNS are informed through ascending input, which also results in a specific change in posture. These postural reactions arising from higher CNS levels follow specific patterns as does the segmental reaction of the patellar reflex. All global postural reactions result from any afferent stimuli based on the initial position of the body and the region of the body acting as the support. Tapping the patellar ligament one time is of course too short of an afferent stimulus to elicit a total motor response, however, if the afferent stimulation is performed for a longer period of time, a noticeable motor response is evoked throughout the whole locomotor system. This can be seen in reflex locomotion according to Vojta i.e. where afferent stimulation at the nuchal line and medial epicondyle, after a certain period of time, produces a reaction throughout the whole locomotor system. All the muscles of the locomotor system are activated automatically, where the support zones become weight-bearing regions for the body. These specific zones of the body are essential for postural control and uprighting mechanisms from which all locomotion follows. If we stimulate zones in a prone or supine position, a different but predetermined motor response is evoked. Therefore, afferent inputs resulting from the actual body position and support zones are crucial for muscular function within postural reactivity. Knowing the exact kinesiological course of motor patterns, it is possible to predict the motor response to afferent stimuli from the position of the body and the regions of support.

Relationship between postural development and reflex locomotion

Kinesiological analysis of functional maturation of the muscles during postural ontogenesis shows that all such functions can be observed in the course of reflex locomotion described by Vojta. These motor patterns are comprised of all the partial motor patterns normally seen during postural development.

For example partial patterns of the whole global pattern of reflex turning can be observed in motor development as follows: lifting the legs above the table in the supine position at the age of 4 months, grasping over the mid line at 4.5 months, turning to the side at 5 months, turning from supine to prone position at 6 months, support on the elbow while lying on the side at 7 months, oblique sitting position at 8 months, crawling at 10 months and the first steps walking sideways at the age of 12 months.

These patterns reveal the genetically determined muscular interplay throughout the whole locomotor system, which works as one unit. The precisely defined phasic muscle function against gravity ensures that appropriate posture and balance is present throughout each phase of movement. Postural control is part of all phases of the movement and matures in the same manner as the partial patterns of motor development.

It is now clear that the pectoralis major cooperates within locomotor patterns with other muscles, which also have an antigravity function (subscapularis, short head of the biceps brachii, coracobrachialis), along with the back muscles, and with the muscles of the lower extremities. This well coordinated system throughout the entire body ensures both the stepping forward and the support function of the trunk and extremities.

During movement, posture is not achieved merely by the activity of the individual muscles or muscle groups, but by specific parts of the muscles, which are functionally connected at each stage of the movement to produce one functional unit. For example the

initial stage of stepping forward requires a combination of flexion, external rotation and abduction. The specific sections of the muscles that are activated simultaneously include the pectineus, the posterior aspect of the gluteus medius and minimus, the lower part of the gluteus maximus and the quadratus femoris acting as one functional unit. During the movement of stepping forward, the position at the hip joint changes requiring more muscle activity to ensure stabilization according to the anatomical orientation of the adductors, abductors and external rotators. The differentiated postural function of the muscles is active during all phases of the global patterns. Just as the function of the muscles of the leg are highly differentiated, so are the muscles of the homolateral arm, ensuring that postural control and phasic movements are coordinated together to produce a complete global movement pattern. Every stage of the complete pattern is connected with a particular functional unit to achieve the antigravity function of postural stabilization.

As the automatic control of posture matures during postural ontogenesis, differentiated functions of the muscles appear to serve specific functions. This differentiated function of the muscle is specifically linked to a certain position in the corresponding joint. This differentiated function not only occurs within one muscle, it occurs within the whole functional muscle group and functions throughout the entire range of movement in the corresponding segment.

If we want to understand the abnormal reflex changes which occur under pathological conditions, it is imperative to understand the kinesiological consequences mentioned above. Understanding the underlying kinesiological course of functional motor patterns will explain the sensory-motor responses resulting from nociceptive inputs.

Abnormal postural activity and re-actions

The kinesiological course of postural activity and re-actions depends on:

- 1. The momentary condition of the CNS:** If the CNS is not functioning normally, the postural program will change. Therefore, kinesiological analysis of postural activity and re-actions can be used to evaluate the CNS, allowing us to determine the stage of maturation or pathological development of the CNS at all stages of life, even in the newborn infant.
- 2. The type of afferent inputs:** Under local pathological conditions “adaptation” takes place as a part of the pre-programmed process of self-regulation, to inhibit nociception and to allow recovery to occur. As a result we often find reflex changes in muscular function, either hypertonus or hypotonus.

It is important to understand that reflex changes do not affect a muscle group as a whole, but are usually found only in one muscle of the group or even only in a certain part of the muscle. These reflex changes in function are called trigger points.

Afferent nociceptive stimuli also influence the pre-programmed postural functions, activating processes of adaptation which never affect only one segment. The entire posture will automatically be affected where the functional muscular interplay ensuring posture is changed. This adaptation is really a protective reaction which protects the segment against the pull of gravity through a purposeful changed postural program.

Due to the close relationship between muscles and joints, any reflex change will also affect joints as well as other tissues. Any afferent stimuli coming from the structures of a certain (lesioned) segment will be altered, which affects the whole postural program to produce a protective postural pattern. By affecting any structure of the segment (e.g. by treatment) we can reflexively influence all other structures in that segment.

Protective postural adaptation resulting from abnormal afferent input can be observed even during postural ontogenesis.

The whole principle can be illustrated by the following examples:

- If the baby has a pathological condition in one CC segment its body posture will be altered. The reactions of the whole locomotor system to this postural change will also be disturbed. Not only will the head react differently, but the spine, trunk and extremities will as well. These changed re-actions, i.e. the response to passive change in the baby's posture, are not part of the tonic neck reflexes (different postural model) but occur from higher levels of integration.
- Another frequent problem is the delayed development of the coordination between the two hands if there is any disturbance at the hip joint. Normally hand to hand coordination appears at the age of 8 weeks. If, however, there is abnormal posture at the hip joint, development of supination at the arms is also retarded. Supination is necessary for hand to hand coordination and will delay development if it is inadequate.
- Similarly a disturbed relationship between abnormal afferent inputs and postural re-actions can be observed in newborn babies. There are abnormal proprioceptive inputs from the area of the pelvic girdle which will change the postural re-actions. For example, the reaction to the traction test in the first days of life will be different where extension of the legs will be seen instead of the normal reaction of a newborn child (flexion and slight abduction). The same holds true for the test where the baby is suspended by the ankles. This abnormal reaction is not due to pathological development of the CNS but due to the change in proprioceptive input.
- Chronic respiratory disturbance is another illustration. Due to disturbed interoception, characteristic changes in posture and postural re-actions can be observed such as disturbed grasping of the hand.

Conclusions

Developmental kinesiology offers a new neurophysiological explanation of postural reactions. This neurophysiological concept allows us to understand local reflex changes as part of the whole system. This concept also explains local lesions as kinesiologically defined consequences of the problem, and not its cause.

Understanding such genetically determined functional synergies opens up a new diagnostic and therapeutic approach, where applying techniques to peripheral structures (manipulation, techniques altering skin and fascia etc..) can influence a whole global movement pattern to allow our clients to reach a higher level of function.

