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A Neuropostural Approach to the Organization of Somatic and Vestibular Proprioception in Children with Learning Disabilities

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Learning Outcomes
The Participant Will be able to:

1. Describe the importance of the neck and trunk in somatosensory-vestibular organization.
2. Describe the concept of ankle and hip synergies.
3. Describe the difference between vestibular and somatosensory dominance in one-foot balance reactions.
4. Describe the general postural characteristics of children with movement and posture disorganization.

Introduction

Children with learning disabilities have consistently demonstrated postural deficits, including motor clumsiness, primitive reflex patterns, and inadequate equilibrium and righting reactions. (1, 2, 3) Postural deficits of body alignment, postural tone, general motor dyspraxia, poor bilateral integration and inadequate equilibrium and righting reactions, have been identified throughout the literature as important characteristics in children with movement and posture disorganization and learning disabilities. de Quiros (4) observed inadequate equilibrium and righting reactions in children with learning disabilities. He considered these difficulties as indicative of poor integration between postural shifts and the alignment of the head, neck and trunk.

Nelson and Benabib (2) considered automatic postural adjustments to be the basis for emergent motor skills. They and others (5-7) suggested postural integrity as a prerequisite to normal coordination and bilateral integration, not well developed in children with learning disabilities.

Postural stability has also been linked to adequate integration of sensory input. Moore (8) stated that the special proprioceptors in the head (vestibular) are dependent upon the position of the cervical spine. She considered the position of the head, based on its postural relationship to the trunk prerequisite to efficient integration of vestibular input. Cohen (9) found through research on monkeys that there was no possibility for the semicircular canals or otoliths to singularly inform the brain of the angle of the head to the body. He concluded this function could only be accomplished by the somatic proprioceptors of the neck and that without proper alignment of the head to the body through the neck, vestibular structures were at a disadvantage in participating in balance and equilibrium. Roberts (10) reported that the sense organs which provide the central nervous system with information regulating the head position and the impression of verticality are sensitive not to the direction of the pull of gravity, but the direction of the supporting contact force opposed to gravity (joint, muscle, and tendon proprioceptors).

Ayres (11) understood that proper alignment of the head to the trunk, through the neck, was a primary prerequisite to the integration of the vestibular system and that vestibular receptors can only tell the brain if the head has moved, not the body. She considered the integration of what she termed "primitive postural reflexes" necessary prior to the application of sensory integration activities that stressed vestibular input.

The organization of visual and vestibular proprioception therefore is in large part dependent on organization of the neck and somatosensory proprioception that allows the establishment of a stable neuropostural base and the integration of sensorimotor systems in the most optimum alignment and co-ordination.

Adler (12) suggests that alignment is a dynamic process of changing positional relationships as movement progresses. Compromises in alignment influence task accomplishment and the performance of skill. Since episodic performance is a critical necessity for building skill and performance success, the musculoskeletal system is a key factor. Sensory information may drive a motor response in reactive situations, such as changes in the BOS or an outside force, however without alignment and postural integrity, the proper response cannot be executed efficiently. Each activity requires a changing demand of postural alignment and musculoskeletal adjustments throughout the performance of an activity. Further through feed-forward mechanisms the body orients to the task. Postural orientation to the task helps to establish the appropriate relationship of the body to the task.

Klieban (13) states that postural control is essential to movement. It is the background substrate for movement and without postural control movement is limited. Posture is the alignment of body segments in relation to each other and orientation in space. Postural control is the activation and control of stability-mobility. Without the interplay between stability and mobility of postural control in relation to the base of support, efficiency and graded movement control are compromised.

Neuronal Group Theory (14) suggests that at birth there are primary movement patterns that are then developed through sensory experiences into secondary repertoires of movement. This is what Moore calls pruning and tuning the nervous system. If any sensory-motor system (somatic, vestibular, visual, musculoskeletal etc.) is not optimal, then sensory-motor experiences will result in compensatory postural development and a compensatory motor repertoire that may well be inefficient.

It is clear that the visual-vestibular-cervical triad, as identified by Moore (15) requires an intricate and changing process of matching and integration to provide the basis for upright control, balance, and functional outcomes. Within that triad, the importance of somatic proprioception and musculoskeletal alignment cannot be underestimated. The integrity of the musculoskeletal system and postural stability and control in alignment and movement is critical to sensorimotor integration. Moore suggests that the visual system is the primary integrator of sensory information and is dependent on cervical and somatosensory integrity to maintain optimal verticality for integrating information. Therefore establishing a neuropostural base can be assumed to be an important prerequisite to sensorimotor or sensory integrative activities.

Somatosensory-Vestibular Issues

The vestibular system his often been assumed to be the primary balance system. However motor learning research into body sway and balance under various conditions identifies the importance of vision and somatic proprioception in maintaining balance.

Nashner (16) studied the relative effects of the visual, vestibular and somatosensory systems through a series of experiments with normal adults that manipulated sensory information from one or more systems. Body sway was measured under six conditions. The least body sway was recorded with the person standing on a normal surface with eyes open. With vision occluded there was slightly more body sway. When a visual surround was added to provide false visual information sway almost doubled, suggesting that the vestibular and somatosensory systems were better at compensating with vision occluded rather than with false visual information. When a moving support surface was added so that accurate information about the support surface was no longer available but vision and vestibular information was accurate, body sway doubled again, indicating the importance of the base of support for activating postural reactions. The most sway was measured when only the vestibular information was accurate either with eyes occluded or with the addition of false visual information. This suggests that when visual information is absent or distorted the somatosensory and vestibular systems have more difficulty maintaining postural control, and that the vestibular system is not very effective by itself in maintaining postural control under these conditions.

In a similar experiment researchers (17) compared normal adults to adults with vestibular dysfunction. In conditions where vision and somatosensory information was accurate patients with vestibular dysfunction were able to maintain stability and only lost stability when vision and or somatosensory information was not accurately available. This might indicate that the visual and somatosensory systems are more primary to postural control and that the vestibular system depends on visual and somatosensory information to participate in or even activate efficient balance reactions.

Shumway-Cook and Woollacott (18) 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 an adequate postural system in order to make the necessary adaptations to challenges in balance and equilibrium.

Keshner (19) studied the relationship of head-trunk coordination during linear anterior-posterior translations. She concluded that “the vestibular system may act to damp later response components and to monitor the position of the head in space secondary to feedback from segmental proprioceptors rather than to generate the postural reactions.”

The lower extremities have also been shown to have an upward summation that incorporates ankle, hip, trunk, and neck afferents to the vestibular system (20). The ankle synergy is the first level of upright postural control and is able to maintain balance in small ranges on a firm support surface without activating hip reactions (18) and appears independent to head displacements of forward and back accelerations (21). When somatosensory information is disrupted by sway-referencing of the base of support, head displacements triggered responses in the leg and trunk, however it was concluded that it was “unlikely that vestibular signals alone can trigger directionally specific postural responses to support surface translations in standing”(21). Therefore if ankle synergies fail or they are inefficient due to either experimental distortions or presumably musculoskeletal inefficiencies in posture, there is an increase in hip synergy activity that relays information to the vestibular system. This further supports the importance of somatosensory efficiency within normal ranges of movement. When the base of support is challenged outside of the center of mass the vestibular system is activated to take reflexive action. It is worthy to note that Cruthchfield and Barnes (22) suggest that the integrity of the musculoskeletal system should be evaluated first in the presence of balance disorders to determine any possible limitations on postural control, and further that the vestibular system is not as critical as once thought in maintaining balance in under certain conditions.

Mittelstaedt H., (23, 24) has recently identified graviceptors in the trunk (lumbar and cervical area afferents) that have direct connections to the vestibular system and influence on the perception of posture in cooperation with the otoliths. The truncal graviceptors yield up to 60% of the total gain. They equal or surpass the contribution of the otoliths in the perception of posture.

Certainly the vestibular system is important in maintaining head to trunk alignment, contributing to the activation of equilibrium and righting reactions, and contributing to the maintenance of balance under certain conditions, however the clear implication to the growing number of research studies on the subject indicate that it is essential to establish postural control against gravity on a somatosensory/neuropostural basis to allow the most optimum integration of visual, somatosensory, and vestibular information.

Children with movement and posture disorganization have been identified as often having poor neck co-contraction.(11) Weak neck co-contraction inhibits the maintenance of the position of the head and its alignment to the trunk. Therefore, any assessments used to determine vestibular dysfunction in these children must take into consideration neck stability so as not to be misinterpreted. Poor neck co-contraction can often result in hyperextension of the neck which has been associated with cervical vertigo and in affecting proper integration of otolithic inputs. (25, 26)

Fig. 1 Inability to initiate forward head/neck flexion due to poor neck co-contraction

Weak neck co-contraction can interfere with the ability of the head to orient to the trunk and maintain proper alignment of the vestibular apparatus for integrating with vision and somatosensory systems.

Fig. 2 Elevated shoulders with a lack of neck elongation

Fig. 3 Loss of head control due to poor neck control

Elevated shoulders may indicate a compensatory form of stability due to poor neck co-contraction. This can be observed when there is exaggerated and severe loss of head control upon being tilted backwards.

Keating (27) and Nelson (28) claimed correlation between the SCPNT and electronystagmography (ENG). Their results indicated that nystagmus in normal subjects was equally well evaluated using both tools. Of course, normal subjects have presumably normal somatic proprioceptive control against gravity. The learning disabled subjects tested in the Keating study did not show test correlation. Further, a study by Kennedy (29) showed that a posture control chair added to the Ayres post rotary nystagmus test and the standardized test without the chair, achieved correlation of post rotary nystagmus findings in normal five- and six-year-old children. However, there was no correlation of findings in a three-year-old population. The author theorized this was due to the lack of developmental postural control in normal three-year-olds, required to maintain proper alignment on the test device without the postural control chair. The discrepancy was due to a lack of postural control of the neck and trunk at that age to maintain an alignment necessary for testing the horizontal semicircular canals during rotation. This study gives further support to the need to rule out postural disorganization of the trunk and neck before assuming a vestibular dysfunction.

In any case, in normal everyday activity and movement the head and trunk relationship is constantly changing dependent on demands of intent and outside forces, therefore semicircular and otolithic, inputs are constantly interacting with changes in posture, center of mass, visual and somatosensory inputs.. It is a dynamic changing process not easily explained and there is new evidence of both efferent copies involved in feed-forward mechanisms, as well as a re-weighting processes between systems during shifting task requirements and movement challenges that impact the relative integration of the sensory systems (30). This dynamic triad is not easily explained by a vestibular dominance.

The dependence however on the neck, trunk, and other somatic proprioceptors, as well as vision to the vestibular system would suggest that the important feature of sensorimotor function is in the matching of these three proprioceptive systems and the efficiency of re-weighting the relevance of sensory input throughout an activity.

One factor is clear. Regardless of visual and or vestibular input to balance and posture, without adequate postural alignment, structure, musculoskeletal integrity, adequate postural responses cannot be efficiently executed. Therefore as a first step toward integrating neural systems, it is important to establish a normalized neuropostural base (alignment, stability-mobility factors, weight distribution and tolerance and the ability to shift weight easily in all directions).

de Quiros (4) identified two types of vestibular- proprioceptive disorders in learning-disabled children during one-foot balance reactions: vestibular-proprioceptive dissociation with vestibular or proprioceptive dominance, sometimes occurring in the same child on different sides of the body. Children who evidenced proprioceptive dominance held their body parts close together: for example, fixing the raised leg to the standing leg for support; holding the raised leg to the trunk with the hands or arms. Vestibular dominance was observed as an over reaction to equilibrium demands and a lack of graded somatic proprioceptive input. de Quiros considered these phenomena indicative of a lack of integration between vestibular proprioceptors and non-vestibular proprioceptors. The resultant confusion between these two systems caused inadequate equilibrium and righting reactions. Based on the assumptions of de Quiros that one-foot balance indicates the status of the vestibular-proprioceptive systems, it would follow that children who evidence improvement in one-foot balance reactions after treatment may be demonstrating improved organization of vestibular- proprioceptive mechanisms.

Fig. 4 Normal right foot balance

Fig. 5 Exaggerated left foot balance reaction

In the above example this child has little difficulty initiating and maintaining one foot balance on his right leg, whereas he has significant difficulty initiating and maintaining one foot balance on the left side, using an exaggerated vestibular response.

Fig. 6 Right foot balance with somatic compensation

Fig 7 Left foot balance with vestibular compensation

In this example it is evident that this child is using proprioceptive input to maintain balance on the right side by holding his leg, whereas on the left side he shows an exaggerated vestibular response.

Research (31,32,33) has also described the process of motor planning and motor control to include self generated motor patterns. These motor patterns are not dependent on sensory input or stimulation. It is clear that, as well as the traditional understanding of sensory-motor processes underlying motor behavior, there is a parallel process of centrally generated patterns that are initiated as motor plans. These patterns are selected through inhibition from lower brain levels and spinal levels that control the various degrees of freedom of the body available for movement. Once these patterns are generated the sensory systems refine and guide the patterns into functional motor behaviors. Stability of the body against gravity through postural tone, reciprocal innervation and righting and equilibrium reactions, largely through the somatic proprioceptors, provides the postural background for the expression of self generated motor patterns and sensory-motor processes. It is this neuropostural foundation for movement that is the proposed basis for the treatment of movement and posture disorganization.

Assessing Postural Characteristics

The assessment of children with movement and posture disorganization is a process of careful observation and clinical trial. Emphasis is placed on identification of the child's postural characteristics and the ways in which these characteristics influence and interfere with the child's movement patterns and skilled performance. The purpose of assessment is to determine specific areas in which the child experiences a lack of control or difficulties in smooth graded movement transition. An adequate assessment leading to clinical intervention is largely dependant on a firm knowledge of normal movement and an appreciation of the various components of normal movement involved in any motoric act.

Various assessments can be used to gauge the child's performance in skilled areas such as writing, bilateral eye-hand coordination, visual-motor perception and the like. Many available assessments are standardized and can be used as a base line for performance, however they are not specific to the underlying causes for the difficulties assessed. For example, a child may score 2 standard deviations below the mean score on a test for stacking blocks in a time-referenced test. What does –2 standard deviations mean? How does that number help us understand underlying causes or plan treatment? Does the child have a "fine-motor" problem, a "functional-vision" problem, or "postural" problem? There is no means through a standardized test to assess the underlying reasons for performance problems. Is there a structural problem with the hand, in terms of arch control, or flexion, extension or rotation of the digits? Is there shoulder stability difficulty, a lack of good trunk control or pelvic alignment inefficiencies that contribute to fine motor problems? Does the child have a binocular vision problem, suppression of one eye that contributes to postural compensations, or the inability to maintain focus without fatigue? The reasons for performance failure cannot be determined through performance testing. Determining underlying causes for performance difficulties requires more specific clinical observation on an individual basis.

It is usually true that by the time a child with learning problems is referred for therapy, a number of conclusions have already been established by traditional educational and psychological testing. The typical disorganized child has general in-coordination in gross and fine motor performance and does not compete well with his more coordinated peers. There is usually normal intelligence. The child may be experiencing social or behavioral difficulties because of lack of success in academic and physical performance. There is typically a lack of variety in movement exploration or creativity in approaching motor planning tasks. More often than not, the child avoids certain activities such as sports, or structured activities requiring concentrated attention to detail. The child may be seen as disruptive, accident prone, hyperactive or withdrawn. He frequently is reluctant to try new tasks and often expresses the notation that he cannot do these things well.

Regardless of the developmental and historical litany the assessment must begin with the presentation of the child, and the characteristics of his movement and posture that may be contributory to his behavioral and performance difficulties. The object of the assessment is to identify areas of movement and posture that need intervention. The goal of therapy is specific to normalizing these factors and establishing a more organized postural base. Adequate compensations to performance areas can then become possible, allowing for an increase in success, self-worth and experiential risk necessary for progressive learning.

The observation begins as the child enters the examining room. Close attention is given to the general movement characteristics of the child. Is the child constantly moving and shifting weight? Is the child slow and lethargic in his entry? What special observations can be made while the child is sitting and standing? Is his weight preferred on one side of his body? Are the shoulders tense or elevated during static postures? Does the child move in straight planes or utilize good rotation during transitions from one posture to another? All these questions and others can be answered through observation of the quality of the child’s motor response, based on a clear understanding of normal movement and posture.

General Characteristics of Disorganization

Generally, disorganized children show a fairly consistent profile. Their postural tone is usually in the low normal range with selective tightness in the proximal areas of the shoulder and pelvis. They often have rather long trunks that appear low tone and sometimes there is a noticeable distortion of the thorax during speech or movement related to disorganized respiratory rhythm. Their shoulders appear pointed and there is sometimes a shortening of the musculature of the thorax, which probably contributes to respiratory disorganization. The scapulae are often pulled laterally or winged with poor dissociation of the arm and shoulder. There is either tension in the cervical area or a lack of good co-contraction. The arms often appear heavy and seem to hang from the shoulders and the hands sometimes lack definition and appear somewhat puffy and limp. The knees and elbows can appear hyper-mobile upon weight bearing with hyperextension or locking. There is usually asymmetry evident either in one shoulder lower than the other or more weight taken in standing on one side. The feet are often flat with poorly defined arches and a tendency to take weight medially. In movement there is often a lack of rotation that leaves the appearance of stereotypic movement patterns and a lack of adaptability in gross and fine motor activities.

The following photos illustrate some general aspects of disorganization.



Fig. 8 Standing alignment Fig. 9 Shoulder alignment Fig. 10 Passive arm traction

General characteristics often seen in standing alignment (Fig.8) include preference in weight bearing to one side, one shoulder higher than the other, trunk shortening on one side, neck shortening on the opposite side, and inactivity of the mid-trunk. A closer look at shoulder alignment (Fig. 9) shows the shortening of the neck on the right side, a slightly shortened trunk on the right side and unequal alignment of the shoulders with the left shoulder higher than the right. Often observed is the laxity of the shoulder joint (Fig. 10) as seen with the arms seemingly "hanging," providing a constant "passive" traction on the shoulder joint.

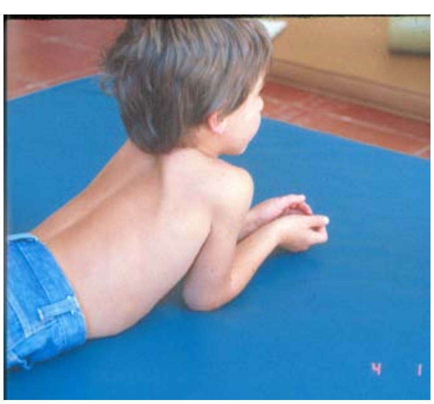


Fig. 11 Shoulder instability **Fig. 12 Respiratory compensations**

Fig. 13 Disorganized attempt at assuming supine flexion **Fig. 14 Example of poor structure of the foot** **Fig. 15 Example of poor structure of the hand**

Once General impressions have been made, a more systematic form of assessment can take place. Movement is generated by specific volitional intention, be it normal or compensatory. The components of a volitional sequence of movement patterns are automatic. If a child is asked to stand up, he will do so in a series of movement components automatic to his particular kinesthetic experience. That means that the goal of standing up takes on the active process of the child's already developed movement and postural base. If that base is compensatory due to disorganization, the child will demonstrate a response that will reveal basic deviations from a normal sequential pattern. For instance, in supine to stand, the child may not be able to raise the head strongly to lead the movement symmetrically. The shoulders may elevate off the surface in an attempt to get leverage, or the child may try to push off the surface asymmetrically.

Fig. 16 Example of poor neck co-contraction evident in severe head lag during an attempt to come to standing from supine.

Any number of compensatory components can be observed depending on the child. The particular set of compensatory patterns observed is not as important as the relationship between compensatory patterns. Theorizing how these maladaptive components are initiated and effect other movements is the key to a successful evaluation. In every case of observing a particular movement sequence, the examiner must consider basic musculoskeletal factors. These factors include the alignment of the body prior to the initiation of the movement, the first movement to be initiated, the postural tone of the body at rest, areas of the body where there is obvious tightness or increased tension (particularly in the proximal areas of the shoulders and hips), the transitional components of rotation which are present or absent and the alignment and weight distribution of the end point or end posture in that particular movement sequence. Each of these observations have problem solving value. A child who does not use much rotation in transition is usually trapped in a standoff between flexion and extension to support himself against gravity. A child who is observed to most often bear weight on one side will not easily incorporate bilateral action in movement transitions or initiate movement in an appropriate alignment. The side more normalized for taking weight will not move as freely or place as automatically during movement. The side not normalized for sustained weight will move more freely, but will not transfer the movement opportunity to the opposite side, thus over placing and moving ahead of the side responsible for the majority of stability of the body.

Figs. 17-19 This boy shows a tendency to prefer his weight on his left side. When asked to initiate and maintain one-foot balance on his left side he has little difficulty. However when asked to initiate and maintain balance on his right side (the less preferred weight bearing side) he has great difficulty.

 

Figs. 20 & 21 Here we see a child with poor alignment of the right side (the side less preferred to take weight) in right side kneel standing. When he stands he shifts his weight to his more preferred weight bearing side (left) and is able to establish good control and alignment.

 

Figs. 22 & 23 Conversely, here we see the same child with good alignment on his left (more preferred side) and when he stands shifting his weight to his right (less well organized side for weight bearing) he does not establish good control or alignment.

Critically important to the assessment is the activity of the neck and trunk. Often, the mid trunk is inactive and the neck is either tense from over-compensation (because of shoulder elevation and lack of thoracic trunk extension) or very inactive in the stable control of the head (due to the reliance on the shoulders to tense for upright stability in absence of trunk support). The inability of the head and neck to be freely dissociated during movement limits the availability of rotational patterns for smooth transitions during movement. Whenever any important areas such as head/neck/shoulder or hip/pelvis are not freely in dissociative harmony, there is inhibition to the natural transitional components of rotation which grade smooth movement sequences. Once compensation causes an over-reliance on proximal areas to maintain postural control, the trunk cannot fully express its dynamic functions of balancing weight shifts and grading transitional rotation.

One means to quantify the quality of movement responses, is through a criteria-based reference format. This format has been organized in ten sub-tests from supine to upright. Each sub-test lists normal and disorganized components for each movement sequence. Careful analysis helps the therapist recognize specific aspects of the child's motor coordination. (34)

Assessment is the key to good treatment and should lead to treatment implications. Performance testing is valuable for test/re-test data, but standardized tests rarely lead the therapist to an understanding of the process of the problem.

Intervention

Traditionally therapeutic intervention for the learning-disabled has centered around the remediation of underlying sensory-motor processes thought to be contributory to academic failure. Due to the complex nature of learning, both behaviorally and neurologically, it is difficult to establish an a priori relationship between motor skill and academic success. Further, any improvements reported over a long duration of intervention, such as an entire school year, are subject to criticism based on the possibility of maturation alone.

In order to study more carefully any relationship between motor function and academic success, the effects of intervention on a sensorimotor level must be established. Improvements in motor function should be documented in a period of time such that maturation of the child is not an issue. Once the effectiveness of therapy can be established on a physical motoric level the possibility of an association between sensory-motor integration and academic success can be more carefully considered.

Nelson and Benabib (2) were some of the first to document the use of NDT principles in the treatment of children with learning disabilities using a short-term intensive treatment strategy. They applied NDT handling techniques to children with movement and posture disorganization on a daily basis for one hour each day for five to ten consecutive days. They reported more normalized postural tone and stability in children receiving the treatment. They applied the basic approach of inhibition and facilitation techniques developed by Bobath (1). In addition to improved equilibrium reactions following the treatment, reports of improved behavior and academic performance were received from the children's parents and teachers. These reports were informal and although the teachers and parents felt that the changes were a direct result of therapy, no scientific data was available to substantiate the claims. Nevertheless, such reports at least imply the possibility of a relationship between organized postural control through integration of the proprioceptive systems and learning.

These results were reproduced by Magrun (3) in two case studies using the same NDT intensive short-term treatment strategy over a two week period. He reported improvement in balance and equilibrium as well as changes in behavior and learning skills reported by teachers.

As previously stated in this paper, in order for smooth motor performance to be possible there must be a neuropostural base to support that movement The following single subject studies show the before and after results on postural organization applying a neuropostural approach using NDT principles on a daily intensive basis for a two week period.

Single Subject Studies

The purpose of these single subject studies was to investigate postural changes (vestibular-proprioceptive in nature) after intensive short-term NDT treatment. One-foot balance was used as a before and after determinant for the study. All four children were treated daily for two weeks by a therapist certified in neurodevelopmental treatment.

Subject A was an eight-year-old boy who exhibited signs of low postural tine and motor awkwardness. Subject A received one hour of treatment daily for two consecutive weeks, excluding weekends, for a total of ten hours of treatment. Treatment was based on NDT principles. Physical handling techniques were employed for the entire therapy time. Inhibition of abnormal compensatory movements and facilitation of normal weight-bearing and transitional movements were the primary focus of treatment. Subject A was treated in supine, prone, and transitional positions up to standing. Emphasis was placed on increasing proximal stability of the shoulders through increased thoracic extension of the trunk. In addition, Subject A was guided through transitional movements and graded control of weight shifts with specific movement components facilitated by the therapist. Therapist control diminished as the child's reactions became more automatic. No one-foot balance training was incorporated into the treatment.

Fig. 24 Standing Alignment Pre-Treatment

Fig. 25 Standing Alignment Post-Treatment

Figure 24 shows subject A's standing alignment. Particularly noticeable is the generalized low postural base, protrusion of the scapula, protraction of the shoulders, and inactivity of the trunk, The shoulders appear passive, that is, not firm and holding; and there is a slight rounding. This posture has been found typical of children with low postural tine, many of whom also have been identified as learning disabled.

Figure 25 shows subject A's standing alignment after ten hours of treatment. There is the appearance of increased postural tone, particularly evident in the shoulders that appear to be more active in holding. There is less shoulder protrusion, more equal alignment of the shoulders, increased trunk activity and the appearance of better elongation and co-contraction of the neck. Although there is still evidence of scapular protrusion there does appear to be overall increased postural control.

Fig 26 Left foot balance pre-treatment

Fig 27 Left foot balance post-treatment

Figure 26 shows subject A's pre-treatment left-foot balance attempt and is indicative of what de Quiros has identified as vestibular-proprioceptive dissociation with vestibular dominance. There is an exaggerated lateral tilt, resulting in mal-alignment of shoulders and hips. The corresponding posture of the right arm is compensatory to a lack of non-vestibular (somatic) proprioceptive control on the weight-bearing side.

Figure 27 shows subject A's post treatment left foot balance. There is noticeably better alignment of the weight bearing side, consequently a markedly less exaggerated equilibrium response and more elevation of the right leg. The right arm is used much less as a counter balance. Although there are remnants of vestibular-proprioceptive imbalance, the overall response is considerably improved after treatment.

Fig. 28 Right foot balance pre-treatment

Fig 29 Right foot balance post-treatment

Figure 28 shows subject A's right-foot balance prior to treatment. He was unable to assume balance long enough for a photograph on repeated attempts.This may be indicative of an inability to grade weight shift to the right side and a need to maintain the legs close together for balance or an over-reliance on non-vestibular proprioception.

Figures 29 shows right foot balance after treatment. There is normal alignment of the weight bearing side, elevation of the left foot without any exaggerated equilibrium responses and the ability to maintain graded weight shift over the right side.

Subject B was a five-year-old boy who exhibited the typical low postural tone previously described. He was treated for one hour every day for a period of nine days, excluding weekends, for a total of nine hours of treatment. Subject B was treated with NDT principles primarily centered around facilitation of an increased postural base and the maintenance of postural shifts on different bases of support. He was treated in a variety of positions from prone to standing. No one-foot balance training was utilized during treatment. The primary therapeutic procedures involved intermittent support in small ranges of movements to facilitate graded postural holding and recovery of posture, facilitative pressure tapping to increase tone provided through the joints in positions of normal alignment, and resistive, heavy work positions to build joint stability.

Fig 30 Standing Alignment pre-treatment **Fig 31 Standing alignment post-treatment**

Figure 30 identifies Subject B's standing alignment pre-treatment. The shoulders and hips are not well aligned on the left side. There is an unequal distribution of weight with more weight taken on the right side. The left shoulder and trunk lean to the left. Figure 30 shows standing alignment post treatment. The alignment of the shoulders and hips are more equal on both sides. There is a more equal distribution of weight. The neck is elongated and there is a general appearance of more "readiness" of resting postural tone.

Fig 32 Profile pre-treatment **Fig 33 Profile post-treatment**

Figure 32 identifies subject B's profile. Notice the anterior pelvic tilt, abdominal laxity, relative inactive elongation of the neck, and general low-tone appearance. Figure 33 shows Subject B's profile post-treatment. There is less abdominal laxity, more neck elongation and slightly less anterior tilt of the pelvis.

Fig. 34 Left foot balance pre-treatment

Fig. 35 Left foot balance post-treatment

Figure 34 shows left foot balance pre-treatment. There is obvious difficulty maintaining balance. The right arm holds the right leg up, there is poor alignment of the left shoulder and hip, and an exaggerated counterbalancing with the left arm. Figure 35 shows left foot balance post-treatment. There is improved alignment of the left side, ability to hold the right leg off the surface, and a much more organized response.

Fig. 36 Right foot balance pre-treatment

Fig. 37 Right foot balance post-treatment

Figure 36 shows Subject B's Right foot balance attempt pre-treatment. He is unable to lift and maintain his right leg without holding it with both hands. His weight is shifted away from the balancing left leg and his head is turned to the right as a counterbalance measure. Figure 37 shows right foot balance attempt post-treatment. Although he still must assist his left leg the overall attempt shows marked improvement. There is better alignment of the right side and more elongation of the trunk on the weight bearing side.

Subject C was a nine year old boy who received daily treatment for one hour over a two-week period, excluding weekends, for a total of ten hours of treatment. Treatment for this subject focused on reducing muscle tightness proximally, particularly in the neck and shoulders due to fixing postures against gravity, followed by dissociation or mobilization procedures to achieve graded separation of the pelvis, trunk and shoulder girdle. Once this was achieved, transitional movements were graded for midline control onto and out of asymmetry, using weight shift and combinations of rotation with flexion and rotation with extension necessary for equilibrium and righting reactions.

Fig 38 Standing alignment pre-treatment **Fig. 39 Standing alignment post-treatment**

Fig 38 shows standing alignment pre-treatment. Notice the tightness in the shoulders and neck, abduction or "winging" of the scapula, elevation of the shoulders and general posture of the arms close to the body and legs together. Fig 39 shows standing alignment post-treatment. The shoulders are more relaxed, scapulae in more adduction and depression and more elongation and relaxation of the neck. The arms and legs are more relaxed.

Fig. 40 Profile pre-treatment **Fig 41 Profile post-treatment**

Figure 40 shows pre-treatment profile. There is elevation and tightness in the shoulders. Pectoral tightness is evident and the neck is not elongated. The pelvis is in anterior tilt. Figure 41 shows the post-treatment profile. The shoulders are relaxed and in better alignment. The neck is elongated and the head position more appropriate. There is the appearance of more abdominal activity and less anterior tilt of the pelvis.

Fig 42 Left foot balance pre-treatment

Fig. 43 Left foot balance post-treatment

Figure 42 shows pre-treatment left foot balance. There is a reliance on somatic proprioception evidenced by the raised leg bracing against the standing leg. There is inadequate alignment of shoulders, trunk, and hips. Figure 43 shows post-treatment left foot balance with excellent alignment, ease of raising and maintaining the elevated leg and separation of the raised leg from the standing leg.

Fig. 44 Right foot balance pre-treatment

Fig. 45 Right foot balance post-treatment

Figure 44 shows right foot balance pre-treatment. Notice the exaggerated equilibrium response indicative of vestibular over-reliance. There is poor alignment on the right side, and compensatory stability evidenced by elevation of the shoulders. Fig 45 shows marked improvement of fright foot balance post-treatment. Alignment is improved, raised leg position has improved and although he uses his arms out for a balance assist, there is an obvious improvement in somatic-vestibular organization.

Subject D was an 8-year-old boy with movement and posture disorganization and learning problems. He was treated daily for two weeks excluding weekends. Emphasis centered around reducing tightness in the chest and shoulders, establishing central trunk stability, rotational components of movement, and reducing compensatory arm and hand posturing.

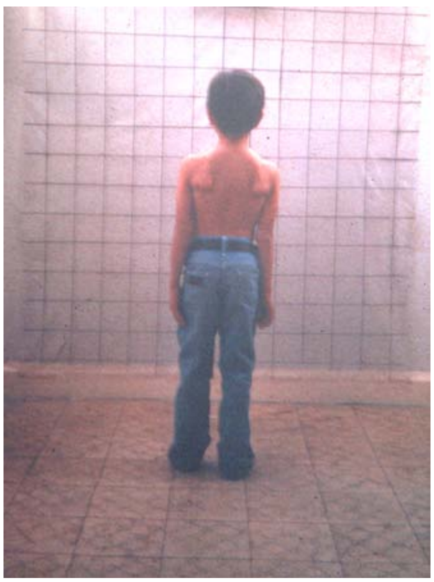

Fig. 46 Standing alignment pre-treatment

Fig. 47 Standing alignment post-treatment

Fig 46 shows pre-treatment standing alignment. Notice the tendency of the head to hyperextend, the inactivity of neck elongation, pointed shoulders, inactive mid-trunk, severely winged scapulae, and the positioning of the arms close to the trunk due to poor shoulder stability. Fig. 47 shows standing alignment post-treatment. The alignment of the head to trunk is more appropriate, the neck is elongated indicating better co-contraction and stability, the shoulders are more stable and better aligned to the hips with less scapular winging, and the arms are relaxed indicating better shoulder stability.

Fig. 48 Left foot balance pre-treatment

Fig. 49 Left foot balance post-treatment

Fig 48 shows pre-treatment left foot balance. There is not good alignment on the weight bearing side, tightness in the pectoral area is evident, the raised leg braces against the standing leg and the hip hikes up indicating compensatory hip hiking to raise the leg.. Fig 49 shows left foot balance post-treatment. There is better alignment of the shoulders and trunk to the hips without hip hiking on the right side and the appearance of a more active and balanced trunk with less restriction of the pectorals. Although there is still reliance on bracing with the raised leg the overall effort is much more organized.

Fig. 50 Right foot balance pre-treatment

Fig. 51 Right foot balance post treatment

Fig 50 demonstrates right foot balance pre-treatment. Notice the fisting of the hands, the elevation of the shoulders compensatory to an inactive trunk, and the tightness of the chest. There is the appearance of anterior pelvic tilt with the weight of the upper body forward over the hips. Figure 51 shows right foot balance after treatment. There is no longer any fisting of the hands as a compensatory stability posture. There is good alignment of shoulders, trunk, and hips. The head is more appropriately aligned over the trunk indicating that there is no need for a righting reaction to maintain balance. The trunk is more active with less tightness evident in the chest area and there is no anterior pelvic tilt indicating good weight distribution between upper and lower body.

The results of these case studies indicates that physical handling applied in an intensive, two week, short-term, treatment period using NDT principles, can be effective in normalizing equilibrium and righting reactions in children with movement and posture disorganization. The importance of establishing a firm neuropostural base against gravity is necessary for controlled balance reactions to emerge and provides the postural control needed to make an adaptive response. A good neuropostural base is critical prior to the use of sensory integration activities in order to provide the postural background for organized adaptation to movement demands with increased sensory stimulation. Without a normalized postural background the child will not be successful in making an adaptive response to sensory-based activity. More importantly, the above cases demonstrate that direct treatment on a somatic proprioceptive level may be more effective than emphasis on vestibular stimulation in achieving sensory integration. The children presented in the above studies did not receive any sensory integration activities involving linear acceleration or rotation, scooter board ramp activities, swinging in nets or platform swings or tilt board activities. Physical handling was primarily used to prepare more normalized postural tone, distribution of weight, more organized weight shifts, alignment and rotational components of movement. A therapy ball and roll were the only equipment used and the emphasis was on establishing more integrated and organized equilibrium and righting reactions to weight shifts and rotational movement demands.

Ayres understood intuitively that sensory stimulation should not be superimposed on a disorganized motor system. Although she advocated the integration of primitive postural reflexes prior to sensory integration activities, this concept was not effectively integrated into the treatment approach beyond reflex inhibiting postures. Further “reflex inhibiting postures” are limited in terms of establishing postural organization and differentiation of movement components. Sensory integration therapy does not emphasize direct physical handling or preparation techniques to increase, reduce, or reorganize postural tone and reactions. On the contrary, sensory integration stresses child-directed activities.

It is true that motor learning research suggests that self-directed activity is most effective in learning new motor skills. However it must be noted that a great deal of that research was performed with normal adults and therefore interpretation of motor learning theory must be carefully applied. Obviously without any preparation or postural reorganization, the child will likely be practicing any existing compensatory patterns and therefore reinforcing inefficiency and/or developing splinter skills.

In contrast, the handling approach described in this paper proposes direct physical manipulation to establish postural integration thus allowing self-directed activity to be more efficient, successful, and adaptable. Postural integration should not be confused with integrating primitive postural reflexes. Postural integration refers to the organization of movement, its component parts, and their transitional control, not a static inhibitory posture opposite the so-called primitive reflex. Although “primitive reactions” may be present they are most efficiently integrated through normalizing alignment, weight bearing and the introduction of rotational movement components.

Conclusions

Direct somatic intervention in children with movement and posture disorder associated with learning disability, presented in this paper, indicated more normalized equilibrium and righting reactions within ten treatment hours. The results imply a direct relationship between somatic integration and vestibular processing, and suggest that organizing posture and movement through direct physical handling may be an important pre-requisite to sensory integration activities.

Any intervention strategy must be able to demonstrate changes directly in areas that the treatment is designed to address. If treatment is targeted at postural reactions or sensory integration, changes in these areas must be demonstrated within a time frame short enough to preclude maturation. Further, academic gains in learning behaviors cannot be associated with therapeutic intervention unless the above changes can be documented. The above single subject studies demonstrated change within a two-week period and were followed by reports from parents and teachers of improved learning behaviors. Although the sample size is to small to make sweeping generalizations, the results suggest a more direct relationship between learning and postural integration and a more believable correlation between therapy and learning than is offered by forms of intervention requiring long periods of treatment.

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These are the verification exam questions to be answered when you click on Take Exam. For ease of completion select your answers prior to clicking on Take Exam.

A Neuropostural Approach to the Organization of Somatic and Vestibular Proprioception in Children with Learning Disabilities

CEU Verification Exam

1. Compromises in alignment can affect the efficiency of task accomplishment and the performance of skill.
   a. True
   b. False

2. Postural control implies the activation of stability and mobility factors for efficient and graded motor control.
   a. True
   b. False

3. Body sway studies by Nashner indicate that balance is primarily dominated by visual and proprioceptive information.
   a. True
   b. False

4. Children with learning disabilities often exhibit disorganization of posture and movement.
   a. True
   b. False

5. The neck is not important in the organization of visual-vestibular-somatic processing.
   a. True
   b. False

6. Children may show either or both vestibular or somatic proprioceptive reliance when attempting to balance on one foot.
   a. True
   b. False

7. Children with movement and posture disorganization may exhibit a preference for weight bearing on one side of the body and a lack of equal tolerance for weight bearing on the opposite side.
   a. True
   b. False

8. Neuropostural base refers to organization of alignment, distribution of weight, ability to weight shift and establishment of mobility and stability integration in movement.
   a. True
   b. False

9. A Physical handling approach the children with movement and posture disorganization attempts to establish a more efficient neuropostural base to provide a better opportunity for motor learning and the ability to initiate efficient adaptive responses to sensorimotor challenges.
   a. True
   b. False

10. Self-direct activity without an efficient neuropostural base may result in practicing inefficient compensatory motor behaviors.
    a. True
    b. False