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Ipsit Brahmachari

A Practical Guide to Hemiplegia Treatment



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CHAPTER

2

The Development of Nervous System

INTRODUCTION

The dynamic process of motor structuration in the early stages of infantile development appears to be essentially an interweaving of various patterns which appear and disappear and overlap with each other in their mutual interacting and modulating influence with an orderly integration in the developmental process.

In order to acquire the progressive refinement of selective motor behavior, the massive, gross functional units of reflex patterns have to be broken down into small polyvalent units available for reconstruction of other new patterns for the performance of normal movements (Milani Comperatti, 1994).

DEVELOPMENT OF MOVEMENT, POSTURE AND DEVELOPMENTAL NEUROLOGY

Movement, in its basic performance, is a series of primitive reflex activity. Learning of movements is "*entirely dependent on sensory experiences*."

Sensory input initiates and guides the motor output.

As the central nervous system (CNS) matures and unfolds, the normal child gradually changes, modifies, integrates, conditions and partially inhibits various statokinetic reflex activity to form automatic postural reflex mechanism for:

- Regulation of body tone
- Maintenance of balance
- Performance of skillful, coordinated, goal oriented movements.

The evolution of our erect posture, narrow base and freedom of upper extremities from the function of support to prehension, demands a fully developed and highly complex postural control mechanism (Bobath).

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Body tone: The smooth performance of the movement demands normal tones of the entire neuromuscular apparatus. Normal tone permits the movement to flow smoothly without interruption, the limb feels light and when placed in a position, it will momentarily hold before returning to its original resting place. The normal tone must be high enough to maintain us upright against gravity but not too high to impede the movement.

Reciprocal innervation and inhibition for the agonists to perform smooth flow of the movement, the antagonist groups instantly adapts and adjust to their increase in length.

The agonists, antagonists, synergists and fixators come into play in exact well-timed, coordinated order and in precise gradation of contractions for maintenance of balance, posture and movement performance, hence voluntary movements are performed totally against the background of the automatic postural adjustments which are beyond our conscious level and are under subcortical influence. The automatic postural sets precede the voluntary activity. Postural adjustments occur not only as a result of the sensory feedback in respect to unexpected perturbations but also as a result of feed forward in anticipation of expected stimuli which are self-generated perturbations. (For example, When an examiner is going to touch a painful area in the subject).

Voluntary movements have these components:

- Volition
- Purpose
- Awareness
- Effort.

Posture is movement arrested. It is the attitude adopted by the body at rest or in movement and is maintained by neuromuscular activity of muscle groups, for maintenance of balance and performance of various skillful functional movements.

Basic essential for good posture and midline alignment is the stability and mobility of the trunk, because the trunk is the basis for head control, limb functions. Head, neck and limbs are the extensions of the trunk. If one loses trunk control, head and limb movements are lost. The statokinetic patterns of posture interact and reinforce each other for:

- Weight bearing
- Maintenance of balance and equilibrium
- Postural adjustments into gravity: Postural adaptation to gravity and against gravity
- Head neck orientation and postural adjustment of the head to the shift of the body

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- Midline orientation: It is the point of references for movement over a base of support; one should be able to stabilize in midline
- To move away and back to midline and to cross over the midline.

Vestibular system plays a critical role in:

- Regulation of the body tone
- Accurate orientation of the body in space
- Development of visuospatial skills.

CNS Functions

Human brain is the most complex system generating both simple and complex behavioral patterns. *Brain is who we are, essence of humanity* (A. N. A 1998). GALEN centuries back stated in his writing, describing the brain to be *the seat of intelligence; movements and sensation.* WALSH (1948) stressed that the *CNS functions as a whole as the integrated sensory motor unit.*

Bobath (1970) said that *the CNS is an organ of reaction rather than action, reacting to various sensory stimuli converting upon it from within and without acting as "coordinating unit" to the multitude of incoming sensory stimuli to produce integrated motor responses adequate to the demands of the environment.*

In the modern day thinking, CNS is looked upon as *a system composed of billions of nerve cells which by virtues of their self-organization, integration, interaction and coordination form a neural network giving rise to how we think, act, decide, remember, perceive, learn, adapt and develop* (Scott Kelso, 1995).

Clinical and experimental evidence indicates that the cortex plays critical role in processing, execution and programming of the normal voluntary motor control on the basis of sensory input signals. Movements are reflex automatic and volitional.

In situation, when speed is paramount to trajectory and accuracy of the movement, the brain abstains from the feedback comparison of the actual with the desired action, like withdrawing finger from a hot burning object and these movements are executed at spinal or subcortical level.

Central nervous system is constantly seeking input for output, for it is continuously perceiving, intending, anticipating, learning and adapting to the environment to form and develop dynamic patterns of function and human behavior (Scott Kelso, 1995).

We are already living in the 21st century but, unfortunately there are therapists who are neglecting the input system and consider only the output of the CNS to improve the motor control or the joint ranges missing out on the CNS function.

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Perception signifies our ability to learn, adapt and adjust to the environment. It refers to the activity occurring in the secondary and tertiary sensory association areas of the parietal lobes, which integrates information such as memory, context and experience.

Perception is defined as the ability to interpret various incoming sensory messages so that sensation has meaning. Perception memory and language are described as cognitive skills and are integrated in higher centers in CNS. Affronter and Striker define perception as: "Understanding how the CNS transforms, analyzes, promptly organizes, integrates and structure the various sensory information received from the environment, there is a constant interaction between the individual and environment. Interaction means to be in touch with or contact with, to be in touch with is 'to feel'. In this 'Key Factor' we cannot decide, if we touch the environment or environment touches us."

Newborn baby, at the age of three months, first touches various objects and manipulates, this is through Tactokinesthetic channel. After that, the following develops:

- Eye objects contact through visual channel
- Turning his head in direction of sound through auditory channel.

As we are constantly in touch with one environment, the primary channel of learning is tactokinesthetic. Perceptual processes must have absolutely intact highly developed sensory feedback system. Minutest flaw causes disturbances in perceptual processes as is observed in CNS lesions. Voluntary movement is dependent on the perception of superficial, deep and proprioception sensation and motor power, coordination and tone. Grossly, functions of CNS are:

- Regulation and distribution of muscle tone throughout the body
- Maintenance of posture and balance at rest and in movement
- Orientation of body in space
- Inhibitory control over the undesired movements, to perform goal oriented, selective, skillful movements, reciprocal inhibition and innervation
- Inhibition of undesired movements or activity or overactivity is one of the most important roles of the CNS as a result of the ratio of the inhibitory fibers are far greater in CNS as compared to excitatory fibers in the subcortical and spinal pathways.

Kokte (1978) has stated that every new activity we learn, *"We are surrounded by wall of inhibition."* Inhibition is active at every level of CNS, at spinal levels, it manifests in larger synergic patterns of flexion and extension (flexor withdrawal, extensor thrust). At higher level, inhibition becomes more and more complex, leading to fractionation of the original primitive patterns for the performance of selective motor activity in various combination and skillful,

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prehensile motor activity. Inhibition is a balance of activity between inhibitory and excitatory fibers and plays important role in the gradation of the movement controlling range, speed and direction of the movement.

Bobath states, "I always think inhibition is a sculpting process, chisels away at the diffuse and rather amorphous mass of excitatory action and gives a more specific form to the neural performance at the every stage of synaptic relay. Removal of inhibition causes excitation by process that is called disinhibition."

The development of the nervous system from conception to maturity is a complex and fascinating process. Development is a concept which implies both growth and maturation. Growth is not just an increase in size, but the development of increasingly more complex interconnections within the brain. The nervous system arises from the neural plate which folds to form the neural tube about the 3rd to 4th week after conception (O' Reilly and Gardner, 1977). The development of a series of flexures then occurs with the different regions of the brain and cerebral hemispheres are visible as paired vesicles at the end of the 5th week.

At birth, the human brain is very well developed; a complex and relatively larger organ than any other animal. The relative size of the brain, 12% of the body mass, is also much larger than at maturity, when it is 2%.

NEONATAL REFLEXES

The neonatal reflexes are responses which can be reproduced readily after a particular stimulus. There are also a number of responses which are patterns of movement regularly seen in the newborn period but which are not elicited after every stimulus.

The neonatal reflexes must be looked at with some circumspection. They are present even in babies with severe abnormality of the brain or even absence of the cortex as in anencephaly. Abnormal reflexes, with asymmetry, or absent or persistent reflexes should be considered significant. Stereotyped responses are particularly significant (Touwen, 1976).

Moro Reflex

The best way to elicit reflex is by the 'head drop' method. The baby is held in supine supported behind the chest and head, the head is allowed to drop about 10°. The arms extend and then flex. The legs also extend and then flex.

The Moro reflex is fully developed in the term infant. It gradually disappears over the first 3–4 months of life, first in the legs, then in the arms.

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Absence of the Moro response may signify severe depression of the CNS or marked hypotonia. Persistence of the Moro, particularly an excessive response, occurs in the absence of inhibition. The Moro reflex is probably a vestibular response (Prechtl, 1956), although proprioceptive responses from the cervical vertebrae have also been considered as mediators of the response.

The Asymmetric Tonic Neck Response (ATNR)

A normal posture seen at rest, it may be imposed by the examiner turning the head, between 2 months and 4 months. A strongly imposable reflex after 6 months, or an obligatory response at any age, is the evidence of significant motor handicap.

Palmar Grasp

The infant should be supine with head in the midline; an index finger is placed in the palm of each hand and the palmar surface pressed. A normal response is strong sustained flexion of the fingers for several seconds.

Plantar Grasp

This can be elicited by stimulating the roof of the toes when active flexion will occur.

Rooting Reflex

While the infant supine, head in the midline, each corner of the mouth is stimulated by stroking laterally, the head turns, mouth open and grasps, the lips may curl to the stimulated side.

Sucking Reflex

The index finger is placed in the baby's mouth, pad up and the sucking action noted. A normal reaction is a sustained strong sucking action.

Walking Reflex

The baby is held in a standing position with the chin and head supported by one's fingers; a normal response is discernible steps with knee and hip flexion and a step on each side. The walking response is usually lost within 4 weeks or so of birth and supporting reactions of the legs do not reappear in the infant for several months. Passive extension of the head results in reinforcement of this reflex (Mac Keith, 1964).

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The asymmetric tonic neck response (ATNR) is a posture seen frequently in normal babies between 2 months and 5 months. The head is turned to the side, the arm and leg on that side are extended and on the opposite side, they are flexed. This is not an obligatory response except in an abnormal baby, when its persistence and reproducibility indicates pathology.

The disappearance of neonatal reflexes during development occurs as the nervous system matures and the neural mechanisms merge into more complex mechanisms. It is for this reason that infantile response reappears after serious brain damage or in degenerative conditions. It is also for this reason that the reflexes persist in babies who have sustained damage to the nervous system at birth. Although, plasticity in the CNS allows for remodeling of some of the damaged brain, the position of the damage is all-important in the final outcome.

Three types of neural mechanisms, as defined by Touwen (1976), can be distinguished:

1. Primary or basic neural mechanisms, e.g. for visual or acoustic perception and mechanisms for generating adequate muscle tone.
2. Mechanisms which merge into larger and more complex mechanisms or seemingly disappear completely to reappear in another form in a later stage of development, e.g. stepping movements and voluntary walking patterns.
3. Mechanisms which mature more or less independently and become linked together at a particular moment. This process results in differentiated motor patterns, e.g. the development of voluntary grasp ending with a pincer grasp and the development of independent sitting, standing and walking.

DISCUSSION OF DEVELOPMENTAL SEQUENCES AND ITS IMPORTANCE IN TREATMENT PLANNING OF THE PATIENT

Mature movements are complex permutations of the basic flexion and extension synergies. Until the patient can mix flexion and extension components of movements, only mass patterns can be produced. The ability to stabilize the trunk and proximal part of limbs while allowing distal parts to move is important where skilled activity is concerned and cerebellar activity is very important to this. Equally well, the ability to retain a fixed distal extremity while the proximal segments and trunk move over it is also essential. Much of the patient's development progress is related to the ability to produce these two varieties of movement, not only as distinct entities, but going on at the same time.

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The Mixture of Flexion and Extension Components

Example 1

When the sitting position is considered:
This requires extension of the vertebral column, but flexion of the hips and knees. If it is impossible to extend the column unless a total extension pattern is used, then the patient is unable to maintain a sitting position.

Example 2

When the lower limbs are considered in the walking synergies:
When the hip and knee flex, the lower limb also abducts and may laterally rotated and the foot dorsiflexes. However, to walk forward we require flexing the hip and knee while adducting the limb. This is followed by extending the knee while dorsiflexing the foot. Here, alone are some interesting synergies. The leg then prepares to take weight it extends at the knee and hip and abducts to prevent a Trendelenburg sign (drop of the pelvis on the nonweight-bearing side). Another mixture of synergy is when the abductors of the weight-bearing limb are working to prevent the pelvis from dropping on the nonweight-bearing side. When the abductors are not working, the pelvis drops into adduction on that side, causing a compensatory lurch of the trunk. This is called a Trendelenburg sign.

The push-off requires more extension of the hip, flexion of the knee and plantar flexion of the foot. This is a very complex series of synergies. The ability is not immediately available. The patient who has recently started walking, flexes and abducts his hip. Only later after proper training, does he keep it adducted as the leg comes forwards.

Proximal Fixation and Distal Freedom and Vice Versa

Example 1

A simple example may be seen when we consider someone in prone lying. When he is able to take weight on one elbow while manipulating an object with the other hand, he is demonstrating distal fixation of the supporting limb with the trunk free to move over it, while the free limb is moving distally against the proximal support of the steady trunk.

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Example 2

A more complex example of the same thing occurs with the much more mature pattern of writing. Here, the supporting arm is offering distal stability to the trunk which is free to move over it. The hand which is putting pen to paper is working freely with a more proximal area of stability in the forearm. However, the forearm must also be partly free to move for each word and so movement at the shoulder has to occur. The shoulder is functioning as a stable and mobile structure at one and the same time against the stable background of the trunk which, in turn, is free to move over the other, or supporting limb. This is a very complex synergy. Little wonder that we cannot write at birth!

Many learning processes depend upon the ability to move. We require movement to be able to explore our environment and unless this is possible, our mental processes cannot develop normally. Head control is essential to movement, but is also essential for the ability to make maximum use of the sense of sight. If we cannot control our head position, it is difficult to gain control over our eye activities. The eyes need to have a stable base from which to work. Eye movements are similar to limbs. They can remain stable while the head moves, or they can move while the head stays still, or the two activities may go on at once, none of this is possible if head control is absent. Assessment of spatial relationship depends upon movement. The relationship between hands and eyes depends upon the ability to move and explore, and the perception of depth, space, height, size and shape have all to be learned by experience dependent upon movements of different area of the body. Balance activities basically start by the balance of the head upon the shoulders in prone lying. Progression is then made by balancing the shoulders over the elbows which offers a forward support in prone lying. In sitting, the body is at first inclined forward so that head balance on the shoulders is still an extension activity and the arms are in a supporting forward position, but with extended elbows. Later, the ability to balance with the arms supporting sideways develops and much later the arms may support by being placed behind as when sitting in a backward leaning position. This requires flexor activity the head and neck to maintain the balance of the head on the shoulders. Before the patient is taught to sit with the backward support training for the rotator ability of the trunk should be done, as it is a precursor to more skillful balance activities. Proper balance is said to be gained when upper limbs can carry out skilled activities, while the legs and trunk are dealing with the maintenance of equilibrium. The development of motor skills is not complete until the hands can be used in prehensile activities and much work has been

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done by various authors on the developments of prehension. The hand activities are inclined to develop from ulnar to radial side. The grasp and release activities of the early stages in development appear to commence with activity of the little finger and radiate out towards the thumb. Gradually, the radial aspect of the hand becomes more dominant and eventually the pincer grasp between thumb and index finger develops while the ulnar side of the hand takes up a more stabilizing function. Much more mature is the 'dynamic tripod' posture described by Wynn Parry in 1966 and explained by Rosen Bloom and Horton (1971). Here the thumb, index and middle fingers are used as a threesome to give fine coordinate movements of the hand. The classic example of the use of this tripod is in writing although it may be seen in other functional activities.

The process of integrating certain reflex mechanisms involved in movement occurs over a period of time and eventually makes controlled purposeful movement possible. The control develops in a cephalocaudal direction. It is closely linked with perception of body image, intellectual and social behavior and, although it is not dependent upon environment factors, these may influence the rate at which perfection develops. Motor development starts with control of the head position in prone, with the upper limbs most able to take weight in a forward or elbow support position. Later development include rolling and supported sitting with the weight supported forwards on the hands at first, and later at the sides and even later behind. Body rotation begins to be perfected as rolling occurs and limb rotation follows trunk rotation as rule. Movements at first follow primitive patterns of synergy, but later the ability to combine flexion-extension patterns to give more complexity of movement should develop. Ultimate maturity of movement is reached when the hands are totally free from an obligation to balance mechanisms, so that they can be freely developed as skillful tools and used in conjunction with visual and other sensory feedback mechanisms.

The patient is always made to experience the normal movement patterns in the actual and factual environment before placing the demand on the developing brain so that the patient will know what exactly to expect while performing a certain task.

Example 3

To sit in a balanced manner, the patient needs to flex at the hips and extend at the trunk. He needs head control and the ability to support himself forwards on his hands. These are minimum requirement. He is prepared for this naturally by the early development of head control; the elbow and hand support prone

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position and by lying on his back working out on the trunk flexors. The therapist helps him by propping him into a sitting position so that he experiences it prior to achieving it. Help in this manner makes him experiment and he tries to balance when he is put into sitting and in fact learns to do so.

In the meantime, his rolling and rotatory activities are developing. The patient gradually develops the ability to get into sitting after he has learned to balance in that position.

THE CLINICAL VALUE OF KNOWLEDGE OF DEVELOPMENTAL SEQUENCE

When working with handicapped children, hemiplegic patients and, in particular, with the very young, it is easy to see that this information is exceedingly valuable. When treating babies with movement defects, it is important to start as early as possible and to bear in mind the normal sequence of development so that one can, as far as possible, channel the child's reactions along suitable lines and encourage step by step progress without leaving gaps which may lead to abnormality. The earlier the abnormal child is given help the more successful is the treatment likely to be. It is much more difficult to correct abnormal habits than it is to prevent them from occurring. The child's nervous system is very malleable and able to adapt very readily. Consequently, it can be most easily influenced before it is fully matured. It is a great mistake to wait until the child can consciously cooperate. By this time, irretrievable abnormalities will have developed. The skilled physiotherapist is able to exploit the knowledge of the nervous system to stimulate suitable responses in the childe long before he is aware of cooperating.

However, many physiotherapists deal only with adults or, at least the greater bulk of their patient load is adult. Where then does this knowledge have value? The answer is simply that injury or disease to the control nervous system frequently brings about demyelization of certain areas and may damage or destroy the nervous pathways which have been used to control certain activities. The patient frequently shows a regression of motor skills to a more primitive level. Certain of the reflex mechanisms, which have hitherto been integrated into mature movement patterns, may be partly released from cortical control and may exert an excessive influence over the patient, dominating these movement patterns into abnormality or even preventing them from occurring at all. The patient will frequently show absence or disturbance of normal equilibrium reactions, poverty of movement synergy, perception difficulties and diminution of sensory discrimination. If the physiotherapist is going to help the patient to make full use of such nervous connections as are left,

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he is more likely to be successful if he has knowledge of the way in which more skilled activities develop in the first place so that he can, to some extent, simulate the conditions to facilitate redevelopment. The following example illustrates this point.

A patient with neurological symptoms can often maintain a sitting position but, on attempting to stand, he pulls himself up by placing his hands on a rigid forward support or by pulling on a helper who is standing in from of him. Frequently, the head is flexed forward or, conversely, it may be thrown back so that the nose is pointing upward. In the first instance, the patient is using the symmetrical tonic neck reflex pattern to aid him into standing, and in the second, his legs are making use of the tonic labyrinthine effect. Neither of these is acceptable as the patterns are those of total reflex synergy, and balance in standing will never be achieved using these patterns. Such a patient has his movement excessively influenced by the tonic reflex mechanisms and requires training to modify them and to start early balance activities. He requires help in receiving weight on to his arms in a forward position. Such activities as elbow-support prone lying are suitable, progressing to hand-support forward side sitting, leading to prone kneeling and hand-support forward standing (standing but resting hands on a stool or low support in front of him). He needs to feel the sensation of weight being received forwards instead of pulling back. There are many other facets to this patient's problems which need attention, but the above example makes the point.

Many head injury case regress to an enormous degree and intellectual and social abilities regress also. Motor training along developmental lines is accompanied, in many cases, by a brightening of intellectual activities and the beginning of social communication. The patient may never achieve behavior patterns which are mature, but he is more likely to make balanced progress if a development approach is used.

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A Practical Guide to Hemiplegia Treatment

This book gives detailed description of etiology, symptomology, in-depth assessment and physiotherapeutic management of patient suffering from hemiplegia. This profusely illustrated compilation should become a quick reference practical guide for a practicing physiotherapist as well as it can serve students of physiotherapy through its detailed approach, by satisfying their curiosities. The main objective of this book is to facilitate recovery of the end user, that is, the patients.

Key Features

- New approach—this book deals with the treatment of patients with hemiplegia using various physiotherapeutic techniques. This book is specific for treatment of hemiplegia patients only. Various treatment approaches are compiled so a physiotherapist can integrate them and concentrate on specific treatment protocol
- User friendly, as this can act as a clinical guide for physiotherapists and as a quick reference guide for students
- Profusely illustrated with photographs of actual patients treated by the author and his team at his clinic, thus, it is a genuine guide
- Treatment techniques discussed are not new, but their relevance and practical aspects encountered while treating the patients are fresh. The author has tried to incorporate basics of pathophysiology of stroke and complete physical rehabilitation program infusing clinical experience of 17 years



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