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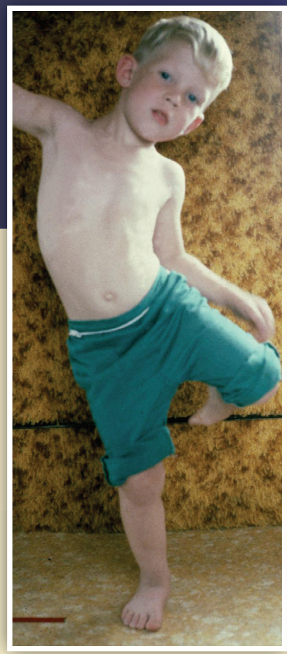


Movement and Posture Disorganization:

Clinical Observation of Posture and Developmental Aspects

By W. Michael Magrun, MS, OTR

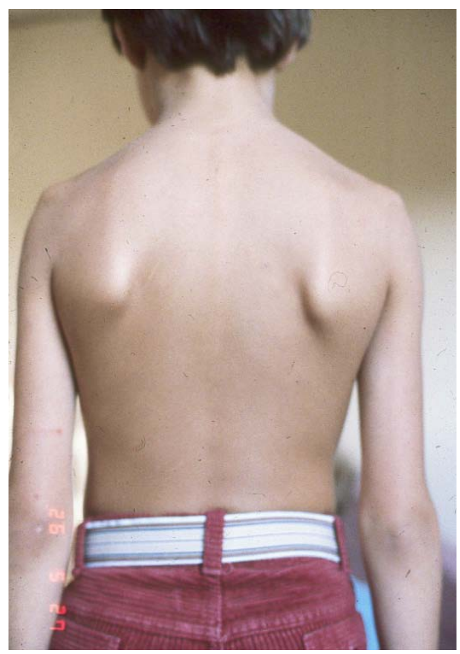
THE CLINICAL OBSERVATION OF POSTURE IN CHILDREN WITH LEARNING DISABILITIES

Key Concepts

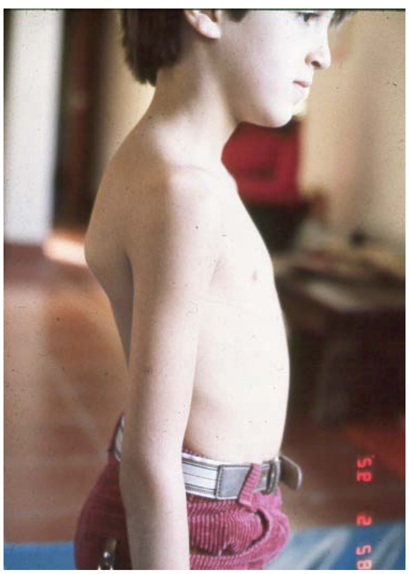
1. What are three basic consequences of postural asymmetry?
2. What is the probable result of unequal alignment of the shoulders on the neck and trunk?
3. What are the probable reason(s) for passive arm traction?
4. What is the influence of anterior pelvic tilt on the legs and feet?
5. Why is there anterior pelvic tilt in standing and posterior pelvic tilt in sitting?
6. What are 3 responses that are inhibited by a wide base of support?
7. What are the the postural and structural characteristics that may interfere with good hand function?
8. Why is it importat to correct the weight distribution on the feet?
9. What are the characteristics of somatic and vestibular dominance in one foot balance?
10. What is the influences of unequal proprioceptive tolerance between body sides.?
11. What are 3 reasons why children with disorganization tend to show stereotypic movements?
12. What are the basic postural characteristics seen in children with movement & posture disorganization?
13. Why is a neuro-postural base important as a prerequisite to sensory integration therapy?

Much can be learned through an initial observation of the child in standing. Almost always, the child with movement disorganization shows some basic postural mal-alignment of the body. In this case we can easily observe an imbalance in the alignment of the shoulders. The right shoulder is lower than the left and as a result the trunk is shortened on the right side. The neck is shortened on the left. The scapulae are slightly forward or protracted with the inferior angles tilted slightly up. The left scapula is higher than the right, with the mid-trunk flat and musculature appearing inactive.

This child shows a similar pattern of asymmetry, with the right shoulder lower than the left, the trunk shortened on the right side with the neck shortened on the left. The scapulae are protracted and the inferior angles of the scapulae protrude posteriorly out and up. Again the mid-trunk extensors and scapular adductors are relatively inactive.



Children with disorganization often show consistently similar characteristics in basic postural alignment. Here we again can observe imbalances in shoulder alignment, scapular protraction and protrusion, inactive mid-trunk extensors and abductors and shortening of the trunk and neck on opposite sides, corresponding to the alignment of the shoulders.



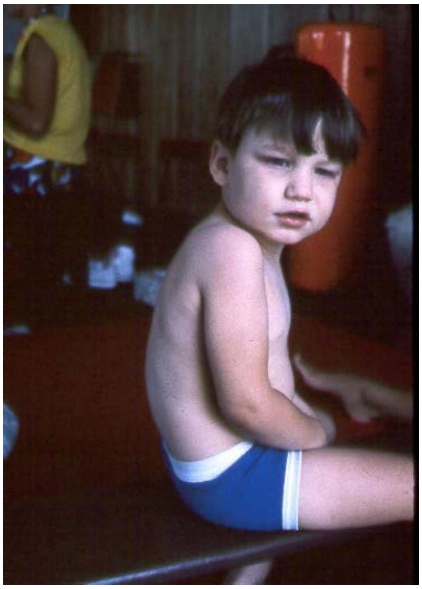
Lateral profiles also reveal the compensatory characteristics of mal-alignment. Here we see that the head and neck are forward. There is lumbar lordosis with compensatory anterior pelvic tilt due to abdominal inactivity. Again we see the scapula protracted with the inferior angle of the scapula tilted upward.

In this example we see similar characteristics of anterior pelvic tilt, lumbar lordosis, protraction and upward tilt of the scapula. Tightness in the thoracic area is probably a result of over use as a compensatory point of stability.

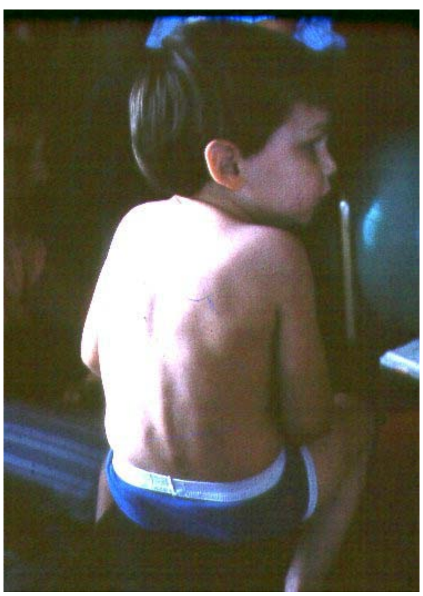
Here we see another example of the same postural characteristics. Notice the passive traction of the arms, which seem to hang in inactivity. This is usually due to the lack of good scapular alignment which compromises the stability of the shoulders and thus does not provide for dynamic alignment of the shoulders and arms.

Observations in Sitting

- Trunk Inactivity
- Posterior Pelvic Tilt
- Lack of Rotation of the Trunk
- Wide Base of Support



In sitting the compensatory result of the lack of active trunk stability is posterior pelvic tilt. In order to adjust the pelvis the trunk needs to have adequate extensor tone. Here we see a rounded back due to posterior pelvic tilt with protracted shoulders and shortening of the neck.



This posture inhibits good trunk rotation due to the position of the pelvis and shoulders. As a result the trunk cannot move on a stabile neutrally positioned pelvis with adequate extension and the shoulders cannot rotate with the trunk. The neck extends backward in an effort to turn the head as a compensation.

Children with postural disorganization often resort to a wide base of support, either in a W sitting posture or in a passive leaning to one side. Both situations are a result of a lack of good central trunk control. A wide base of support serves as compensatory stability but inhibits rotation of the trunk or ease of adaptive positioning during play.

Observations of the Hands

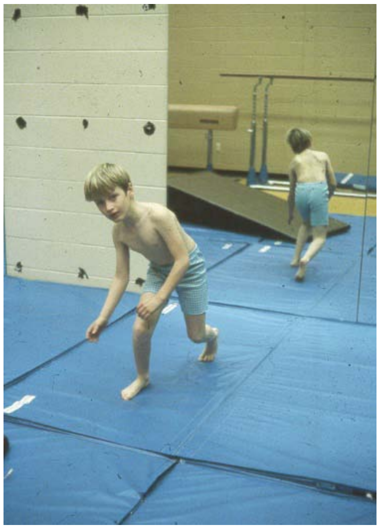
- Shoulder alignment and stability
- Structure of the hands
- Hand grip
- Proprioceptive placement.

Fine motor difficulties and writing problems are common in children with movement and posture disorganization. This is due in part to the postural elements previously discussed as well as the development of the structure of the hand itself. Good dexterity and manipulation requires interplay between the wrist and the fingers. The wrist and fingers function as a unit and the lack of stabilization of the wrist will compromise abduction of the thumb, arching of the hands and isolation of finger movements. Children often compensate for poor wrist stability by flexing the wrist. The wrist must be able to stabilize in extension for proper hand function.

Again we can observe the result of unequal weight distribution. As the child bends to retrieve an object, his left side does not accept a simple weight shift. As a result he internally rotates his left leg, hyperextends his left knee for stability and uses his left arm as a counter weight. Each attempt shows a compensatory variation, due to the inability to organize weight shift and maintain weight on both body sides properly.

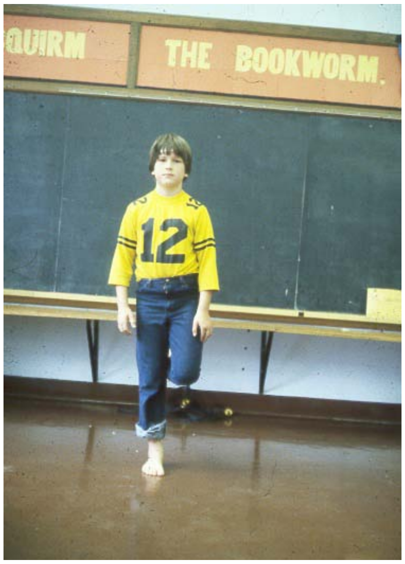
As he stands he does not adequately diagonally transfer his weight. His trunk remains flexed, his shoulder remains dropped and due to the internal rotation of his right leg he is unable to align his right side while standing. The pattern is disorganized and poorly coordinated as his weight is transferred to his less normalized side.

Another example of the influence of unequal weight distribution on movement can be seen in alternating one foot kneel to standing. Here we observe that the child is able to maintain his weight in good alignment on his left side. His right shoulder however is dropped, his trunk is shortened on the right and his right leg is slightly internally rotated with his foot not positioned optimally for standing. This indicates the possibility of more disorganization on his right side.



As he stands he does not adequately diagonally transfer his weight. His trunk remains flexed, his shoulder remains dropped and due to the internal rotation of his right leg he is unable to align his right side while standing. The pattern is disorganized and poorly coordinated as his weight is transferred to his less normalized side.

When he assumes one foot kneel on his right side, his alignment is not as optimal, as one would expect from his less normalized side. The poor alignment influences the position of his more organized side as well. However when he stands, shifting his weight to his more normalized weight bearing side, he is able to make a more organized adaptation.



It is not uncommon to see a somatic-dominant response on one side and a vestibular-dominant response on the other. Although the somatic reliance is subtle in this case, this child does hold his raised leg to his standing leg and assists stability with his left hand on his raised leg. These types of responses reflect an inability to integrate vestibular and somatic proprioception. Without organized matching of these systems, balance is compromised.

Organized and controlled motor learning requires organized sensory-motor systems. Children with co-ordination difficulties have specific characteristics of postural and movement adaptation that contribute to disorganized motor learning and influence efficiency in motor co-ordination, hand function, handwriting and other areas of learning.

Functional vision is another area often overlooked in children with learning disability. Children may have been given a standard eye chart exam and glasses for near or farsightedness, however, often times they are not carefully examined for functional vision skills. Whereas "sight" refers to the ability of the eye to receive light, functional vision refers to the motoric process of how the eyes work together to maintain binocular focus to be able to identify objects as well as use ambient vision for spatial-temporal awareness. A functional vision exam, should be performed by a qualified functional optometrist who can not only evaluate basic eye health, refractive error and acuity, and also can determine how the child uses his eyes at various distances, whether there is any indication of suppression, how the eyes are able to accommodate and whether there is efficiency in rapid changes of focus are varying distances. These among other skills are essential for learning and go far beyond simple acuity.

Basic functional vision skills include visual regard, fixations, saccades or tracking, pursuits, rotational movements, convergence-divergence and binocular function. All of these skills need to be addressed if the child is to perform optimally in learning. Raquel

Benabib, M.S. has developed an excellent functional vision screening tool and a "Goal-Oriented Curriculum to Establish Functional Vision Skills In The Clinic And Classroom." She has identified four categories of functional vision efficiency that are well defined and can be easily screened. The success of any vision therapy program is in properly identifying specific efficiencies and inefficiencies and using appropriate vision therapy activities to develop better functional binocularity. Functional vision will be the subject of additional courses in this series on learning disabilities.

Here we see the result of mal-alignment of the eyes as this child attempts to converge. His left eyes turns in, which is a clear indicator that binocular fusion is compromised. This has a great influence on reading skills and maintaining focus at near distance.

Notice the inability of this child to converge on the bead in front of him. His eyes move in and up and indicates he cannot smoothly control the motoric demands of maintaining binocular focus.

Monocular tracking is also important to establish. In this example the child is unable to maintain his head in mid-line as he tries to follow the moving object.

These are but a few examples of visual function difficulties experienced by children with learning disabilities. The area of functional vision is essential to address and to actively treat through vision therapy in children with learning problems.

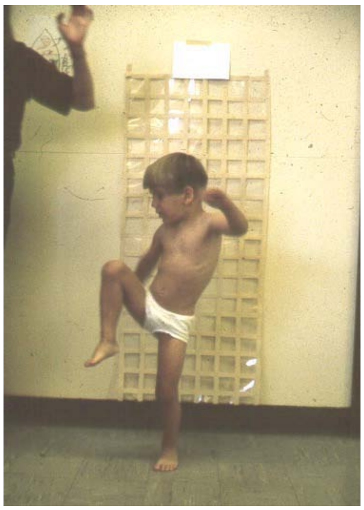
Establishing a neuropostural base is a good step in organizing functional vision potential. The eyes need a stable reference point in space and therefore establishing a good midline orientation, alignment of the head-neck and trunk are essential. Improving the child’s neuropostural base may have an impact on how the eyes move and can improve ocular motility and alignment. However direct and specific intervention is necessary on a vision therapy level to train efficient visual behaviors and correct mal-alignments of the eyes and the ability of the eyes to work together smoothly.

Treatment Emphasis

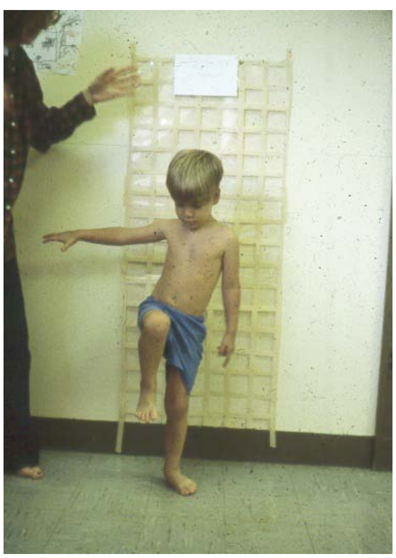
The treatment emphasis for these children should be the establishment of a normalized neuropostural base. Specifically the establishment of normal body alignment in various positions, equal distribution of weight and tolerance for weight bearing on both body sides and ease in transferring weight from one side to the other. Central to these needs is the establishment of good proximal stability of the shoulders and pelvis, an active trunk for central stability and activation of the abdominal musculature and activation of the musculature around the scapulae. Much of the activation required to establish better postural tone can be accomplished through establishing proper body alignment and the facilitating movement and postural adaptation through functional activities. Muscular areas are automatically activated when movements are carried out from a proper base of support with proper alignment. Only under these circumstances can agonist and antagonist relationships properly function to provide the mobile-stability needed to perform smooth and graded motor activity. Often major changes in a child’s posture and movement can be accomplished in a relatively short period of intensive treatment. The following two children are examples of the change that can be achieved in a two week period of daily treatment. Treatment addresses the specific areas of disorganization that are determined through clinical assessment. Establishing equal distribution of weight, graded weight-shifts, normalized body alignment and postural adaptation to movement through organized rotational components is an essential prerequisite for developing efficiency in motor performance. Additional aspects of assessment of movement disorganization and specific treatment approaches are the topics of additional texts in this program. Treatment must emphasize organizing alignment and adaptability in movements over the base of support. Physical handling requires clear understanding and expertise in facilitating postural reactions that will integrate posture and movement to be more efficient.

These are just a few examples of the type of physical treatment that is required to establish a neuropostural base. Specific on-line courses will deal in depth with treatment activities and clinical problem solving for determining physical handling treatment. Hopefully it is obvious by the video clips of postural movement problems and sample treatment clips, that without a well established neuropostural base the child cannot easily make efficient and integrating adaptive motor responses to sensory integration activities.

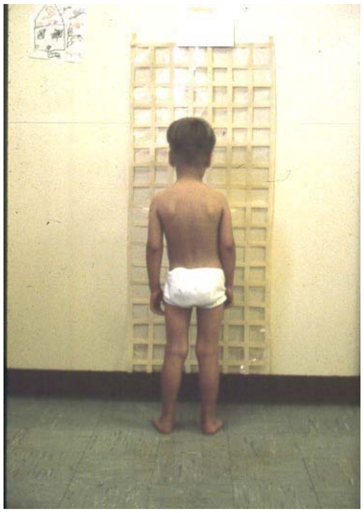
Before and After Results of Intensive Short Term Treatment

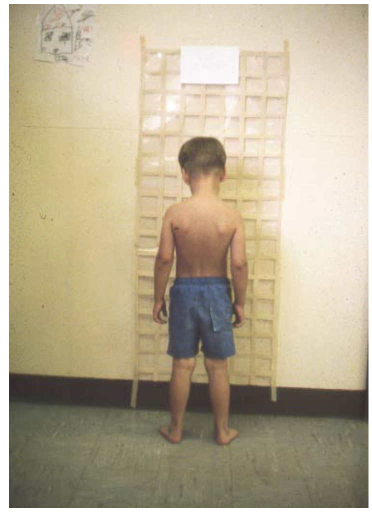


In this example we can observe this boy attempting to balance on one foot. He is unable to grade his weight shift over the standing leg, and therefore cannot control proper alignment on the weight bearing side. As a result he experiences an exaggerated equilibrium reaction.



After 9 hours of neuropostural treatment his balance attempt is much more normalized. He has good alignment over the weight bearing side, and as a result is able to grade his weight shift and allow controlled elevation of the other leg.





Here we see the before and after standing alignment. Before treatment (on the left) we observe mal-alignment of the shoulders over the hips. The trunk is shortened on the left side and the right shoulder is lower than the right. The left leg is internally rotated and the neck is not elongated. After 9 hours of treatment (on the right) we see that this child's alignment is improved with his shoulders more aligned over his hips, his neck elongated and his scapulae more even. His pelvis is more aligned and there is no internal rotation of his left leg.

In this example we can again appreciate that this child is unable to align his weight bearing side. He must use his elevated leg for postural security and his arms posture in extension as a counter balance.

After 5 hours of treatment he demonstrates good alignment of the weight bearing side and the ability to easily control the elevated leg away from his standing leg. His arms no longer need to posture for stability.

Standing posture before treatment shows legs touching, knee hyperextension, left shoulder lower than the right and his pelvis not aligned well with his trunk.

After 10 hours of treatment, his legs are separated with knees relaxed with more equal weight distribution on both body sides. His shoulders are aligned over his hips and his pelvis is aligned under his trunk. His legs no longer touch for compensatory stability.

Neuropostural treatment requires physical handling to establish equal weight bearing on both body sides, graded weight transfer from one side to the other, activation of rotational patterns and smooth transitions through an established midline of the body.

Hopefully it is clear that movement and posture disorganization is a consequence of various postural characteristics that interfere with smooth motor performance. And equally important to understand s that before children are confronted with movement and sensory challenges such as are used in Sensory Integration Therapy, it s essential to establish a normalized neuropostural base from which the child can make postural adaptations and organized adaptive responses. Without this preliminary emphasis on postural control, the child is likely to become more disorganized or strengthen his already inefficient compensations to the demands of motor challenges.

Prior to sensory integration therapy activities it is essential to establish a normalized neuropostural base. In so doing, it is possible for the child to initiate adaptive postural responses to the challenges of sensory integration activities. Without the ability to make an efficient postural adaptation, the child will use compensatory patterns to accomplish the activity and therefore will reinforce inefficient compensatory adaptations.

This program has demonstrated the postural compensations often seen in children with movement and posture disorganization associated with learning disabilities. These clinical characteristics of postural compensations have critical relationships with the ability to activate, initiate and grade controlled movement and skilled motor function.

Short-term intensive treatment over a two-week period can be effective in reestablishing a neuropostural base that allows more organized motor function.

Summary

1. What are three basic consequences of postural asymmetry?

Postural asymmetry influences motor control. Compensations to normal weight distribution influence normal body alignment of the head, neck, shoulders, pelvis and the base of support. It influences the distribution of postural tone that is critical to anticipatory initiation of controlled motor responses to the dynamic organization of movement. It influences the ability of the body to accept sustained proprioceptive tolerance to both body sides equally and therefore the graded control of weight shift required for transitional movements.

2. What are the probable results of unequal alignment of the shoulders on the neck and trunk?

Unequal alignment of the shoulders is a result of poor central trunk stability. When one shoulder is aligned lower than the other, there is a compensatory alignment of the trunk. The trunk is shortened, usually on the same side as the lowered shoulder. The neck is usually shortened on the opposite side of the lowered shoulder. This influences the ability of the neck to elongate and maintain good vertical head-trunk alignment. Often times the pelvis compensates with lateral excursion to the opposite side of the lower shoulder.

Figure 22
Early activation of posterior pelvic tilt With lifting of the legs in flexion.

Two month old normal infant has the ability to begin to elongate the neck, maintain visual gaze, depress the shoulder girdle with elevation of the knees with the activation of posterior pelvic tilt.

Figure 23
Early dissociation of upper and lower body.

This infant demonstrates dissociation of upper and lower body. Elevation of the knees with posterior pelvic tilt and symmetry of the lower extremities is present while at the same time rotating the upper trunk without any distortion or compensatory posturing.

During this same time the normal infant bridges in supine with the pelvis anteriorly postured. This provides additional tension on the shoulders to functionally help establish stability of the shoulder girdle and neck. Remember "Weight equals Structure equals Function." This normal experience is in stark contrast to that of pushing into gravity illustrated in figures 19-21.

Figure 25a

Figure 25b

Early posturing resulting in using the feet to push up and arch.

Normal bridging involves the entire body in an active state, providing proprioceptive input into the feet, into the neck, and into the shoulders and pelvis.

The important concept here is that this experience of posterior pelvic control and anterior pelvic control develops the ability for the pelvis to establish "mobile-stability." Mobile-stability is a term that was used by Quinton (8) as a way of understanding the functional consequence of stability first and then movement expression superimposed on that stability to allow function to be initiated from a stable base of control. This results in the future ability for the pelvis to maintain a midline orientation or neutral control with graded postural adaptations into and out of anterior and posterior postures which are important to activate the abdominals and support a variety of movement adaptations of the trunk.

Although the child with developmental delay or low postural tone may prefer supine because it offers less challenge against gravity, their passive experiences in that position, as has been previously described, do not assist them in developing an active ability to flex forward against gravity. This is important because it helps to establish abdominal strength and activity, the ability to elongate the neck and develop neck-shoulder synergies, as well as coordination with the pelvis and lower extremities for a dynamic posture. The ability to assume and maintain dynamic postures provides the stability for mobility. In other words, dissociation of the body into a variety of functional synergies cannot take place on a passive and inactive postural base. The importance then of the ability to assume postures such as supine flexion or prone extension is not so much that it is a milestone accomplishment or some demonstration of reflex integration, but that they demonstrate a dynamic postural set that can allow dissociation, synergistic movement components, and an infinite variety of organized sensorimotor learning experiences.

What might be the consequence later on in development for a child who did not experience quality in supine experiences? A number of postural characteristics observed in children with movement and posture disorganization relate to a lack of these early experiences in supine. They include a lack of good control in supine flexion, lumbar hyperextension with anterior locking of the pelvis in standing, passive posterior tilt of the pelvis with rounding of the back in sitting, and difficulty in organizing and sustaining lateral weight shifts equally well to both sides.

Children who do not develop good supine skills often show head lag in movement attempts requiring antigravity flexion. Poor prone development also contributes to this phenomenon as previously described. Good neck control and stability is critical for initiating most all movement patterns, not only in initiating body reactions but in organizing head on body responses, visual pursuits, and maintenance of gaze etc. Poor supine flexion experience is demonstrated in older children when asking them to stand up from supine.

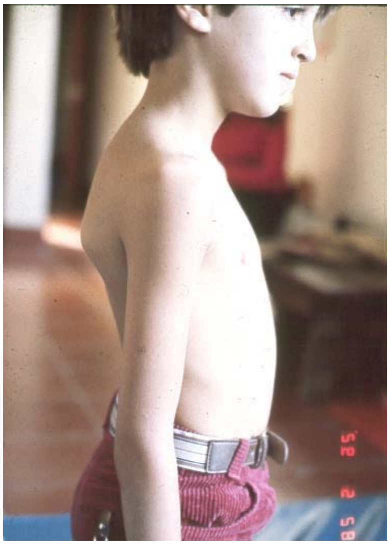
Figure 26
Inability to assume supine flexion due to lack of neck stability.

Figure 27
Example of normal supine flexion.

The 8-year-old boy (upper left) demonstrates an inability to initiate a flexor response primarily because he is unable to elongate his neck and provide stability for the head to come forward to initiate abdominal flexion. As a result his head drops back with neck hyperextension and his lower extremities struggle to elevate of the surface. The 9 –year-old girl (upper right) demonstrates a controlled response lead by the neck and head and is able to initiate and maintain a supine flexion posture. Notice the chin position indicating "chin tuck" which is possible only with neck elongation and stability to allow capital flexion of the head.

Another observation in children with movement and postural disorganization is a locking into anterior pelvic tilt in standing or posterior pelvic tilt in sitting. It is reasonable to assume that inadequate early supine experiences contribute to this inability to maintain mobile-stability of the pelvis later on. In addition the lack of mobile-stability of the pelvis influences the trunk and rotational patterns.

The ability of the infant to posteriorly tilt the pelvis in supine as seen in figures 23 & 24 allows the legs to elevate off the surface and together with abdominal flexion and neck elongation the baby is easily able to maintain this posture wile they play with their feet or a toy in midline. Bridging as seen in Figure 25 provides experience in anterior pelvic tilt to support extension during the bridging activity. Therefore the baby begins to experience a controlled range of anterior and posterior tilting of the pelvis. This dynamic process is necessary later on to allow for grading flexion and extension of the trunk and lower extremities. A lack of development of midrange control of pelvic tilt contributes to a "locking or fixing" of the pelvis as a compensatory stability point in older children.

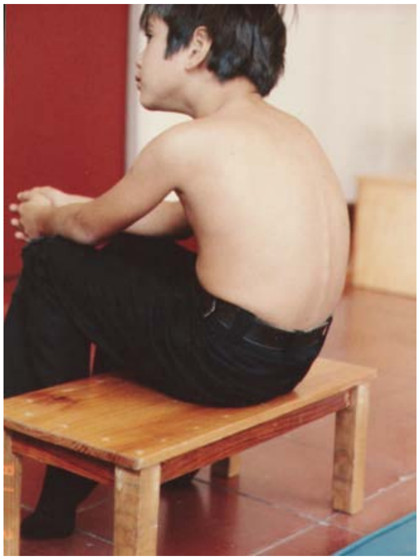


Here we can observe a child with lumbar lordosis with the pelvis in anterior tilt. In addition the knees are often hyperextended. This is a very static posture and one that does not allow smooth transitions to other dynamic movements without a complete release of the stability fixation, which generally leads to another compensatory fixation.

Figure 28
Example of lumbar lordosis with anterior pelvic tilt.

Here we observe a similar posture that shows anterior locking of the pelvis with lumbar lordosis, and hyperextension of the knees. This is a static posture that is compensatory for a lack of good midrange control of the pelvis and active trunk extension through the thorax.

Figure 29
Example of anterior pelvic tilt, lumbar lordosis and hyperextension of the knees



Here we see posterior tilt in sitting that does not allow for a dynamic trunk and therefore a static compensatory posture using the pelvis as a stability point.

Figure 30
Example of trunk compensation due to posterior pelvic tilt.

At about four months the normal infant begins to roll in a total pattern and then refines that into a rotational pattern later in development. “Log-rolling” as it is sometimes called is initiated through a lateral shifting of weight over the center of gravity, often initiated by turning of the head due to visual interest. This experience results from the baby’s spontaneous movements that allow weight to be distributed in various degrees laterally. This is a culmination of earlier experiences in prone and supine from physiological flexion which displaces weight forward into the cervical area, to lifting and turning the head in prone which displaces weight laterally, to asymmetry in supine (ATNR) which displaces weight toward the flexed arm side and provides lateral compression of the neck musculature, to the elevation of the pelvis in supine through posterior tilt that displaces weight both forward and laterally through the action of the legs. The normal infant is able to roll to either side in supine and can soon thereafter roll from prone to supine using emerging rotational components.

Figure 31

Figure 32

Log rolling initiated by visual interest.

This 4-month-old visually engages a toy and manages to distribute enough weight laterally to cause a rolling toward the toy.

Conclusion

Throughout development one tenant is consistent. Where the weight goes structure develops and function emerges. This function can be efficient or inefficient. Function is a consequence of the structural development of the body. Weight bearing and proprioceptive stresses against gravity result in structural development. Structural development results in functional skill. This musculoskeletal matrix is the basis for the foundation of function and the ability to demonstrate skill. This matrix is dependent on an organized visual, vestibular, and proprioceptive process and the efficiency of this process is dependent on normal alignment, normal distribution of weight and the ability to grade weight shift, thus coming full circle to the concept of weight-structure-function.

Any developmental anomaly to alignment, distribution of tone and the distribution of weight results in a lack of stabile proximal control, central trunk instability and a lack of quality dissociation of movement. And as a consequence, this results in an inefficient system of motor control.

Key Concepts Review

1. **What is the importance of fetal and newborn experiences for normal development?**

Fetal movement patterns are the basis for movement after birth. When exposed to gravity these patterns or reactions begin to modify to more organized control. Children with low to low normal tone begin at a disadvantage to gravity because they lack the tonal integrity to work efficiently against gravity. As a result they are apt to develop compensatory movement patterns that over time become more and more inefficient.

2. **How does a lack of early fetal and newborn development interfere with development?**

The early experiences in development establish the shoulder girdle and the pelvis as proximal areas of stability. This is initiated first through weight forward on the shoulders, chest, and neck in physiological flexion in prone and through surface contact and spontaneous movement patterns in supine. Without these weight bearing experiences and sufficient tone to establish the ability to work against gravity the infant does not develop efficient stability control for supporting future postural development.

3. **What are the important aspects of prone development?**

Critical competencies in prone include the ability to raise and turn the head, prop against the surface to support the head in vertical and strengthen shoulder stability, establish full extension through the trunk, push up on open hands, and push up off the surface with only feet and hand contact.

4. **How does a lack of quality development in prone result in specific movement and posture disorganization?**

Without dynamic prone experiences the child will have difficulty developing efficient stability of the shoulders and pelvis, thus there will be compensatory postures used for stability. The shoulders will elevate and the pelvis will "lock" in anterior or posterior tilt, inhibiting the ability for the trunk to activate and provide central core stability.

5. What are the important aspects of supine development?

Critical competencies in supine include the ability to maintain the head in midline with neck elongation, raise the legs and feet toward the hands, maintain and move out of midline postures, and develop the beginnings of rotational patterns through diagonal movements of feet and arms.

6. How does a lack of quality supine development result in specific movement and posture disorganization?

Without dynamic supine experiences the child will have difficultly efficiently orienting to midline, establishing forward flexion and elongation of the neck musculature, developing midrange control in posterior-anterior pelvic tilt, and efficient rotational patterns.

7. Important are the important aspects of development in sitting?

Establishing verticality in sitting is a critical competency and provides the child with the ability to use rotational patterns, move into and out of sitting to reach and pursue objects, and allows vision to guide motor activity for more specific cognitive learning.

8. How does a lack of quality of development in sitting results in specific movement and posture disorganization?

Without efficient development in sitting the trunk will not become dynamic as a central core of stability. The pelvis will lack efficiency in midrange control thus preventing the trunk from initiating stable extension as a base to initiate rotational movements.

9. What is the importance of the concept of multiple midlines?

Mary Quinton's unique concept of multiple midlines helps us understand and visualize the interaction of body sides, diagonals, rotational components, and the dissociation of the limbs from the trunk in various planes of movement. This concept allows the understanding of the organization of movement components necessary for normal motor learning to occur.

10. How does a lack of developing quality midline control result in specific movement and posture disorganization?

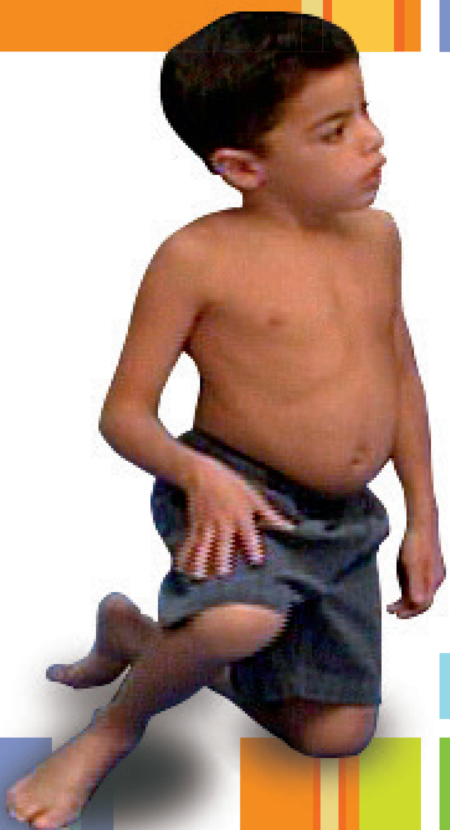
Without the development of efficient midline relationships in various planes and postural orientations, the child will have difficulty with bilateral coordination, lateral weight shifts, diagonal movements and rotational control.

11. What are the important aspects of hand and foot development?

The development of the structure of the hands and feet along with the ability to stabilize proximally allows for the efficient development of manipulation skills of the hands and forefoot-hind foot organization of the feet. The process of developing distal skill is a continuous developmental process dependent on proprioceptive weight bearing and the relationship of stability-mobility factors. Poor structure leads to poor development of motor patterns and will impact on the quality of sensory experiences to the hands, and stability factors of the feet.

clinician's view

Evaluating Movement & Posture Disorganization



A Criteria-Based Reference Format for Observing & Analyzing Motor Behavior in Children with Learning Disabilities

By W. Michael Magrun, MS, OTR

3RD EDITION

EVALUATING MOVEMENT AND POSTURE DISORGANIZATION

A Criteria-Based Reference Format For Observing And Analyzing Motor Behavior In Children With Learning Disabilities

3rd Edition

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About the 3rd Edition

This 3rd edition of the Evaluation of "Movement and Posture Disorganization," condenses and modifies some of the observational criteria in each subtest. The subtests are reorganized to reflect specific criteria for the movement sequences in the categories of starting position, initiation, transition, and final position. This assists the examiner in identifying more specifically the critical components that result in disorganization, such as, alignment, initiation of compensatory patterns, poor grading and weight shifting during the transition of the sequence to the final posture, and asymmetries between body sides. In addition, examples of disorganized responses are presented for each subtest.

INTRODUCTION

One of the challenges in the assessment of motor behavior is the determination of the quality of motor behavior and performance. In children with movement and posture disorganization, the clinician is often faced with making judgments about the child's level of performance and the underlying difficulties that impact on motor organization and coordination.

There is a growing emphasis on establishing efficacy of assessment and treatment through research that depends on statistical analysis and standardized measures. Whereas this approach has merit to professionalism and establishing the effectiveness of therapeutic intervention, it is important to remember that we are dealing with a dynamic process. When we consider movement it is clear that it can never be fully understood by studying isolated or individual variables based on calculated "standard deviations." There is a lack of depth of consideration into the underlying factors that contribute to the performance deficit.

Standardized testing of specific motor skills may be helpful in establishing a level of performance in relation to a normal population of similar age. Standardized tests, however, do not explain the "reason" for failure or below average outcome of a particular performance skill. They provide a standard deviation from a statistical norm. They are essentially meaningless in terms of developing effective intervention strategies.

Variables of performance are difficult to isolate because normal movement and motor function is dynamic and ever changing, incorporating numerous components required for a normal performance outcome. The "reasons" for a child's poor performance therefore cannot be fully understood through standardized testing. Insight into the child's difficulty requires good observational skills to determine how the child's performance is attempted and carried out from a functional point of view. The "reasons" for the child's performance problems are what the clinician wants to know so that appropriate treatment strategies can be determined to remediate the underlying dysfunction.

The use of standardized testing is appropriate for establishing base-line data on specific skill performance prior to treatment. Treatment however, if it is to be specific to the child's needs, must be determined through good clinical observation of the underlying characteristics of dysfunction that are present and must have some relationship to the performance being measured.

Ultimately the most important result of any assessment is that it provides the clinician with an understanding of the underlying problems of the child and directly leads the clinician to treatment priorities. The criteria-based format of this assessment, if used properly with a knowledge of normal movement and clinical experience, should be effective in guiding the clinician to an understanding of the child's functional inefficiencies and to specific treatment priorities.

Observing Quality In Motor Performance

The intent of the criteria-based design of this assessment is to assist the clinician in the observation of specific movement and posture characteristics that may be contributing to inefficiency in performing the movement sequences of each subtest presented.

Disorganized movement "looks" different than smooth coordinated movement. It may first appear to the observer as labored or inefficient. Disorganized movement lacks fluidity and adaptability. It is often characterized as stereotypic or recurring because the child's effort to move through a sequence does not demonstrate a smooth grading of flexion, extension and rotation. The child usually does not efficiently activate rotary patterns in transition. Flexion or extension may dominate a movement or posture with the child activating extension too forcefully (jumping up or thrusting up) or sinking into flexion rather than grading into gravity with stability. All disorganized movement is comprised by a disharmonious combination of flexion, extension and rotation. Understanding normal movement allows the clinician to appreciate the components of movement that are dysfunctional and that lead to dyspraxia or poor coordinated motor patterns.

There are several guides that can assist the clinician in observing and analyzing quality in movement and posture. They are:

1. Starting Position
2. Initiation of Movement
3. Transition
4. Final Position

The **starting position** determines a great deal in the outcome of control of a movement. Movement initiation changes with a change in starting position and the sequence of movement is therefore different in terms of the cooperation of flexion, extension and rotation that is required to perform the movement.

The patterns used to stand up from supine require a completely different sequence than the patterns required to stand up from a sitting position. The particular patterns required are dependent entirely on the starting position. The alignment of the body and its relationship to gravity, bias what movement patterns are used to accomplish the movement.

The distribution of weight influences, and is influenced by, the alignment and postural tone of the body. An imbalance in alignment, whether structural or postural will result in an imbalance in the distribution of weight and the ability to shift weight smoothly from one side to other. Postural tone will be unevenly distributed to compensate for alignment or weight distribution imbalances.

For instance, lying in supine with the shoulders, hips and lower extremities in a straight alignment allows the body to symmetrically assume standing from an alignment that is prepared to support symmetrical movement. If the starting position is initially misaligned with one side out of alignment, the movement initiation would be biased and therefore the body would need to make some type of compensatory adaptation to come to stand. This might include propping to one side or even roiling to one side to gain support for moving against gravity. The starting position and its relative alignment is therefore important in terms of how the motor plan is initiated. Alignment is determined by the distribution of weight, postural tone and structural characteristics of the child. Any imbalance between body sides of these factors will inhibit a smooth initiation of the movement attempted.

Initiation of movement refers to what part of the body begins the movement first; initiates the movement pattern of intent. Most movement is initiated by the head and neck lead by, or supported by, the visual system. To move the body through space it is necessary to initiate inertia. In many movement sequences, if not most, inertia is created through an initial flexor component. Standing up from a chair for instance, requires the initiation of flexion before extension. It is nearly impossible to stand up using only extension. Flexion therefore, serves as a catalyst or a preparation for extension. By activating flexion, the body is tensing for support against gravity to provide the stability to activate extension.

Simultaneously with initiation of movement there is weight shift to allow freedom for the body to move. Weight shift is an integral part of the initiation of movement. It provides the interplay of stability-mobility that is required during movement.

If the initiation of movement is compromised by poor alignment from the starting position there will be difficulty in smoothly executing a motor plan without compensatory adjustments or disorganization. Imbalances in postural tone and the distribution of weight can also interfere with the initiation phase. Difficulties in the initiation of movement will cause additional movement disorganization in the transitions required during movement from posture to posture.

Transitions during movement, primarily through rotational components grade extension and flexion and provide organization to movement. Rotational components of transition also grade weight shifts through midline and integrate bilateral cooperation between body sides. Transitions in movement refers to the movements that are used between postures and link into a sequence of functional motor patterns. Transitional components include rotational patterns of the trunk, spine, and shoulder girdle, rotational components help to grade weight shift laterally, forward and backward, through a sequence of movements. Normal movement does not just include flexion or extension and is not limited to symmetrical straight plane movements.

Children with movement and posture disorganization do not efficiently use transitional components of rotation. They have difficulties therefore controlling weight shifts during dynamic movement patterns and this affects smooth balance reactions. Transitional movements can be inhibited through poor starting alignment and/or inefficient initiation of movement.

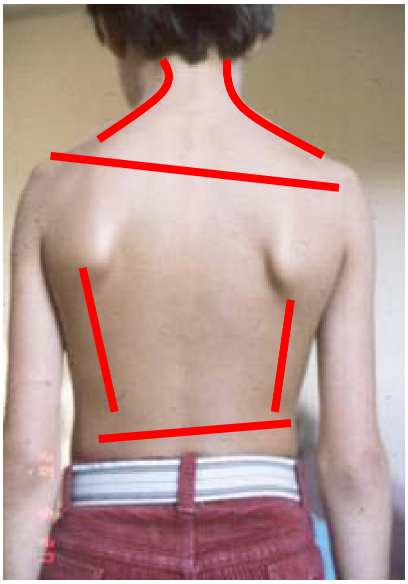
The final position is the final or ending posture of the movement sequence. The ending posture serves as the new starting posture for the next series of movement components that are initiated. Motor planning depends on good kinesthetic feedback and good kinesthetic targeting of the pattern, or feed-forward information. If motor function is continually disorganized from the starting position through initiation and transitions to the ending posture, then there is little opportunity for the child to gain consistent sensory-motor constancy to establish the kinesthetic mechanisms required to perform a smooth movement sequence.

Clinical Observation

Movement consists of a series of postures chained together by organized components, or synergies, of flexion, extension and rotation. All movement has a starting and ending posture and at any point during the sequence the movement can be stopped and the posture at that point revealed. For a posture to be functional and organizational it must be maintained with normal alignment and normal distribution of postural tone and weight. Before analyzing the child's movement it is important to observe any structural or alignment asymmetries and any compensatory habit patterns in the distribution of weight and postural tone.

Children with movement and posture disorganization often show misalignments of the body and compensatory postural patterns. Observed in standing, the shoulders may be uneven, with one shoulder lower than the other. The neck may be shortened on one side as a consequence to shoulder misalignment. The scapula may be abducted and protracted with inactivity of the mid-trunk. The lateral trunk may also be shortened on one side corresponding to the lower shoulder. The arms may hang in passive traction. The legs may be internally rotated, knees in hyperextension and the feet medially collapsed with poor arch support. The hands may also suffer from poor arch structure and weak stability at the wrist. There may be a definite preference to take more weight on one side of the body and not the other. In sitting the child may also be observed to sit with more weight on one side of the body with a consistent posterior pelvic tilt and the trunk in passive flexion. These are typical postural findings in children with movement and posture disorganization.

Neck-Shoulder-Trunk-Pelvis Asymmetry
In this example it can be observed that the right shoulder is slightly higher than the left. There is poor stability around the scapula with passive mid-trunk postural tone. As a result of the uneven alignment of the shoulders, the neck is shortened on the left, which tilts the head slightly to that direction. Due to the lower alignment of the right shoulder, the trunk is shortened on the right and the pelvis is slightly higher on the right side.

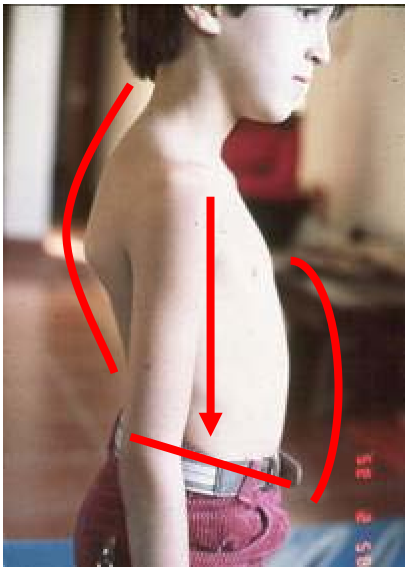


Inefficient Sitting Posture

This sitting posture is characteristic of children with movement and posture disorganization. The weight is distributed more to the right side. The neck is shortened and the trunk is in passive flexion with the pelvis tilted posterior. It is a stable position but does not allow a readiness to move or smoothly activate weight shifts, extension, or rotational patterns.

Passive Traction Of The Upper Extremities

Poor proximal stability of the shoulder girdle and general low tone support of the trunk results in a passive traction posturing of the arms. The arms appear long and there is not a good readiness to move or initiate distal movement from a stable proximal point of control. The abdominals also appear inactive and the head is positioned slightly forward of the shoulders as a postural compensation for the lack of shoulder girdle stability. The pelvis is anteriorly tilted and there is lumbar lordosis.



Postural Characteristics In Standing

These children show some typical postural characteristics seen in children with movement and posture disorganization. Shoulder misalignment, inactive abdominals, pelvis anteriorly tilted and corresponding lumbar lordosis. The knees are hyperextended. There is an imbalance of flexion and extension and consequently there is poor mid-range control at the pelvis. The weight is often distributed more on one side of the body.

Distribution Of Weight In Standing

Postural alignment in children with movement and posture disorganization is often asymmetrical and due to these compensations there is often a corresponding imbalance in the distribution of weight in various postures. In these examples it can be observed that there is a slight preference to take more weight through one side or the other, usually to the same side as the lower shoulder. This effectively results in a postural midline shift. In addition, the child has more difficulty shifting weight and maintaining balance on the side that is used less in weight bearing.

Weight distributed more to the left

Weight distributed more to the right

CLINICAL OBSERVATION OF MOVEMENT AND POSTURE DISORGANIZATION

Subtest 1:	***Supine To Stand***
Subtest 2:	***Supine To Flexion Hold***
Subtest 3:	***Prone Reach***
Subtest 4:	***Alternating Prone Reach***
Subtest 5:	***Long Sit To Side Sit***
Subtest 6:	***Kneel Standing To Side Sit***
Subtest 7:	***Kneel Walking Forward And Back***
Subtest 8:	***Alternating One Foot Kneel***
Subtest 9:	***Alternating Half Kneel To Stand***
Subtest 10:	***One Foot Balance***
Subtest 11:	***Squat Pick. Up***

Child's Name: ***Age:***

Date of Assessment: ***Examiner:***
Referred by:

Reason for Referral:

SUBTEST 1: SUPINE TO STAND

This subtest is designed to evaluate the movement sequences of the child as he comes to standing from a back-lying position. The examiner demonstrates the movement sequence and asks the child to duplicate the sequence. As the child initiates standing from supine the examiner observes the sequence and answers the criteria questions of the subtest.

Some children may rotate to one side, which if done smoothly and without undue effort, is acceptable and a normal preference for some children. However, if there appears to be effort or difficulty, the side rotated to should be noted and cross referenced with other subtests to determine if the child repeatedly relies on one side for other movement sequences in the assessment

Children who have disorganization in motor behavior often show difficulty in initiating the sequence. They show effort in raising the head off the surface, sometimes with slight head lag and facial grimace or distress from effort. Their legs may lift off the surface in extension in an effort to recruit one side to assist in raising the head. Additionally disorganizing factors include rolling to one side and propping for support or even moving into a four-point position and pushing against the legs for stability to stand.

Disorganized Examples

Key Observations

- Is the starting position symmetrical?
- How is the movement initiated?
- Is the movement symmetrical?
- Does the child maintain good body alignment during movement?
- Is the end position symmetrical?

This movement sequence is initiated from the head and neck. Note if the head moves forward in capital extension and neck flexion. Observe the symmetry of coming forward with the upper body and bringing the weight over the hips and legs. Note any compensations such as:

- One side leading the movement and one side lagging behind.
- Rotating toward the lagging side to prop for standing.
- Legs elevating before the upper body flexes forward.
- Asymmetrical standing.

Administration

Starting Position: Child starts in supine after demonstration.
Command: "Now you do the same thing, Lie down and stand up."

Subtest Observations

Starting Position

a.) Does the child appropriately assume a symmetrical starting position? Yes___ No ___

If No:

b.) Is the asymmetry to the right or to the left? Right___ Left___
c.) Is the right or left leg internally rotated in the starting position? Right___ Left___
d.) Are the shoulders elevated in the starting position? Yes___ No___

Initiation

a.) Does the child appropriately initiate the movement with capital extension and neck flexion? Yes___ No___

If No:

b.) Does the head lag or is the neck in hyper extension? Yes___ No___
c.) Do the legs extend off the surface as the head attempts to raise? Yes___ No___
d.) Is there evidence of facial grimace or extreme effort? Yes___ No___
e.) Does the child fist his hands? Yes___ No___
f.) Do the shoulders elevate? Yes___ No___
g.) Do the elbows flex with shoulder elevation? Yes___ No___

Transition

a.) Does the child appropriately sit up symmetrically with the legs flexed ready to stand over the feet? Yes___ No___

If No:

b.) Does the child lean to the right or left? Right___ Left___
c.) Does the child rotate to the right or left and forearm prop? Right___ Left___
d.) Does the child go to side sit or four-point right or left? Right___ Left___

Final Position

a.) Does the child stand up appropriately with equal weight on both feet? Yes___ No___

If No:

b.) Does the child stand with more weight on the right or left? Right___ Left___

Repeat Several Times

Repeat the sequence several times. If the performance becomes more disorganized, it is an indication of significant neuropostural disorganization. If the performance shows initial disorganization and either stays the same or improves slightly, it is an indication of a more mild neuropostural disorganization.

Subtest 1: General Level of Disorganization

Adequate response with no indication of disorganization or difficulty. ☐

Slight indication of disorganization seen in several disorganized criteria initially seen but improving or remaining the same over repeated attempts. ☐

Mild disorganization as identified by presence of a number of disorganized criteria and not substantially improving over repeated attempts. ☐

Significant disorganization as indicated by numerous disorganized criteria and remaining the same or becoming more disorganized over repeated attempts. ☐

Interpretation of Subtest 1

When interpreting the child's performance of **Supine To Stand**, it is important to determine the initiation of the movement and any preference for a reliance of one side over another. Critical to the performance of this subtest is whether the child can easily initiate forward flexion of the neck to start the movement pattern against gravity. Any head lag or compensatory responses such as extending the legs or elevating the legs indicates a problem with initiating flexion. This may be due to weak neck co-contraction, a lack of proximal stability of the shoulders or poor abdominal support. Additionally it is important to identify whether the child relies on one side in an attempt to flex against gravity. If the child leans to a side and appears to struggle with effort such as facial grimace due to straining against gravity, or has difficulty bringing the side initially relied upon into symmetry for coming to stand, then it indicates an imbalance in the use of the two body sides. If the child simply rotates to a side and then smoothly comes to stand it is a motor preference which does not imply disorganization without the presence of undo effort. Keep in mind the need to use one side to prop even if there is no obvious appearance of effort, since in the administration phase of the subtest, the child was shown and then instructed to come up symmetrically.

SUBTEST 5: LONG SIT TO SIDE SIT

This subtest is designed to evaluate the child's ability to use rotational components and the ability to organize bilaterally to cross midline from a symmetrical starting position. The child starts in long sitting and is asked to side sit to each side, always coming back to long sitting before moving into side sit. This movement pattern requires rotation with trunk extension and lower extremity flexion. The child also must shift weight laterally and activate elongation on the weight bearing side and lateral flexion on the opposite side of the trunk.

Children with movement and posture disorganization may have difficulty in the starting position of long sitting. They may tend toward posterior pelvic tilt which will inhibit good rotation and weight shift. They may need to prop with a hand to the surface and they may not easily return to long sitting as a transitional posture, preferring to maintain lower extremity flexion and simply shifting weight side to side. There may also be difficulty in maintaining and alternating trunk elongation and lateral flexion from one side to another.

Disorganized Examples



Key Observations

- Is the starting position symmetrical?
- How is the movement initiated?
- Is the movement symmetrical?
- Does the child maintain good body alignment during movement?
- Is the end position symmetrical?

This movement sequence is initiated from long sitting and requires alternating rotation from one side to the other while grading lateral weight shifts. Note any compensations such as:

- Lateral shifting better to one side.
- Knees flex without full weight shift or rotation.
- Arms flex and shoulders elevate.
- Loses balance to one side or both sides.
- Trunk collapses on the weight bearing side.

Administration

Starting Position: Child starts in long sitting after demonstration.
Command: "Now you do the same thing. Extend your arms and sit with your legs straight. Now sit with both legs to one side and then go back to long sitting and then sit with both legs to the other side."

Starting Position
a.) Does the child start from a symmetrical position? Yes___ No___

If No:
b.) Is the pelvis in posterior tilt? Yes___ No___
c.) Are the legs internally rotated? Right___ Left___
d.) Does the child lean to one side? Right___ Left___

Initiation
a.) Does the child shift easily to the left side, rotate to side sit and maintain good alignment with elongation on the weight bearing side, and lateral flexion on the opposite side? Yes___ No___

If No:
b.) Does the trunk flex forward? Yes___ No___
c.) Does the trunk lean over the hip so the shoulder and hip are not in alignment? Yes___ No___
d.) Do the arms excessively flex and shoulders elevate? Yes___ No___

Transition
a.) Do arms remain extended during side to side shifting? Yes___ No___

If No:
b.) Do the arms excessively flex while rotating? Yes___ No___
c.) Do the hands prop for support to either side? Right___ Left___
d.) Do the shoulders elevate during rotation? Yes___ No___

Final Position
a.) Does the child return to long sitting between each side rotation? Yes___ No___

If No:
b.) Do the legs only partially flex and move side to side without returning to long side? Yes___ No___
c.) Do the legs remain extended as the child shifts side to side? Yes___ No___

Repeat Several Times

Repeat the sequence several times. If the performance becomes more disorganized, it is an indication of significant neuropostural disorganization. If the performance shows initial disorganization and either stays the same or improves slightly, it is an indication of a more mild neuropostural disorganization.

Subtest 5: General Level of Disorganization

Adequate response with no indication of disorganization or difficulty. ☐

Slight indication of disorganization seen in several disorganized criteria initially seen but improving or remaining the same over repeated attempts. ☐

Mild disorganization as identified by presence of a number of disorganized criteria and not substantially improving over repeated attempts. ☐

Significant disorganization as indicated by numerous disorganized criteria and remaining the same or becoming more disorganized over repeated attempts. ☐

Interpretation of Subtest 5

When interpreting the child's performance of **Long Sit to Side Sit**, it is important to observe the key components of elongation, lateral flexion and rotation of the trunk and shoulder girdle. The child should be able to flex the legs and laterally shift weight to the side with forward weight shift over the hip. The trunk should elongate on the weight bearing side and laterally flex on the other side. The arms should remain extended with the trunk and shoulder girdle rotating for counter balance. The pelvis should align in neutral or in slight anterior tilt and laterally tilt with the weight shift.

Children with movement and posture disorganization often show a better ability to one side. They may perform side sitting from a long sit starting posture with good lateral shift and trunk reactions, however, when shifting to the opposite side there may be a need to prop or to eliminate long sitting transition and there is often difficulty maintaining good elongation on the weight bearing side. Some children experience difficulty to both sides due to a poor pelvic starting position of posterior tilt and a tendency to keep the trunk flexed forward which inhibits good lateral shifting and rotational components. If the child has more difficulty to one side, make a note and reference with other subtests to determine if there is a consistent presence of difficulty to a particular side.

IMPLICATIONS FOR TREATMENT PLANNING

A comprehensive treatment program should include a progressive approach of establishing a neuropostural base. In order to provide a child with movement and posture disorganization a chance to succeed, a firm relationship with gravity that supports organized motor planning must be established. Further, the child must be able to refine those skills which are critical to the learning process. These are the functional skills by which children demonstrate, and to a large extent, develop their cognitive abilities.

Once the child has been assessed for movement and posture disorganization by using the subtests included in this assessment, the clinician should carefully consider the child's postural characteristics and movement trends before planning specific intervention activities. By referring back to the interpretation suggestions of each subtest and looking for trends in the child's performance, it should be possible to determine initial treatment priorities.

Generally the goal of physical handling is to facilitate functional control of flexion and extension against gravity combined with functional rotation. Treatment must center around the following parameters.

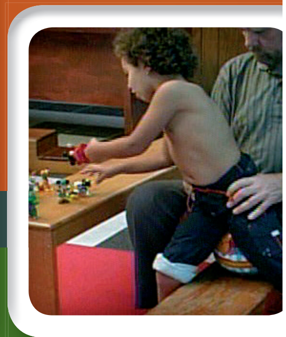
- Establish alignment of body parts to each other.
- Establish equal distribution of weight.
- Establish graded weight shifts in all directions.
- Establish controlled upper and lower body organization.
- Establish bilateral control throughout movement transitions.
- Establish graded control of flexion, extension, and rotational movement components.

Critical to this approach is the understanding that comprehensive sensory motor organization is dependent on specific facilitation through physical handling. Sensory stimulation is not an integrating force for these complex motor patterns.

Misalignments need to be identified and corrected. The use of techniques for changing tone are effective in reestablish normal body alignment. Establishing normal alignment is the first goal. Without normal alignment other aspects of motor function and control cannot be efficient.

Another important issue is to determine if the child has more difficulty unilaterally. This can be observed initially in the standing alignment if the child tends to take more weight over one side than the other. If this observation is a specific problem it will also be observed in the child's attempt at other movement sequences in the assessment. The child may lean consistently to one side during **Supine to Flexion Hold and Prone Reach.** This type of somatic preference can also be easily observed in **Alternating One Foot Kneel, Kneel Standing to Side Sit, and One Foot Balance.** Obviously a tendency to over rely on one side somatically indicates that the child has more tolerance for proprioceptive weight bearing on one side of the body. This unilateral imbalance in somatic tolerance for weight will influence the internal perception of the body midline and the ability of the child to grade weight shifts across midline from side to side.

Intervention strategies need to include specific guiding of the body weight over the "less" normalized side, first through direct facilitation of weight shifting and then through clinician's view



Sensory-Motor Integration in Learning Disabilities:

A Neuropostural Approach to Direct Treatment Strategies – 2nd Edition

by W. Michael Magrun, MS, OTR

Introduction

The difficulties in motor performance in children with learning disabilities come from a lack of integration of sensory-motor processes, in specific, the efficient proprioceptive matching of visual-vestibular-somatosensory information. Inefficiency in the organization of these systems interferes with the child's ability to learn and their ability to express what they know.

To effect a change in disorganized movement and posture, one must control, modify and grade sensory input and shape, refine and repeat functional motor output. This text suggests that the most effective and comprehensive way to achieve positive change in sensory-motor integration is through direct physical handling which incorporates the principles of:

- Facilitation and inhibition
- Musculoskeletal alignment
- Postural stability-mobility
- Organization of movement components

Treatment strategies presented in this text are based on the necessity of establishing a normal neuropostural base in relation to gravity, reorganization of somatic-vestibular proprioception, facilitation of graded movement components for functional motor patterns, and the establishment of efficient motor learning through improved feed-forward and feedback processes.

A Neuropostural Perspective

The neuropostural approach utilizes principles of facilitation and inhibition and is a therapist-directed physical handling approach to foster the organization of an efficient neuropostural base for functional movement and posture.

Facilitation requires an active response from the client. The therapist uses various techniques to activate musculature, establish alignment, and prepare postural tone, but the actual organized response is always initiated by the client. Facilitation techniques by the therapist allow the child to be more successful in initiating an adaptive response to controlling the center of mass over the base of support and efficiently grading movement components necessary for efficient function.

Inhibition is a component of facilitation in that it prevents through the use of positioning or specific input, inefficient compensatory responses so that the child can initiate a more organized response.

An efficient neuropostural base includes:

- Normal postural alignment
- Equal distribution of weight
- Ability to weight shift in all directions with graded control
- Efficient righting and equilibrium reactions as an underlying foundation for volitional movement
- Efficient organization of flexion-extension-rotational components of movement
- Dynamic interaction of stability and mobility requirements for movement
- Anticipatory initiation for efficient functional movement
- Volitional movement with efficient underlying postural control and support

For movement and posture to be organized, the child must be able to make a sensory-motor adaptation to the demands of gravity, sensory stimulation and environmental influences. To make a normal adaptive response, the child must have a firm base of support; a neuropostural base, from which to activate his adaptations to sensory demands. As such, a neuropostural base is considered a critical and necessary prerequisite to sensory integrative activities that stress sensory input but do not directly prepare the postural basis for adaptation to occur.

- **Normal Postural Alignment**

Normal postural alignment is the most critical prerequisite for establishing efficient functional movement capabilities. The ability to maintain dynamic alignment provides the basis for an organized initiation of movement with graded control of movement components during the process of performing a functional task or movement sequence. Alignment refers to the relationship of each body part to each other and to the relationship of the body to the base of support (BOS). Body alignment is dependent on the kinesiological alignment of muscle groups which in turn depends on joint alignment.

Normal postural (musculoskeletal) alignment establishes:

1. Kinesiological alignment of joint and muscles to activate dynamically and in the best possible efficient functional manner.
2. Alignment of the sensory systems (visual-vestibular-cervical triad) in the best possible vertical orientation for maximizing efficient integration and matching between systems.

Normal postural tone refers to the resting tension of the musculature and the modulation of muscle tensions during movement demands. The tension of the musculature must be sufficient to maintain the body against gravity while allowing tonal changes to produce movement. The background tone must be sufficient to maintain stability and there must also be a corresponding increase or decrease in tone surrounding the demands of movement and the mobility of the joints required to accomplish that movement. Postural tone therefore modulates in a normal range from a resting state to higher or lower levels of tone within and around structural factors of the body's musculature. Without normal postural tone there is inefficiency of equilibrium and righting reactions and the organization of synergies of movement components.

Postural tone therefore is a dynamic and constantly changing process which must be interactive and competitive in order for there to be sufficient tone to allow mobility while at the same time sufficient tone to maintain stability. Postural tone is never too low to jeopardize stability against gravity nor too high to restrict movement. Different parts of the body's musculature achieve different levels of postural tone simultaneously and interactively so that this dynamic process is possible.

The dynamic nature of postural tone allows for reciprocal innervation. Agonist and antagonist, within muscle groups and motor patterns, provide a balance of postural tone to allow stability and mobility by constantly modulating increases and decreases of the tonal relationships needed to accomplish a movement pattern. Reciprocal innervation allows for the combination and competition of flexion, extension and rotational components of movement and their organization to perform a functional motor behavior.

Normal postural tone and reciprocal innervation, provides the skeletal system with the possibility of establishing and maintaining normal bony alignment, articulation of joint function, stability around the bony structures and an adequate range for function.

- **Equal Distribution of Weight**

Normal postural alignment allows for the body to distribute weight over the base of support in all planes of movement. In a standing or sitting alignment, weight should be able to be evenly distributed on both body sides. Although we are rarely in a perfect vertical standing or sitting alignment, it is important that this be easily achieved.

Without this ability, weight shifting and crossing the midline for lateral or rotational movements becomes much less efficient and indicates asymmetry of graded control. Observing weight distribution in standing and sitting allows for the determination of a possible postural midline shift and proprioceptive preference in sustaining weight unevenly. This can be a lateral distribution on one side of the body over the other, or an anterior, posterior distribution of weight, or a combination. The distribution of weight over the base of support will determine the efficiency or inefficiency of the initiation of movement, the transitions of that movement and the alignment of the end posture. We move from posture to posture through graded transitions of movement components. The distribution of weight of the starting position and the ability to anticipate the adjustments required to initiate movement and grade the transitions required are critical to efficient sensorimotor function.

For example, if we are sitting and leaning to one side resting on the arm of a chair our weight is not equally distributed. However if we decide to get out of the chair, our first initiation is to reorganize midline and distribute our weight more evenly. We don't stand up with all our weight on one side of our body. We anticipate the action required and make the initial adjustment to midline and more equal weight distribution before shifting our weight forward over our base of support to stand up.

The ability to control and grade weight shift and weight distribution over the base of support establishes a bilateral relationship between body sides around an organized and stable central midline core. Without such an ability and relationship, efficient coordinated movement and functional performance with adaptability is compromised. Movement and functional performance become compensatory to the underlying postural inefficiencies and splinter skill learning results. Normal alignment allows weight to be distributed appropriately to the task and allows the task to be performed in a coordinated and efficient way.

- **Ability to Weight Shift in all Directions with Graded Control**

Graded control of transitional movements requires the ability to dynamically shift weight and modify the amount of weight shifted in all planes of movement throughout a motor sequence or performance of a task. All movement requires a synergy of flexion, extension and rotational components. Graded control of weight shift allows these movement components to interact efficiently and provide movement of the body over the base (flexion), movement away from gravity (extension) and transitional movements (rotation). Various combinations of these movement components are required for any particular task as well as throughout the task. For such a dynamic synergy to be efficient there must be normal postural tone (stability-mobility synergies) normal postural alignment over the base of support (equal distribution of weight) and the ability to shift and sustain weight over various aspects of the body (proprioceptive tolerance for sustained weight.)

- **Equilibrium and Righting Reactions**

Equilibrium and righting reactions can only occur efficiently when there is musculoskeletal alignment in relation to the base of support and sufficient postural tone to provide the activation of postural responses to visual-vestibular-somatosensory information related to the changes in the center of mass over the base of support. The primary function of the righting reactions is to maintain verticality of the head and neck to the midline of the body. Equilibrium reactions, both fixing reactions and tilting reactions relate to a shift in the center of mass outside the base of support which compromises the integrity of the body's balance. Righting and equilibrium reactions occur in concert with one another to provide reactive motor responses as background maintenance for proactive volitional motor control during movement through space and in relation to the surface upon which the movement takes place.

The normal functioning of the postural system is essential for a normal neuropostural base against gravity. Without the integrity of a normal neuropostural base, organized motor behaviors for learning and the performance of functional activities become inefficient and less adaptable.

Equilibrium reactions consist of fixing reactions, tilting reactions and protective extension reactions.

Fixing reactions are activated when there is an outside force to the body, such as being bumped or pushed. **Tilting reactions** are activated when there is a change to the base of support such as uneven terrain or being on a tilt board. **Protective extension reactions** are activated to protect against a fall when balance cannot be maintained.

Fixing reactions are important because they activate elongation of the weight bearing side and lateral flexion of the opposite side. This is important in physical handling because as we shift the child's weight laterally it should activate fixing reactions. These are centered around the midline and are important for grading weight shift and managing control of the center of gravity. If the child has low resting tone and cannot react spontaneous to the shift in the center of gravity, then the reaction is less efficient and gets exaggerated with less graded control.

Fixing reactions active the ankle- foot strategy. Balance reactions in the foot and ankle are the first initiated from an outside force. This is important to realize since many children with movement and posture disorganization have instability in the ankles and medial arch collapse of the foot. The foot is not prepared for the reaction and thus the response is slow and the balance reactions is more exaggerated. Once the center of gravity is more challenged without firm fixing reactions, balance shifts to a hip strategy with more trunk participation. Again, this is significant because children with movement and posture disorganization often have slow pelvic adaptation and a lack of quick active trunk control.

Tilting reactions are initiated from changes in the base of support. Fixing reactions are also initiated .As the tilt gets more extreme or happens more quickly, it causes more activation of elongation stability and greater lateral flexion, with abduction of the opposite side seen both in upper and lower extremity reactions, depending on whether in sitting or standing and the degree and speed of the tilt. Without graded midline control and efficient fixing reactions, tilting reactions will be less controlled and more extreme and inefficient.

Young babies with low tone that use a wide base of support, such as w-sitting or sitting with a wide base with legs spread apart inhibit any experience in developing efficient fixing and tilting reactions. This contributes to the disorganized movement and posture that is seen later.

Righting reactions include the optical and labyrinthine reactions and the neck, head and body reactions. Optical and labyrinthine reactions are dependent on the neck. They don't appear until around two months when the neck musculature is sufficient to support the head. This is important to consider since many children with movement and posture disorganization have less

Treatment Techniques for Changing Tone

It is necessary to establish a normal distribution of postural tone. Imbalances of postural tone can be observed in areas of the body which are overused, presenting as areas of tightness or fixing and in areas of the body which are underused, presenting as low tone or passive inactive musculature. Areas of tightness need to be inhibited or reduced and passive or lower tone areas need to be facilitated and activated.

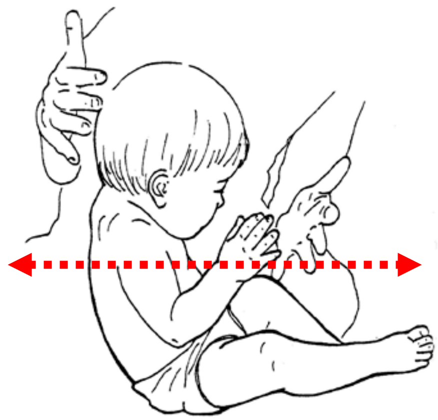
As previously described, the child with movement and posture disorganization often has tightness in one or both shoulders, due to misalignment of the scapula and posturing in elevation, abduction and slight protraction. The thorax may also have some tightness due to this chronic posturing. The mid-trunk is often inactive or passive and therefore, lower in tone. The low back may be tight due to anterior pelvic tilt in standing postures and the pelvis may be tight on one side or the other due to lateral alignment imbalances. The hamstrings may be over lengthened in the presence of back kneeing. The feet are usually low tone, as well as the hands, and the wrist may posture in flexion that inhibits good availability of active wrist extension in support of distal finger control. All of these areas need to be fully addressed to determine specific needs for inhibition or facilitation in relationship to normalizing the distribution of active postural tone.

Normalizing postural tone is important as a preparation for initiating activities to increase the organization of flexion-extension-rotational components of movement. Weight bearing over a body surface tends to inhibit tightness while intermittent support and quick tapping lend itself to increasing tone. Compression into a joint, for instance the shoulder helps to reduce tightness while approximation into the shoulder tends to increase tone and therefore stability.

Preparatory techniques are designed to influence the general state of postural tone and are used to prepare the somatic system for movement. Postural tone is influenced by various factors of sensory input, such as speed, frequency, duration and intensity of specific sensory cues. In general, fast input tends to increase tone while slow input tends to decrease tone. Input can be long in duration and intensity, such as compression into a joint or short and alternating such as approximation of a joint. The actual response to the presentation of sensory input depends on the child's individual nervous system and the degree of sensitivity of the handler to monitor and modify the input.

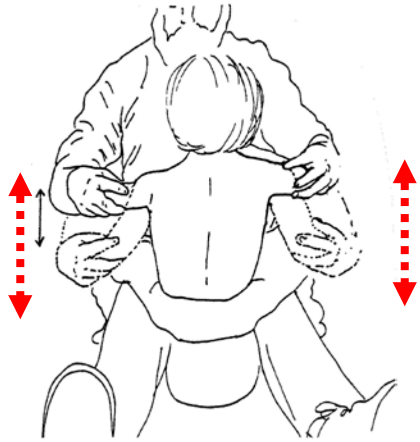
Tapping is a technique that is used as a means to apply repetitive sensory input or tapping to the surface of a muscle. **Quick tapping** or fast tapping increases tone. This type of tapping is used to increase the muscular activity of low tone children or to balance agonist and antagonist muscle groups in areas of high tone or tightness. **Sweep tapping** is another form of stimulation to facilitate motor patterns of muscle groups. Sweep tapping is a technique that provides a facilitating input in the direction of a desired movement, such as sweeping the triceps and extensors of the arm in the direction of extension to inhibit flexor tightness. Slow sweeping can also be used with deep pressure to tight muscle groups in the direction of the desired response, such as slow deep pressure sweeping of the biceps to reduce tone and facilitate an extensor response of the arm. **Alternating tapping** is used to control a small range of movement to increase graded control. It can be used to inhibit low tone collapse into gravity or to maintain active tone for stability.

Alternating Tapping



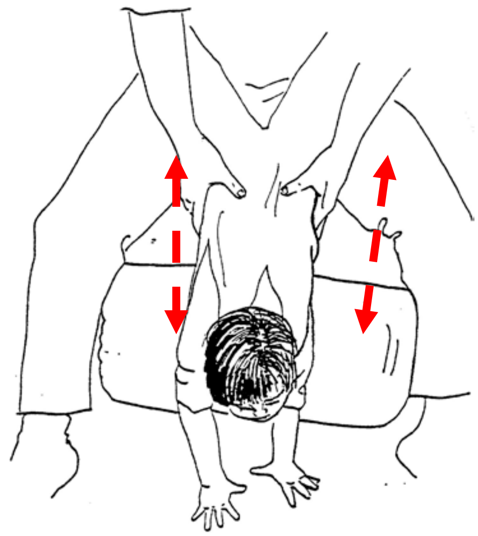
Oscillation is a term that is used to describe a repetitive swinging or swaying of a limb. As with all sensory techniques, the speed of application determines the sensory-motor response. Fast oscillation tends to decrease tightness when applied distally to a limb. However, this fast oscillation may need to be interspersed with times of no oscillation or slow oscillation, to avoid compensatory tightness from returning. Prolonged oscillation, applied bilaterally to the arms, has a tendency to increase trunk tone in a low tone child as it stimulates arm motion for the joint receptors. Slow oscillation, particularly with slight traction of the limb can result in decreasing tightness, while repetitive quick traction has the tendency to increase tone around a joint. Extreme care must be exercised during these techniques to protect the joints from subluxation or dislocation.

Oscillation



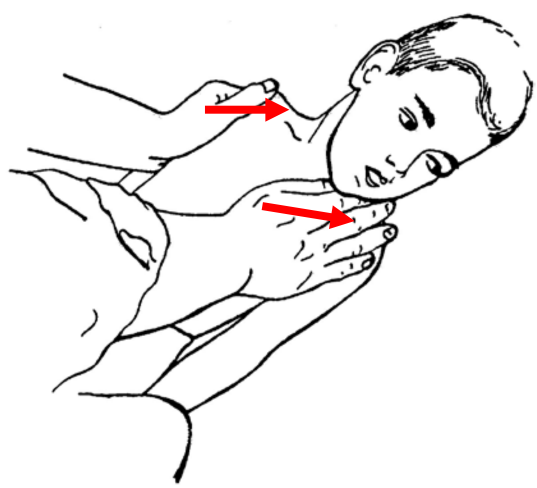
Intermittent support is a term used to describe active stabilization within a range of movement. It is essentially a hold and release technique that supports body weight and releases it with various frequency and duration as needed to enhance active stability and equilibrium. It can be performed with the body weight slightly off center to activate automatic responses or in a stable midline position to enhance stability. It is a good technique for stabilizing fluctuations in midline postures and activating low tone responses to a shift in the center of gravity.

Intermittent Support

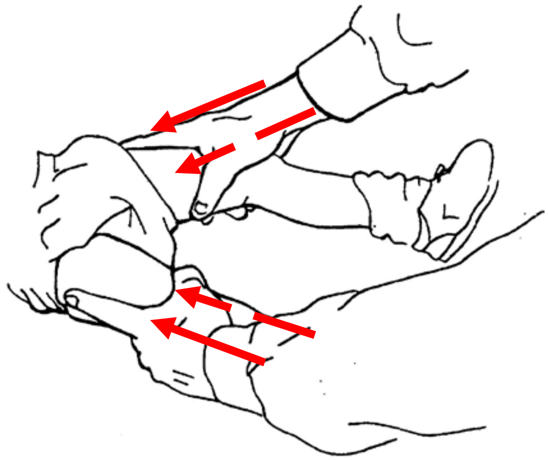


Compression is a sustained pressure into a joint in alignment. Sustained pressure into a joint has the effect of reducing tone or tightness around the joint. Intermittent compression into a joint, or approximation can increase joint stability and tone if repeated rapidly or decrease tone if performed in a slow and rhythmic manner. Deep sustained pressure over a muscle belly has an inhibitory influence and is effective in reducing tightness.

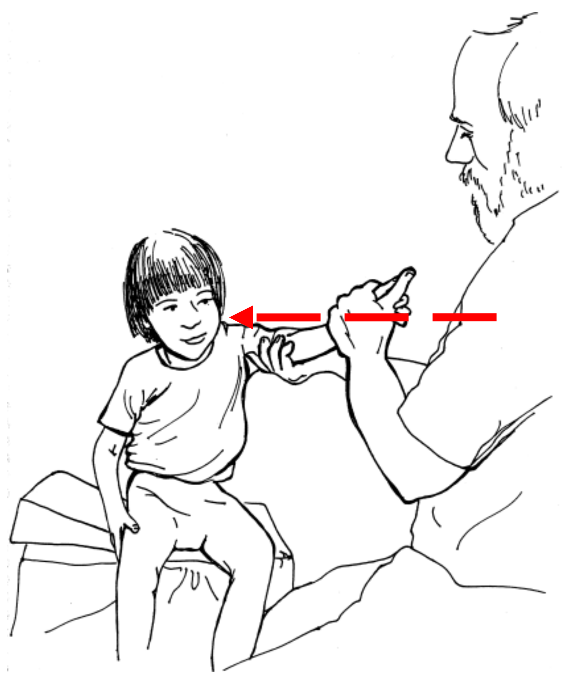
Sustained Pressure/Compression



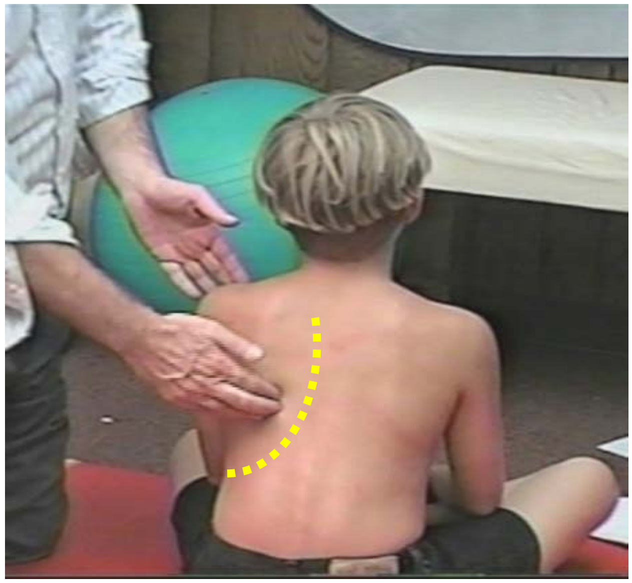
Sustained/Alternating Compression



Approximation into a Joint

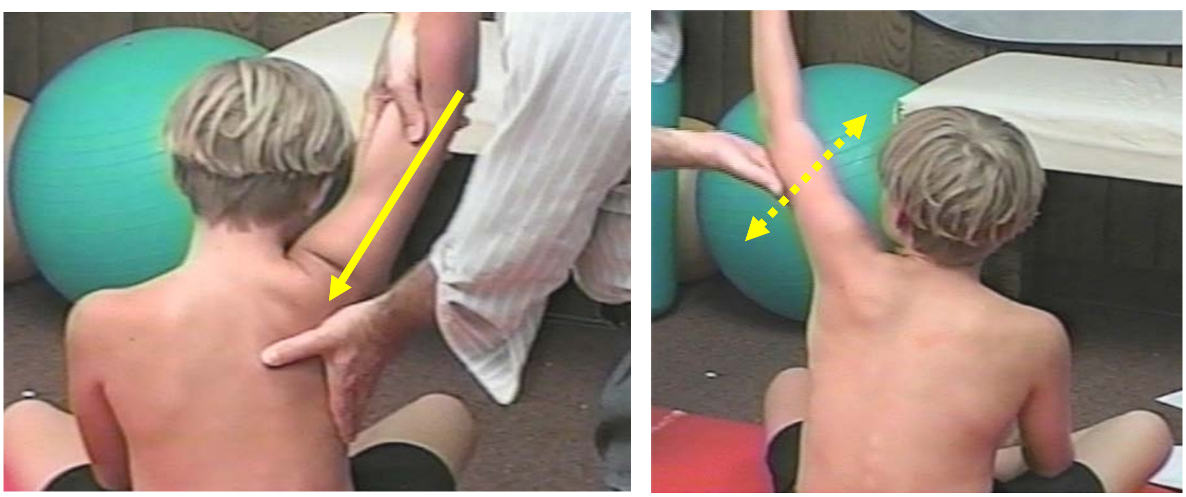


Repetitive approximation into a joint to influence tonal changes, followed by sustained compression into the joint to increase sensory proprioceptive tolerance.



Increasing stability around the scapula

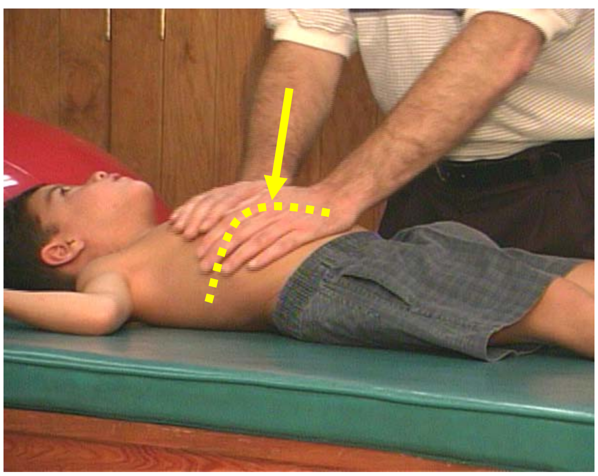
Quick tapping around the scapula helps to increase muscle tone to stabilize the scapula in the more efficient alignment.

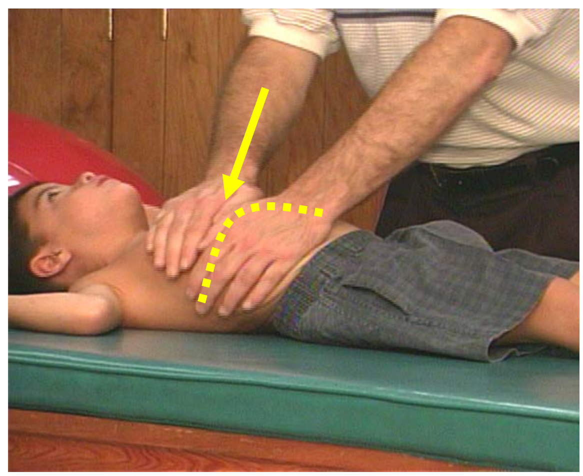


Using sustained pressure and intermittent support

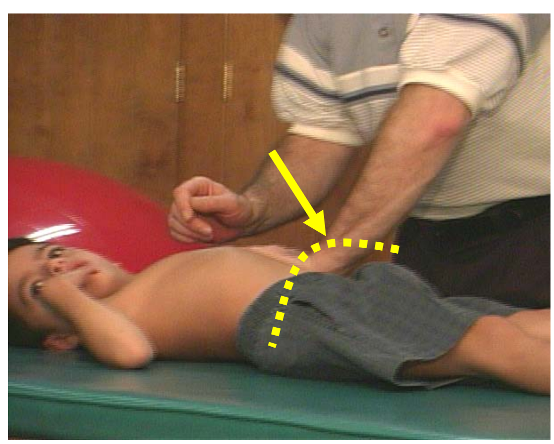
Sustained pressure can also reduce shoulder tightness. Stabilize the scapula with the arm in 45 degrees of extension and provide sustained input into the shoulder. Slowly release the input and repeat. Once the shoulder relaxes, use intermittent support. Support the weight of the arm and then release slightly and quickly and then regain support. This tends to increase shoulder stability in the new and more efficient alignment.

Place your hands over the ribcage and use firm sustained pressure.Move the tissues laterally with oscillation as you move the tissues over the ribcage. Repeat the procedure until you feel more freedom of movement and ease of tissue gliding.

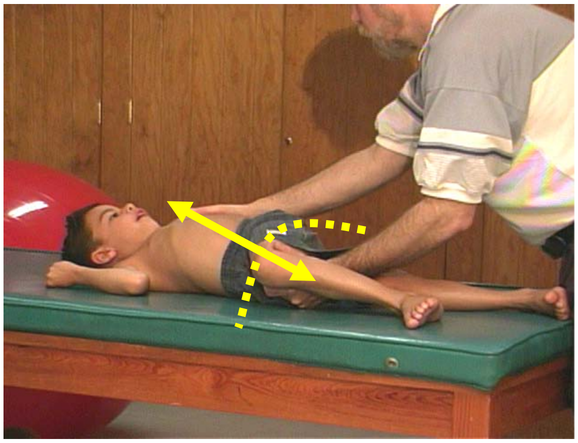


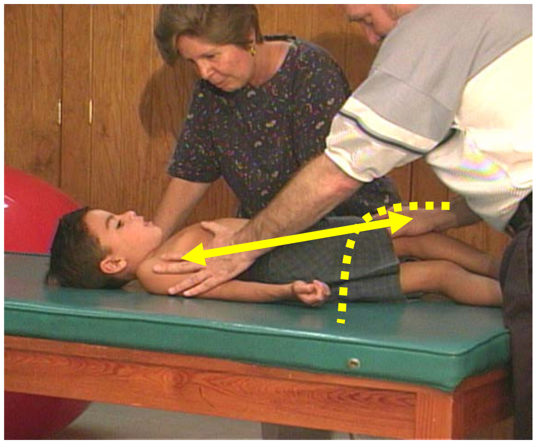


Repeat the procedure in both directions.



Once there is more movement of the ribcage and the chest musculature, stretch in a diagonal to gain more adaptability of the trunk and shoulders. Maintain stable pressure on the shoulder and move the leg and hip across the body. Oscillate as you increase the range of the diagonal stretch.





The photo on the left shows the initial presentation of chest tightness, shoulder protraction, and lack of neck elongation. On the right we can see the changes after a 1 hour session that included specific mobilization of the rib cage and chest musculature. The chest is more elongated, the shoulders are in a better alignment, the trunk has more active extension, and the neck is elongated.

Changes after a 1 hour assessment/treatment session

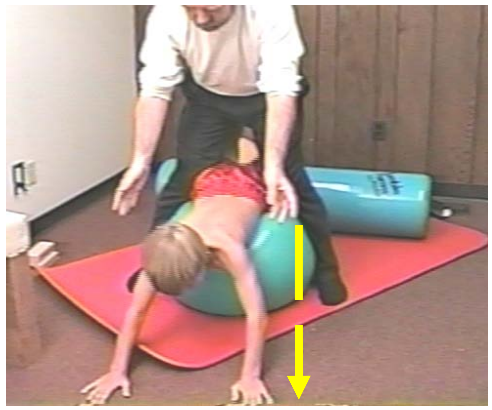
In sitting, the photo on the left shows this child's postural compensations of posterior pelvic tilt, rounding of the back, inactive chest musculature, and poor head/neck alignment. The photo on the right shows the changes in alignment and more efficient postural organization after the treatment session. The chest is elongated. The shoulders, head and neck are aligned with trunk extension and there is slight anteriot tilt of the pelvis which supports and activates trunk extension.

Changes after a 1 hour assessment/treatment session

In cases of low tone in the shoulders, there is joint laxity and the arms tend to hang in a passive traction. The shoulders are not able to provide proximal stability for the arms or the trunk.

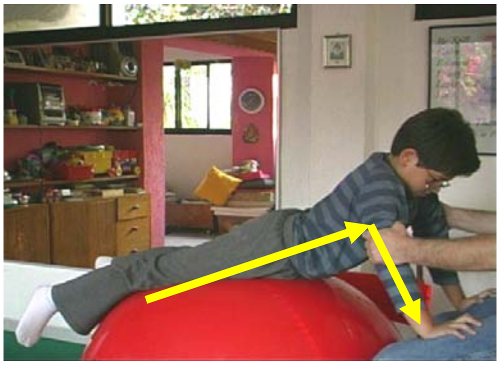
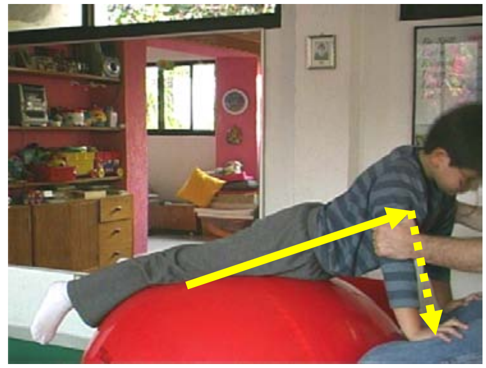
Preparatory Trunk Activities

In order for the trunk to grade extension, flexion and rotation, and provide mobile-stability throughout those ranges of functional components of movement, it must first be able to activate and hold extension with a balance of flexion to provide stability for the adaptations of the shoulders and pelvis. There are a number of ways to prepare the trunk for active responses. Both flexion and extension may require preparation before more active trunk activities can be efficiently activated.

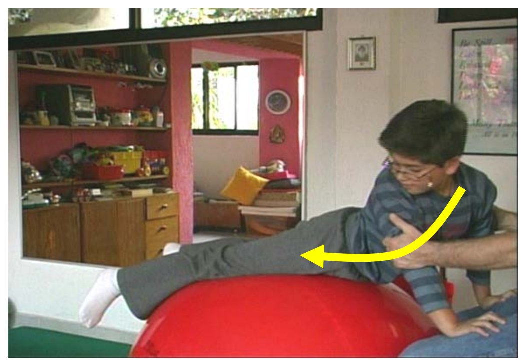



Trunk tone can be increased by lifting the child in prone over a ball, lowering him toward the floor and gently dropping the arms to the surface. This provides firm compression into the shoulders and requires an increase in trunk tone to sustain support of the arms against the surface. This should not be done with children who lock their elbows in hyper extension. The elevation of the hands off the surface before gently dropping should only be a few inches to begin with and gradually higher to about 1 foot high. Extreme caution must be taken in the alignment of the wrist to the hand, and the arms to the shoulders.

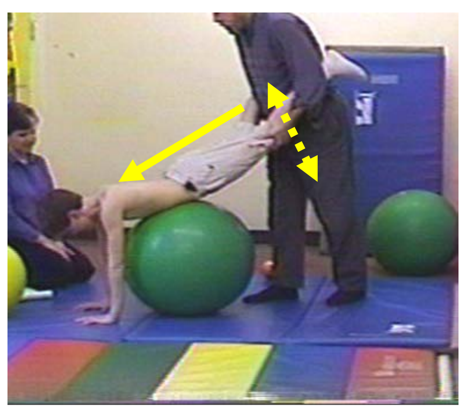

Distal control with intermittent compression and intermittent support helps to increase trunk tone and promote holding in extension for improved stability. Hold the hands and provide repeated quick compression input through the arms into the shoulders and trunk to elevate the resting tone of the trunk. Caution must be taken to be sure safe and proper alignment of the arms to shoulders is maintained. Use intermittent support by diminishing the support of the arms andguickly regaining maximum control. Doing this repeatedly increases the holding tone of the trunk.

Using a large ball supports full body extension. Bringing the weight forward over the hands provides the input to facilitate more active holding of trunk extension. Use intermittent downward input into the hands and intermittent support to keep extension active.

Asking the child to turn his head side to side adds the demand to activate lateral flexion and elongation of the trunk, as a preparation for more active trunk responses in standing and sitting.

Elevating the legs places more weight forward and requires more trunk extension and holding as you bring the body weight over the hands. Intermittent support keeps the extension active.

clinician's view®

Neural Systems Integration:

Improving Performance in Children with Learning Disabilities

by W. Michael Magrun, M.S., OTR/L

"This book should be in the library of all rehabilitation professionals."
– William V. Padula, O.D., FAAO, FNORA

"This is a 'must read' for all therapists who work with infants and children."
– Josephine C. Moore, Ph.D., OTR, FAOTA, DSc. Hon. (2)

"This is a work that is sorely needed in the therapy professions."
– Christine A. Nelson, PhD, OTR, FAOTA, NDT Coordinator Instructor

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Integrating Neural Systems:
Improving Performance in Children with Learning Disabilities

Introduction

The foundation for skilled performance lies in the ability to match and integrate neural systems, particularly the visual, vestibular, and somatosensory systems. Within this triad, the infinite possibilities of movement, posture, and skill acquisition exist. Each system has fundamental characteristics that provide us with knowledge of our external and internal world. These sensorimotor systems allow for the dynamic process of matching information, re-weighting information, and integrating information that is task-specific and provides the foundation for learning through experience. Weighting and re-weighting refers to how the sensorimotor systems are intra-organized and how functional tasks, movement, and learning are a complex interplay between systems, not only in anticipation of the functional task, but within and during the activation and process of the task. The sensorimotor systems have interchanging responsibilities and varying levels of influence during task-specific performance.

Functional performance is both a top-down and bottom-up process. Function is driven by cognitive desire, orientation to a task, reactions to outside forces within the task and, of course, is learned through practice. Function is goal-specific and is therefore often described within a top-down model.

Function requires a foundation of musculoskeletal alignment, postural organization, and mechanical factors, to allow the initiation and the maintenance of a task-specific movement. Without this "dynamic foundation," there can only be splinter skill training. Practice on a misaligned, posturally disorganized base, will result in compensatory function and a learning process that is confined to the child's dysfunctional range of performance, thus, "splinter skill" learning. The sensorimotor systems responsible for organizing the underlying foundation for skill acquisition are sometimes described within a bottom-up model.

Obviously, we must always consider this interchange of functional initiation both from a volitional, or proactive learning process, as well as from a non-volitional, reactive supporting process. Both processes are simultaneously engaged in all performance and learning experiences. So it is fundamental to our clinical thinking to understand not only the success or difficulty of a functional process, but even more so the underlying efficiencies or inefficiencies that contribute to, and are the ultimate reasons for, success or failure.

This text will discuss each major sensorimotor system, its functional importance and influence on other systems. The concept of neural systems integration will be presented as a dynamic weighting and re-weighting process between systems that provides the foundation for skilled performance and learning. The concept of the visual-vestibular-cervical triad as a basis for neural system organization and integration will assist in the understanding of how neural systems interact. A problem in one system can result in compensatory inefficiencies. Each system leads, and is lead by the other systems, through

Comparator Systems & Internal Maps

This diverse processing allows for information to be compared (comparator systems) with efferent copies (corollary systems) and ultimately helps to develop an anticipatory nervous system prepared to initiate a process already knowing the outcome. Each experience stimulates a modification of the whole system so that there is a constant re-weighting of sensory organization (16). For instance, the amount of force and strength used to pick up a heavy object as opposed to a lighter object is anticipated and stability/mobility factors are initiated before lifting the object. Similarly, the anticipatory control and motor sequences initiated walking down a set of stairs knowing and anticipating each step prior to taking the step. It is why we are “surprised” when we expect an object to be heavy that turns out to be light as we initiate picking it up with too much force and must make a feed-back adjustment, and why we are “surprised” when we expect that there is one more step when there is not, as we abruptly “feel” the floor, instead of an additional step. We anticipate the force, amplitude, strength and movement ranges necessary to carry out a known task. We initiate feed-forward “proactive” sensorimotor sequencing. Feedback allows us to confirm success of the anticipatory initiation. When we are “surprised” the feedback is abrupt and alerting and we make reactive recovery and then reset a new anticipatory sequence.

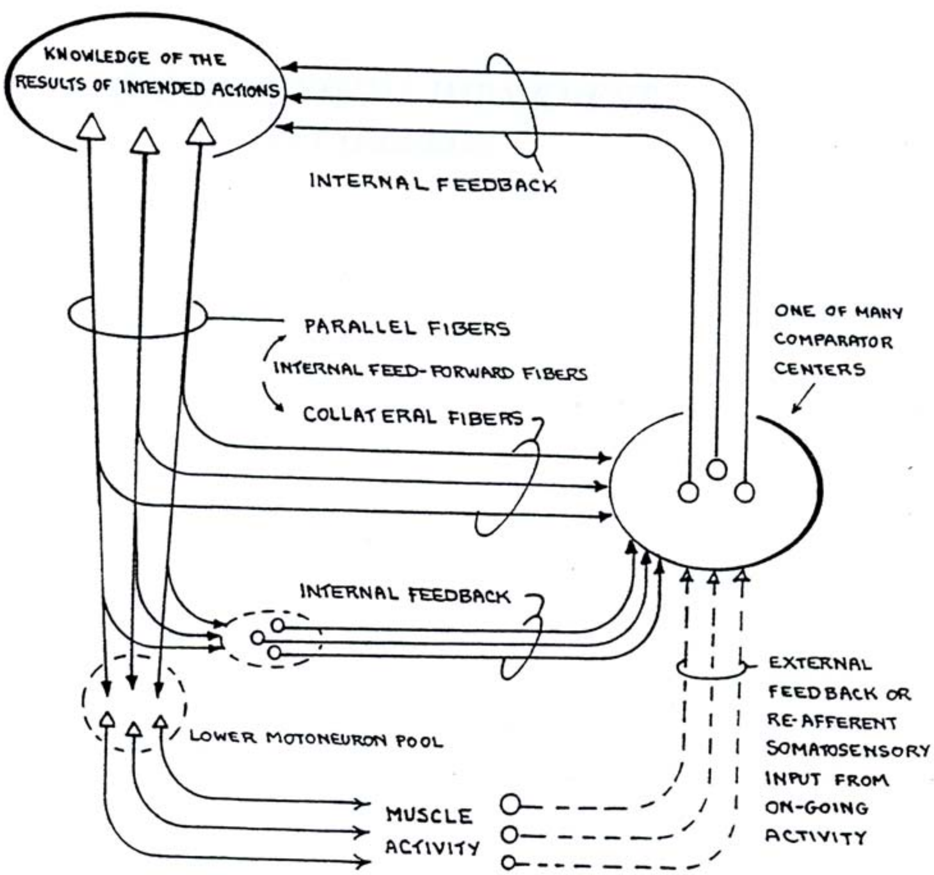
Internal maps, both sensory and motor, exist for comparing the external environment with internal perceptions and performance. This process results in matching of information that confirms the action or performance or identifies mismatching that requires adaptation and correction for a successful outcome. Comparator systems are both hard-wired and soft wired. Hard-wired comparator systems are those that are more basic such as reactive righting and equilibrium responses, reflexive reactions and basic automatic reactions necessary as a foundation for developing a repertoire of more sophisticated movement patterns. Hard-wired systems rely primarily on feedback. Soft-wired comparator systems are those that are built up through experience and environmental exposure to opportunity and experimentation. These comparator systems develop through repetition and the ability to interact spontaneously with the environment in a vast variety of ways and are less dependent on feedback than on feed-forward initiation of known outcomes (corollary discharge) based on its known repertoire of comparator circuits and internal maps. Corollary discharge disperses the intended action to comparator systems that automatically initiate feed-forward action and compare and correct ongoing activity. Figure 4 shows a schematic of the interrelationships between comparator and corollary discharge centers.

Figure 4. Comparator System & Corollary Discharge
Drawing by Josephine C. Moore, Ph.D., OTR, DSc. Hon (2)
Schematic of corollary discharge. Reprinted with permission.

FOR A GIVEN MOTOR COMMAND, THESE SIGNALS WILL BE SENT TO SEVERAL COMPARATOR CENTERS, AS WELL AS TO THE LMNs (LOWER MOTONEURONS) WHICH CARRY OUT THE COMMANDS.

3. THE COMPARATOR CENTERS COMPARE THE INTENDED RESULTS OF AN ACTIVITY WITH THE ON-GOING ACTIVITY AND MAKE INTERNAL CORRECTIONS IMMEDIATELY IF THE ACTIONS ARE NOT CONGRUENT WITH THE INTENTION.

B. COLLATERAL FIBERS AND PARALLEL FIBERS, ALONG WITH INTERNAL LOOPS ARE INVOLVED IN COROLLARY DISCHARGE. THUS THE CODED MESSAGES SIGNALLING THE INTENTION CAN BE DISPERSED TO SEVERAL CENTERS SIMULTANEOUSLY WHERE THEY ARE COMPARED WITH THE INTENTION, OR THE ON-GOING MOVEMENT, IF NECESSARY.



The Importance of the Neck

Neck control in children with learning disabilities has been documented repeatedly as being less than optimal and is evidenced by residual head lag and elevated shoulders as a compensatory stability substitution. In addition, difficulties in assuming and maintaining supine flexion and prone extension responses have been associated with vestibular dysfunction in sensory integration theory (10,11).

As previously stated, the neck is critical in the organization of sensory processing for motor performance. According to systems theory (1) at about 2 months, coordinated neck musculature action for posture is present. This is followed by the mapping of the visual system to the neck musculature, followed by the mapping of the somatosensory system to the neck, followed by mapping of the vestibular system to the neck. This priority mapping is significant for understanding the influence and importance of each sensory system to postural control and each other.

Once postural neck control is established in the first two months, vision becomes the driving force for the development of movement and posture up to around 7 years of age when the somatosensory system becomes more primary for postural control. This shift in sensory system "weighting" allows the visual system to become more involved with spatio-temporal awareness, feed-forward processes, and experiential learning.

An interesting study by Kennedy (19) supports the notion of the importance of the neck in adequate vestibular function. She placed normal 3, 5 and 6 year-olds on a rotating disk used in the postrotary nystagmus test developed by Ayres (12), with and without a stabilizing head device. The postrotary nystagmus responses of the 5 and 6 year-olds correlated with and without the device. The responses of the 3-year-old children did not. Their responses were much less organized without the device. This suggests that the postural control of the neck musculature, and its relation to trunk control at that age, is not sufficient to maintain the correct 30 degree alignment of the semicircular canals for a normal vestibular response to rotation. The important conclusion here to understand is that many children with learning disabilities have low-normal postural tone and reported poor neck co-contraction. The question arises as to whether vestibular dysfunction as reported in the sensory integration literature, is being confused with a lack of rostral neck control and somatosensory and visual matching to allow for vestibular responses to be organized. Most children labeled as having vestibular dysfunction in sensory integration theory are labeled based on clinical behavioral interpretations. These clinical behaviors, however, have other alternative interpretations that will be discussed.

Figure 5 shows residual head lag in a 5-year-old child inverted on a ball being pulled up to sitting. Several clinical assumptions may be made. There could be a possible vestibular dysfunction resulting in a lack of initiation of head lift against gravity. There could be a lack of neck strength and co-contraction resulting in the inability for the head to right itself in relation to the trunk. Since the stimulus for head lifting here is pulling on the arms, a somatosensory and joint traction stimulus (reactive response to external input), it is likely that the neck is not able to stabilize well to allow vestibular-visual information to assist and maintain the head position. And if we look carefully at the child's eyes we see he is not visually orienting to the plane of action. Eyes that are in a consistent upward alignment bias the body toward extensor tone. Eyes that are consistently in a downward alignment bias the body toward flexor tone. In addition, the head-back and neck-extended position is the most challenging for vestibular organization (20).

Figure 5

Five year old child being pulled to sitting from supine on a ball. Residual head lag evident. Neck does not activate to stabilize for head raising, therefore eyes do not orient toward the midline.

Figure 6a, 6b, 6c shows an 8-year-old child attempting to assume supine flexion after instructions and demonstration. Head lag is obvious in his attempt. There are several different ways to explain this clinical observation. There could be a vestibular dysfunction that results in poor activation of head lifting. There could be poor neck control resulting in the inability to elongate and flex the head/neck thereby diminishing the opportunity for the vestibular-visual systems to activate with the neck musculature to lift the head as the initial response to supine flexion. There could be a lack of visual alignment of the eyes to orient the head and signal the musculature and vestibular system to activate. Since the initiation was based on cognitive instructions and not ongoing movement, the response is proactive and therefore more likely to be a result of poor neck strength and/or visual regard interfering with necessary alignment to initiate the required plane of movement.

Figure 6a

Figure 6b

Figure 6c

Eight-year-old child attempting to assume supine flexion on command after demonstration.

Asking a child to assume supine flexion (proactive soft-wired response) is activated through anticipatory feed-forward mechanisms of the somatosensory system. Figures 6a-6b shows an inefficient response while Figure 6d shows an efficient somatosensory initiation with confirmatory visual and vestibular support.

Figure 6d

Ten-year-old child maintaining controlled supine flexion after initiating from a supine lying position.

When evaluating a postural response, it is important to be aware of the position and initiating stimulus. Slowly tilting a child backward will result in a graded flexor response to the change in the center of gravity (Fig. 7a). Quickly tilting a child backwards will

The Importance of the Somatosensory System

In addition to the importance of neck proprioception, somatosensory input from the rest of the body has also gained more attention. The somatosensory system is increasingly being suggested as a primary influence on vestibular function and balance maintenance. Cruthchfield and Barnes (29) state: “the vestibular system is not as critical to maintaining certain conditions of balance as was once believed, that is, balance is not provided by the vestibular system alone.”

Studies on muscle states, tension, golgi tendon organs and muscle spindles, indicate that proprioceptive information shapes reflex responses and is the root of postural maintenance. Further, proprioception was seen as the most important factor in postural alignment. (30). Alignment is so critical to balance and the maintenance of posture that structural integrity of the musculoskeletal system is the first thing that should be evaluated in order to determine its effect on postural control (29).

The base of support, namely the feet and ankles, plays a critical role in balance. Studies have identified the importance of the biomechanical constraints of the ankle and the importance of an ankle synergy in balance. Small perturbations do not challenge the center of mass and are easily handled by reactions at the ankle as long as there is a firm support surface and the outside force is not too intense (29). Ankle strategies do not necessarily require vestibular input to maintain balance. This is important when we evaluate children with postural disorganization in terms of the structure and activity of the feet and ankles. Poor structure will result in a progressive compensation through the legs and pelvis and trunk and contribute to a chain of inefficiencies in balance, movement and posture.

Hip synergies are activated once the center of mass goes beyond the control of a stable base of support. Hip synergies assist in activating vestibular responses. Horak et al. (31) indicates that the cutaneous and joint somatosensory information from the feet and ankles play an important role in assuring postural control and monitoring appropriate biomechanical constraints and once hip strategies are activated vestibular information along with somatosensory information contribute to the selection of postural movement strategies.

Shumway-Cook and Woollacott (1) describe neuroscience studies of postural control under various tilt conditions. In standing, when the tilt was small and the surface firm the primary balance reaction was initiated at the ankles (ankle strategy). In standing when the tilt was larger and the surface was a narrow balance beam, the primary reaction was initiated at the hips (hip strategy). When sitting on a surface without the feet on the floor, the primary response was initiated with the trunk (trunk strategy). These investigations were conducted without interfering with vision or vestibular conditions. In other words, different challenges require different postural responses. These responses require a flexible postural system in order to make the necessary adaptations to challenges in balance and equilibrium.

In the three above studies, the musculoskeletal system reacted differently to different environmental demands, suggesting that there is a selective process by which the somatosensory system reacts to balance challenges. These experiments involve hierarchical reactive conditions where balance is compromised from unexpected external forces. The ability to adapt to these postural changes is largely dependent on the integrity of postural tone, alignment, musculoskeletal strength, etc.

In addition, Mittelstadt (32, 33, 34) has recently reported the discovery of graviceptors in the trunk. These receptors are important in the perception of body posture and according to Mittelstadt, these somatic graviceptors equal or surpass the contribution of the otoliths and further contribute to the control of the posture of the eyes, neck and limbs. In order for the eyes and otoliths to know the spatial orientation of the body to vertical, the relationship of the position of the eyes to head to trunk must be known which is deduced through efferent copies measured by proprioception. Thus, proprioception mediates the perception of position that allows the sense organs in the head to orient to vertical.

If we think about how establishing trunk stability and mobility in children with both neuromotor and postural disorganization positively affect the quality and adaptability of movement, the importance of truncal proprioception to establishing alignment and therefore sensory matching becomes more evident.

In other experiments it was found that somatosensory loss increased vestibular sensitivity (31). The results suggested that under conditions of neuropathy or if the surface was unstable, the vestibular system was more sensitive to the control of posture. Interestingly however, this study reflects two different conditions, peripheral neuropathy or loss of proprioceptive information, and an unstable surface, or proprioceptive disruption. Obviously proprioceptive disruption results in a reactive state and therefore a more reflexive process. Vestibular sensitivity is thus logically increased to initiate trunk and head and neck reactions to maintain balance. Conversely vestibular responses are negated or dampened in self-generated (proactive) movement to allow adaptability and dynamic motor control and efferent feed-forward processes without disruption by constant vestibular weighting for balance reactions (35). Dynamic movement is context dependent and the interaction of sensory systems is completely different than in reflexive activity. In neuropathy, however, this increase in vestibular sensitivity is compensatory, not reactive. There is a loss of proprioceptive information due to the disease state requiring the vestibular system to compensate. Compensation is an entirely different process than integration.

Applying this notion to children with learning disabilities who are considered vestibularly over-reactive or over-sensitive, there may be a link or mismatch between poor organization of proprioception from the base of support, diminished somatic input, and vestibular reaction, rather than a vestibular problem. Diminished reception of somatic proprioception due to low tone, intolerance of weight bearing on a body side due to a visual midline or somatosensory midline shift, would likely result in an increase in vestibular sensitivity contributing to a hypersensitive vestibular state and therefore a matching of sensory systems under inefficient conditions; in other words, a mismatch of normal.

How do these concepts relate to children with movement and posture disorganization associated with learning disabilities? Because the V-V-C Triad may not be well organized and integrated, these children may not have developed efficient more adaptive sophisticated soft-wired comparator systems or internal mapping or signal coding. Thus they tend to function more stereotypical with less spontaneous adaptive motor planning (Figs. 19a-19d). Contrast Figures 19a-19d with the smooth, spontaneous adaptive motor behavior of a normal 5 year old shown in Figures 20a-20f.

Figure 19a

Figure 19b

Figure 19a shows a nine year old child playing with a toy. Notice the sitting posture, with rounded back and posterior pelvic tilt and wide base of support. Figure 19b shows an adaptation that maintains the wide base of support and posterior pelvic tilt and rounded back.

Figure 19c

Figure 19d

Figures 19c and 19d show the lack of variability of movement as the activity progresses.

Figure 19c shows the next adaptation consistent with a lack of variety. The legs stay in nearly the same position at the hips. Posterior pelvic tilt and flexion of the trunk maintain as the child moves over his wide base. Figure 19d shows the child's response to the toy moving away and pursuing it with straight plane movement and consistent posterior pelvic tilt. This response would not be expected in a child with adaptable postural control as it is inefficient for reaching forward to pursue a toy. The child's wide base of support never changes thus not allowing a more adaptive response using lateral displacement of the center of gravity or trunk rotation.

Figure 20a

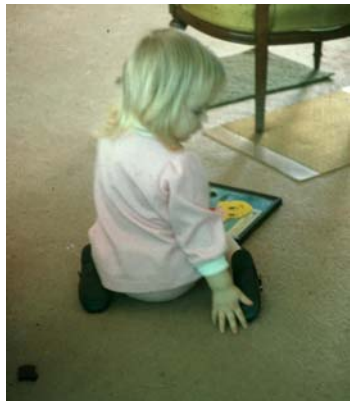


Figure 20b

Figure 20c

Figure 20cd

Figure 20de

Figure 20f

Figures 20a-20f shows the variety of adaptation at play of a normal 5 year old. Contrast the variety of postural responses to the figures above of the 9 year old. Note how this young girl naturally places her foot in contact with the surface for a stable pivot point. The legs adapt as the center of gravity is shifted and the arm is used for support as needed.

Stereotypical motor behavior is less versatile than dynamic motor adaptation. Reactive feedback responses are more inefficient for activating a smooth repertoire of movement responses that adjust to changing demands and show the lack of variety referred to as "limited" motor adaptations. Figures 21a-21h shows another example of what some call "poverty of movement" (4). The movement activity is limited in variety and adaptability.

Figure 21a

Figure 21b

The center of gravity is unable to shift over the base of support.

Figure 21c

Figure 21d

Simple lateral weight shift over the elbow but the long extensors are insufficient to lift the head.

Figure 21e

Figure 21f

Lack of adaptability in the trunk results in pushing the head against the surface to accomplish a change in alignment.

Consider the following example: The young adult in Figures 32a & b suffered a closed head injury. He was discharged from the hospital without any Neuro-Optometric assessment of his functional vision. This individual, as can be seen in Figure 32a, is unable to walk without losing balance, or leaning up against the wall for support. In fact he was "testing" with his foot for the surface before each step.

Figure 32a

Figure 32b

Figure 32a shows the independent walking of a young adult after closed head injury. There is obvious lack of balance and inability to shift weight to his left side.
Figure 32b shows the immediate results on motor control and balance after the introduction of prism lenses without any other intervention.

Dr. Padula then placed a pair of base right prisms on this individual, due to what Dr. Padula assessed as a right visual midline shift. Base right prisms have the affect of shifting the perception of space left. Figure 32b shows the immediate results with no other intervention.

This remarkable example should impress the reader with the importance of the ambient visual process in motor control. The somatosensory and vestibular systems had no problem relating to the new shift in ambient perception of space, clarifying that the problem was not a physical musculoskeletal-motor problem or a vestibular problem, but a visual distortion problem. This response can also be related to the confirmation by Josephine C. Moore and others that the CNS recognizes and is drawn to constellations of input characterized as "normal" (29). Due to the visual distortions and the dominance of the visual system in all movement, this individual's CNS related "normal" to be a shift of body orientation to the right. Applying vestibular therapy and/or physical handling to bring the posture back to midline, without changing the individual's perception of space would have been ineffective, if not frightening and potentially dangerous. This example should give therapists pause before applying treatment techniques without carefully evaluating the potential interaction of the visual-vestibular-cervical (somatic) systems.

Prism lenses are prescribed by optometrists to affect the way that space is perceived, and to affect how the body reacts to that change in perception. Prisms are 3-sided transparent pyramids that have a base and an apex.

The Importance of the Vestibular System

The vestibular system plays an important role in balance and postural control. The vestibular system, like the visual system and the somatosensory system, is a proprioceptive system. Integrating these three forms of proprioception is essential for efficient movement and posture.

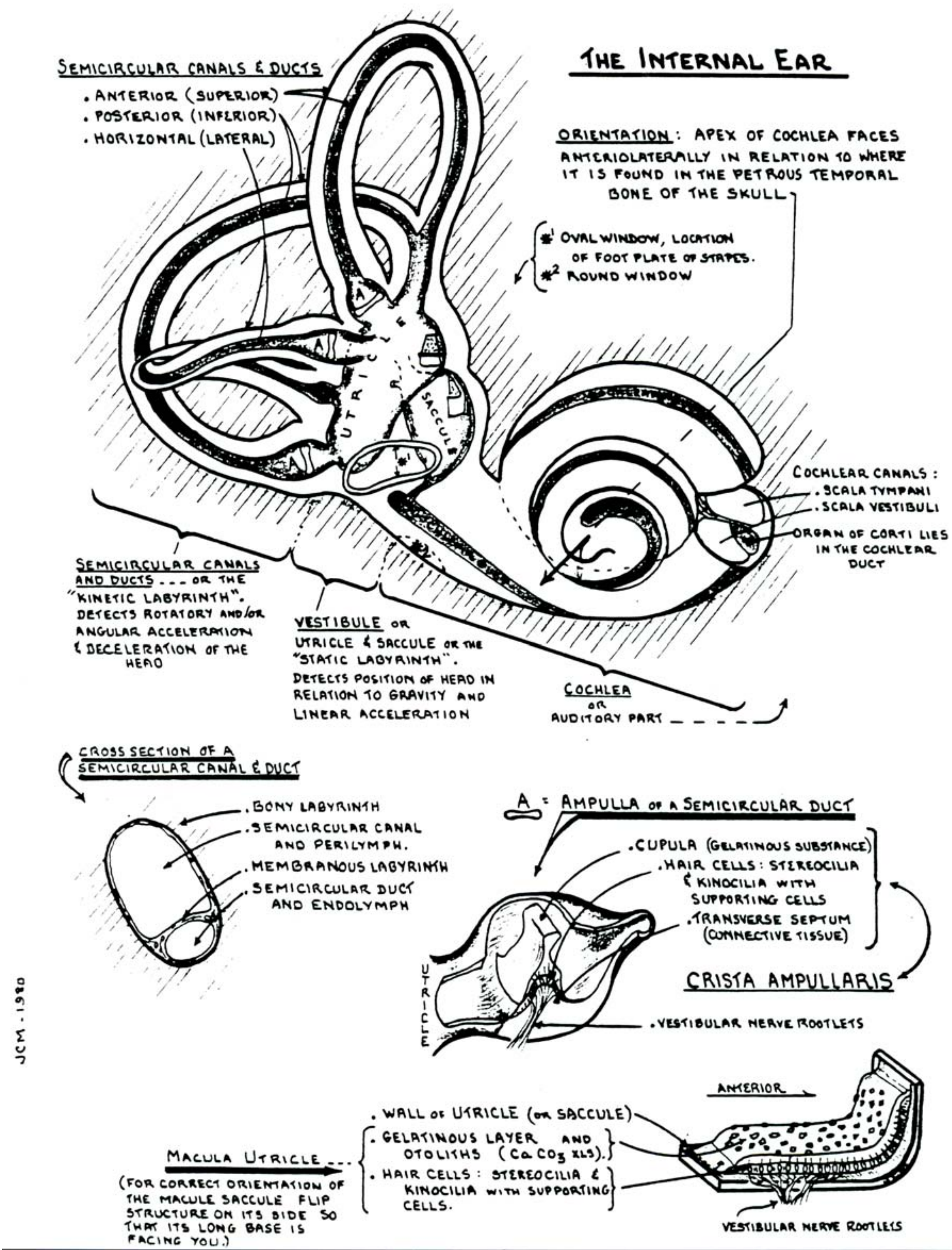
Functionally the vestibular system consists of parallel structures, the semi-circular canals and the utricle and saccula. The three semi-circular canals register rotational acceleration. Structurally each canal is located in a different plane such that rotational forces can be measured and integrated in all planes of movement. Within the semicircular canals is a receptor organ that reacts to rotational forces.

Within the utricle and saccula are the otoliths which respond to the force of gravity and linear acceleration. The otolithic organ in the saccula functions to keep vertical orientation to gravity. It measures linear accelerations of up and down and back and forth. The otolithic organ in the utricle responds to lateral or horizontal forces and registers linear accelerations side to side.

These five individual motion sensors work dynamically in all planes of movement to maintain balance and equilibrium, monitor motion of the head and neck, and stabilize the eyes relative to the environment. Normal movement involves all aspects of these five motion sensors. We rotate as we bend diagonally forward or back. We accelerate forward and turn our head laterally. We stop, start, turn, and constantly tilt and sway laterally, forward, and back. Every movement we make combines some aspects of the five vestibular proprioceptive sensors. And in order for this information to be relevant and efficiently used it must be matched with what is happening with the eyes, visual perception of space, the neck, and the body proprioceptors, both upper and lower body. So movement is an extremely complicated process and a harmonious dance between our proprioceptive senses. Each proprioceptive system is dependent on the other. Imbalances in any system will cause compensation by the others. In some cases compensatory responses maintain efficiency, particularly through the visual and somatosensory systems. However, many times compensations are inefficient and practice of inefficiency strengths the imbalances.

Understanding these interrelationships is important to observational assessment and treatment strategies. They must be appreciated in total. Much of our testing attempts to isolate specific aspects of our sensory systems, For example the vestibular-ocular-reflex (VOR) has historically received a large amount of interest as a way to determine vestibular dysfunction. And to some extent there has been an assumption of the dominant influence of the vestibular system to ocular control. Interestingly, the VOR is reflexive, while the visual system is responsive. The VOR is important for maintaining fixed gaze on an object. This is critical when chasing an object like a baseball, or running after an animal or a person. Fixed gaze is important to maintain contact with an object of interest and regardless of the bouncing of the head or effects of terrain on the movement, the eyes maintain stabilization. However, we do not always, nor constantly, move with a

Figure 39. The Structure of the Vestibular System
Drawing by Josephine C. Moore, Ph.D., OTR, FAOTA, DSc. Hon. (2)
The Structure of the Vestibular System. Reprinted with permission.



fixed gaze. We constantly shift our gaze, perhaps periodically returning to an object of interest but certainly we do not function through life with eyes fixed. Therefore the VOR is only helpful in certain situations. The VOR must be released or inhibited so that we can shift our gaze, scan our world, and attend to other stimuli within a task-oriented context (44). So the visual system can initiate through various pathways, feed-forward processes that regulate the vestibular systems reflexive reactions, while at the same time these reflexive reactions can be instantaneously invoked when needed to maintain gaze, then regulated to release. This dynamic interplay of volitional proactive movement intention, superimposed on underlying reflexive reactive responses, provides movement and postural control, intention, maintenance, recovery, adaptability and functional skill acquisition.

Rotational movement around the body axis involves the horizontal semicircular canals. There are no standard tests that can totally isolate the superior or anterior canals, so rotational tests measure only one function in the absence of actual body movement through space or in consideration of visual and somatosensory influences. So when we test for vestibular function using rotation we are attempting to evaluate the horizontal semicircular canals.

Otolithic organs are important to the organization of body sway and therefore weight shifts, which are a part of all movement. When we move laterally, the otoliths in the utrical provide inertial mass through the movement of otolithic-gel. This provides for a reactive righting response to maintain verticality. The otolithic organs in the saccula respond to gravitational forces in body sway forward and back and up and down. So when we are tilted forward or back, for example, we respond with head righting to maintain vertical. The two otolithic receptors of the utricle and saccula give us all three planes of movement to which we can react.

Again these responses are reflexive but can be volitionally inhibited or dampened in context-dependent tasks. For instance we use forward flexion to get up from a chair, to pick up an object from the floor, to get up from a lying position, etc. In actuality, many if not most movements we make comprise an initial component of forward flexion. We don't stand up by thrusting backwards, for instance. Therefore in proactive volitional movements we must dampen the utricular otolithic response. Similar to dampening the VOR, it is context-dependent. When we intend to get up from a chair, we set up efferent copies throughout the CNS and anticipatory muscle activation of the trunk, neck and lower limbs precedes the movement. The head goes forward and that "controlled" proactive inertial force is used to increase musculoskeletal reactions to take weight over the feet, stand and then return the head to vertical. This is completely different from having your chair unexpectedly tilted forward. Again there are proactive response initiated behaviors superimposed over reactive, reflexive support. In all movement there is interplay between these factors depending on the level of difficulty of the task.

The otoliths, like the semicircular canals, do not initiate movement but react to it. Volitional proactive movement is initiated through the visual system or through cognitive desire, and sets up potentials for activation of the somatosensory and vestibular systems.

Figure 40a and 40b depict differences in sensory organization between right and left foot balance. Figure 40a shows a more exaggerated (vestibular) reaction of the upper body while holding the legs together for compensatory proprioceptive stability. The right side does not participate in maintaining the body weight for the left foot to lift. This would be an example of a vestibular dominant attempt. Figure 40b shows better alignment and control on the left side but again holding and bracing with the hands and legs for compensatory proprioceptive stability. This would be an example of a proprioceptive dominant attempt.

Figure 40c

Figure 40d

Figure 40c shows relative success at right foot balance with the tendency toward compensatory proprioceptive stability seen in the posturing of the right arm, fisting of the right hand, and elevation of the right shoulder. Figure 40d shows an exaggerated vestibular reaction to the attempt to assume and maintain left foot balance. Again there is no clear weight shift onto the standing leg. Without a clear and controlled weight shift the vestibular system is more activated to attempt reflexive compensations. Contrast these examples with the example of a normal 5 year-old.

Figure 40e

Figure 40f

Figure 40e&f show a normal five year-old easily able to balance on either body side with a clear and controlled weight shift to the standing leg and without a vestibular reaction.

Physical Handling to Change Neuropostural Organization

Direct physical handling treatment, emphasizing normalization of bilateral weight tolerance, to establish more appropriate structural and body alignment, graded weight shifts, and the incorporation of rotational patterns, has shown improvement in posture and one-foot balance without specifically providing vestibular stimulation. Magrun (52), Nelson and Benabib (53) demonstrated improvements in postural organization and one-foot balance in children within 5-10 hours of treatment (figures 39a-39d). These postural changes were accompanied by reports from parents and teachers of improved behavior, school performance, and self-image.

Figure 41a Before

Figure 41b   After 5 Hours

Figure 41a shows the standing alignment of a 9-year-old prior to physical handling treatment. Figure 41a shows the change in standing alignment after 5 hours of treatment (consecutive daily 1 hr. treatment sessions). Notice the elevation and scapular abduction in Figure 41a and the relative improvement of shoulder and scapular alignment in Figure 41b. The head and neck are also slightly extended before treatment and there is better head alignment and neck elongation after treatment.

Figure 41c   Before

Figure 41d After 5 Hours

Figure 41c shows right foot balance attempt before physical handling treatment. Figure 41d shows the improvement after 5 hours of treatment. With more organized weight shift

The Concept of Multiple Midlines

Rotational components of movement, particularly with diagonal planes of movement are the “integrators” for graded controlled postural adaptations. These learned (“soft-wired”) components of postural movement integrate earlier more limited “hard-wired” reactions such as those that were described in the past as “primitive postural reactions.” They organize and utilize flexion and extension in terms of the degree and range of rotation.

Neuronal group selection theory (61) suggests that primary repertoires of movement and spontaneous movement patterns, such as described by Prechtl (62) are present at birth and are modified, secondarily and tertiarily into more variable and integrated movement patterns through developmental sensorimotor experiences. This concept correlates with the neuroanatomical concept of “pruning and tuning.” (Pruning and tuning is a phrase first coined by Josephine C. Moore, OTR, PH.D., FAOTA, DSc. Hon (2) as a description of how the nervous system matures and develops). Important in these more dynamic modified patterns are rotational components of movement.

Rotational components require dissociation of body segments and limb movements and therefore provide the variability and adaptation of responses that are required to generalize sensorimotor skill and direct it for learning. Rotational - diagonal movements require an integration of visual, vestibular, and somatic information. Rotational movements assist in integrating and making more efficient the matching of these systems.

Mary Quinton (63) eloquently described the development of these rotational and diagonal processes through her construct of “multiple midlines.” Rather than think only of one midline of the body that runs vertically from head to feet, Quinton suggested that there were other organizational planes, or “midlines” of the body. She identified vertical, horizontal, lateral, and diagonal midlines that she observed from her experiences in direct handling of infants with developmental challenges, over many years.

This concept is important because it provides an understanding of how dissociation and integration of early primitive patterns takes place and therefore provides the foundation for adaptive postural responses and the ability for unlimited modification of movement and learning.

As Quinton states, “*We think of a midline as a directed line of sensorimotor activity, a hypothetical pattern of activation, that moves along an axis in relation to which movements take place. It is a hypothetical line which lies at the center of a pattern of synergic activation and which later becomes a focus of organized integration. We may think of the midline as a line of energetic or dynamic activity that is the guideline for integrated movement. This new way of thinking about movement organization provides the therapist with a deeper understanding of the progression and integration of postural control as it develops in infancy…. To think of more than one midline for the human body is rather a new idea. We are accustomed to thinking only of the vertical midline that is recognized as the hands of the infant come together over the chest and in front of the eyes. Now we will develop an image of various midlines that play an active role in organizing the postural and movement control of the infant. The realization of this multiple midline organization* (in children with disabilities or disorganization*) occurs through active* *therapeutic handling. By considering and visualizing these hypothetical midlines, we can organize the sequences of developmental movement in a way that permits us to recognize incomplete or inadequate developmental patterns. On the basis of such observations the therapist can assist more effectively and directly, the infant, who has special challenges in development."*

Quinton suggested that midline development, through various planes of movement, organizes emerging "mobile-stability" of the head, trunk and limbs and is the foundation for function to emerge spontaneously through developmental experience. These midline organizational patterns integrate earlier, more primitive (less adaptive and more stereotypical reactions such as the ATNR, TLR, etc.) patterns, sometimes referred to in past literature as "primitive postural reflexes."

Vertical and horizontal midlines provide organized symmetry, while lateral and diagonal midlines refine sensorimotor responses that incorporate dissociation of body segments and in this way provide the possibility for adaptive postural control upon established vertical midline stability. Quinton felt that the development of these various midlines activated the "chain of righting reactions" and integrated them into more dynamic movement patterns.

Vertical-horizontal midlines refer to the vertical and horizontal axis of the body. The vertical axis is identified by the vertical arrow, and the horizontal axis is identified by the horizontal arrow (Fig43a).

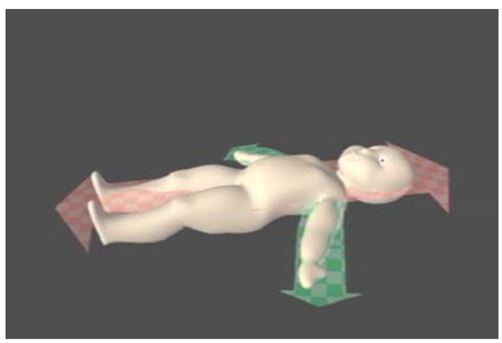


Figure 43a

There can be movement of the horizontal over the vertical as shown in Fig. 43b or movement of the vertical over the horizontal as shown in Fig 43c.

Ribs that are flared and do not coordinate respiratory adaptation with phonation or movement, cause trunk disorganization and impact postural adaptation and movement control (Figs. 47a&b)

Figure 47a

Figure 47b

In general we know that many children with movement and posture disorganization do not choose to spend much time in prone. This impacts the development of neck control, easy head turning, and elongation of the neck. It further results in a lack of antigravity responses in the chest and trunk, limiting lateral trunk movements and contouring of the rib cage. Lack of postural experience in prone negatively influences the organization of midlines and the adaptation of the rib cage for respiratory support of movement and mobility necessary for developing efficient rotational patterns. Lack of experience with sustained head/neck control in prone, normally seen well established by 3 months of age, will limit early matching of the visual-vestibular-cervical triad (see Figs. 15b &16).

Rotational patterns permit grading of our movements, provide skilled control of flexion and extension patterns, and integrate lateral weight shifts in a wide variety of possibilities. Rotational movement is one of the keys to organized motor control and provides the ability for graded use of dissociated movement. Rotational patterns permit the development of a well organized integration of visual-vestibular-cervical relationships. Rotational patterns do not develop their maximum efficiently without well established vertical-horizontal-lateral midline organization and structural and functional development of the rib cage.

Children with learning disabilities, as previously described, show inefficiency in rotational patterns, tend to move in straight planes with a wider base of support, and cannot control lateral weight-shifts well. These factors directly influence bilateral integration, coordination, and the efficient matching of the visual-vestibular-somatic systems, that are needed for efficient learning. Skilled movement requires graded dissociation of movement of limbs to each other as well as to body segments, in both lateral planes of movement, anterior and posterior planes of movement, and combinations of various planes of movement. Rotation through diagonal organization allows for an almost infinite variety of movement combinations.

the visual system persists past this point developmentally, it interferes with dynamic postural adaptation and becomes a visual-dependence pattern. Visual over-reliance will interfere with anticipation and therefore motor planning. The visual system will function more as a feedback system as opposed to a feed-forward system, thereby, inhibiting dynamic sensorimotor anticipation necessary for efficient learning and performance.

This same condition is often observed in children and adults with neurological disorders. Individuals with closed head or brain injuries become subject to their visual distortions, and the somatosensory system is unable to make proper dynamic postural adjustments because the visual system signals a spatial orientation that is incorrect. Without intervening visually, through orthoptics and prism lenses, there can be no rebalancing for efficient sensory matching between visual, vestibular, and somatosensory systems. Re-weighting will not take balance and functional performance will deteriorate.

An over-reliance on somatosensory information leads to a *surface-dependence pattern.* This condition relates to an inability to adjust to changes in surface inputs. When the surface is more challenging, such as on sand, an incline, thick carpet etc., the individual is not able to adequately use ankle or leg proprioception to maintain dynamic postural verticality. This causes balance difficulties which activates reactive processes and inhibit feed-forward anticipatory efficiency. This type of dependence is often related, not only to sensory issues but more likely, to biomechanical and structural issues as has been previously discussed. Regardless of appropriate vestibular or visual function, sensorimotor performance will be limited due a lack of an adaptive and efficient somatosensory system. Intervention that does not address the fundamental underlying biomechanical structure and alignment of the body will not be effective in improving functional performance, regardless of the amount of vestibular stimulation or visual therapy that is performed. Re-weighting of sensory systems, that must be dynamic and interchangeable throughout a functional performance, will not take place if the somatosensory system is limited in its ability to dynamically respond to the base of support.

When inaccurate information from one or more senses is experienced, individuals with *sensory selection* problems are unable to select a sense with accurate information to overcome the faulty sensory information. These individuals are best at maintaining balance and postural control when all sensory information is consistent and accurate. When there is conflict between sensory systems they are unable to maintain efficient postural control. The inability to make sensory selection under varying conditions inhibits the possibility for re-weighting of sensory influences required for efficient sensorimotor function. Under this condition, sensorimotor function is primarily reactive. Since there is a lack of dynamic re-weighting and sensory selection, feed-forward anticipatory proactive sensorimotor function suffers. This condition is observed in patients with CVA, TBI, and developmental disorders. It would seem logical that a primary focus in therapy would be to establish one primary sensory system that can be relied upon for matching of other systems. The primary system most powerful for orientation in space is vision. Establishing good visual orientation can help provide the ability to organize the other systems around the accurate information of the visual system.

Summary

How the neural systems match within a functional context will determine the efficiency or inefficiency of learning. If they are matching reactively, then there is a constant feedback process of dealing with outside influences. It is less adaptive and more reactive, within a feedback dominated context. When they are matching proactively, there is a feed-forward initiation of the adaptability of neural systems that is supported by the underlying reactive processes of the neural systems. The variations in the reactive and proactive nature of neural systems will assist in determining which sensory system may be “locked in” to a compensatory process that inefficiently matches with other systems, causing further inefficiencies. Changing the adaptability of that system leads to “unlocking” of the compensations of the other neural systems. Thus, a more dynamic matching can be guided through reorganizing how these neural systems relate, release, and re-weight.

Sensorimotor control and sensorimotor learning are dependent on appropriate sensory system matching between visual-vestibular-cervical and somatic proprioception. Sensory system responses are both reflexive (reactive to outside forces) and proactive (self-initiated behaviors). These two unique but intricately intertwined processes must be supportive, integrative, and able to shift and re-weight depending on the nature, demand, challenge or threat of an activity. To intervene effectively with children with movement and posture disorganization, it is important to understand this dynamic interplay. Preparation activities to establish musculoskeletal integrity may be necessary. Stimulation activities to arouse or activate systems may be necessary. Facilitating controlled equilibrium and righting reactions may be necessary. All these preparatory procedures, however, should be incorporated into meaningful transitions that allow the sensory systems to match effectively for efficient function. Physical handling that gradually allows spontaneous control by the child would appear superior in strategy than simply child-directed, stimulatory, compensatory practice, or other forms of intervention that do not specifically guide dynamic sensorimotor organization, and can often result in practicing and strengthening dysfunctional processes.