Abstract - Transverse Myelitis Symposium, Seattle, August 12 - 15, 1999

The Use of Dynamic Orthotic Systems and Electrical Stimulation as Therapeutic Support Systems in Rehabilitation

Dynamic AFOs have been in process of development for over 25 years. These are thin and flexible polypropylene braces, functioning as a flexible exoskeleton which provides improved stability, balance and movement control at the ankle and foot. The orthosis permits yet controls small increments of physiologic ankle/foot motion to assist maximal rehabilitation and active use of residual muscle strength through the mechanical and postural chain. Flexible Compression Bracing is an extended system which operates around the same biomechanical and postural controls. Medium density custom contoured foam positional inserts have been used very successfully to produce improved stability, balance and movement control. Though all of these systems were originally designed to assist movement and tone control in children with cerebral palsy, they have been used with good success in spinal cord injury and other neurological impairments. Low intensity electrical stimulation and vibration can be used in a similar way to enhance information to deep sensory systems and thereby improve stability, balance and movement control. Recent research in neuroplasticity supports a tremendous adaptability and recovery power within movement control systems. Dynamic orthotic systems are a growing set of therapeutic tools designed to enhance biomechanical and postural stability and balance and deep sensory information to permit maximum recovery of functional movement control.

Development of Dynamic Bracing

Shoe modifications - Began 1970
Inhibitive casting - Began 1971
Transition to Ankle Height casts/AFOs - 1980
Continued development and refinement of Dynamic Orthotic Systems
- Early 1980's until the present time, including DAFOs, Flexible Compression Bracing, Contoured Foam and Low Intensity E-stim

Dynamic Casting and Orthotic Systems were developed as Therapy Tools to permit greater challenges to movement, balance and active stability in therapy situation and in daily life carry-over of therapy. Early experiences with C.P. transferred to other pediatric and adult neuromotor impairments and other conditions of instability&poor movement control.

Improved Midline Stability and Sensory Feedback appear to be the Primary Functions of these DAFOs/DFOs and other dynamic bracing systems.

Inhibition of hypertonus appears to be secondary to:

1. Improved active stability in mid-ranges of muscle function

2. Improved sensory precise informational feedback
   -- proprioception, deep pressure, precise touch and vibration

3. Improve and assist small (mm) graded amounts of movement and muscle control for better postural, balance and transitional movement control.

4. Permits damaged CNS to have more precise and greater amount of information to assist re-organization.

WHY??? Hypertonus, Tightness, Muscle Tension

1. POOR COORDINATION - limited movement and active stabilization options

2. POOR STABILITY - Low tone, ligament laxity, biomechanical (tightness covers underlying instability)

3. POOR PROPRIOCEPTION/DEEP SENSORY DEFICITS -

**Most often it is a complex interaction of many factors and layers of compensation
**Addressing the Primary Deficits provide the largest global improvements; addressing compensations tend to improve situation more locally, but the problem often re-emerges somewhere else.

(REFER TO PAGE 15)

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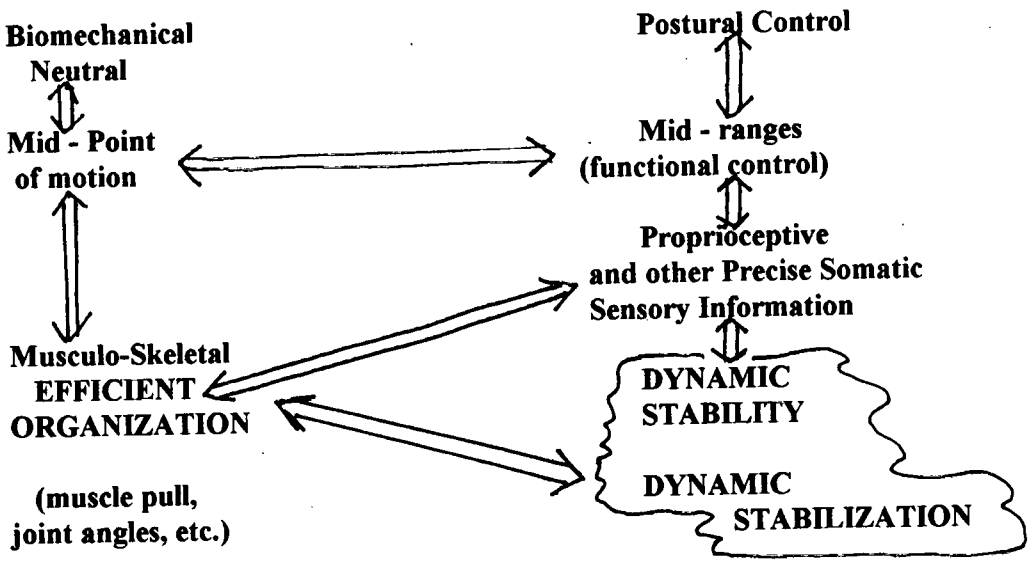
BIOMECHANICAL-POSTURAL CONTROL CONNECTIONS



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ONE ASPECT OF NEURAL ORGANIZATION

Somatic Inputs

EPICRITIC	PROTOPATHIC
****Environmental Exploration and Learning****	****Survival****
Proprioception (large, fast, heavy myelination)	**Light Touch**
Deep Pressure (small, slower, less myelination)	**Pain ("tickling" transmitted here)**
Vibration (small, slower, less myelination)	
Precise Touch (large, fast, heavy myelination)	

SPECIFIC INFORMATION for 3-D Body Map	GENERALIZED INFORMATION
Input is topographically specific.	**For Cortical, CNS Alerting**
**** one location on/in the body****	**** autonomic alerting****
connects with specific CNS location	***make us ready for danger***

neural.doc.....nancy hylton 9/98
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DYNAMIC AFOs and other high temperature molded DYNAMIC ORTHOTIC SYSTEMS

The development and specific use of DAFOs is dealt with elsewhere, but my earliest history came in 1969-70 as a young therapist searching for ways to have "more hands" available in treatment. Soft adaptations to shoes that managed excessive toe curling freed my hands to assist movement elsewhere. The current evolution has come through a period of "inhibitive casting" to the present over the ankle, extremely thin and flexible support system. This assists the foot and ankle in stabilizing movements around a defined midline orientation, using specific support and enhancement of natural dynamic arching systems. Quite by accident, we have discovered that **flexible is more tolerable**. Children who are so stiff that they have never before had successful orthotic wear, repeatedly find comfortable support in ultra thin DAFOs.

Polypropylene, though a very old plastic, is used because of 2 specific polimerization properties which are helpful.

1) **IT STRETCHES** - This allows the plastic to remain relatively thicker under the sole, around the heel and over the ankle for greater stability while being pulled much thinner over the top of the foot and under the toes for better tolerance and movement possibilities.

2) **IT HAS EXCELLENT MEMORY** - Due to the nature of the plastic polymer, when distortion occurs, the plastic has a strong rebound energy to return to it's original shape, even when it is pulled ultra thin . This **rebound memory** is quite helpful as a gentle but consistent assist to active movement control and alignment toward a midline positional orientation. Another interesting and helpful property of the plastic is that the greater the degree of distortion, the stronger the polymer rebound energy becomes. There is high dynamic corrective energy against extremes of distortion or extremes of joint positioning.

The beginning thickness of only 2 mm or 3/32 inch mandates generous flexibility which makes the brace fit as a **"flexible exoskeleton"** rather than a noticeable appliance. Extreme detail to precise volume, total contact, subtalar neutral alignment and midline foot/ankle orientation in the plaster positive mold produce a "glove like" fit. A woman of 34 years with moderate spastic diplegia once described her DAFOs feeling like a "pair of control panty hose". She then stated that with them on, she no longer needed to "worry about" her feet. If contact produces generalized rather than specific point support, the sensory experience will more likely be experienced 3 - dimensionally throughout the supported body part. **The combination of moderate tissue compression, precise total contact and very flexible support appears to provide very helpful organization to movement and postural control.**

Cascade Prosthetic and Orthotics in Bellingham, Wa. and many others have continued to explore the incorporation of greater flexibility into more traditional bracing systems with many good successes. Flexible body jackets constructed of polyethylene or plastizote and very thin polyethylene rather than more thick polypropylene are often tolerated much better in children who have some amount of active shoulder/trunk/hip movement. **Flexible body jackets** provide excellent control in the vertical dimension and the brace and person move together. Again the principle of **flexible exoskeleton** emerges. Traditional rigid body jackets can cause problems of pressure and rubbing because the person moves within a rigid orthosis.

Flexible polyethylene **circumferencial leg extension braces** have also experienced some very good success. Interestingly, when they are pulled of less flexible material, tolerance and

usefulness often decrease dramatically. Recent exploration into 2 new areas of molded high temperature orthoses are showing good preliminary results in the management of previously very difficult problems. A **molded total body orthosis** for very severely handicapped youngsters has been tolerated very well by several children with low tolerance for other types of support in standing. These are fabricated to permit slight twist flexibility and rebound into original orientation, giving excellent total body contact in a supported standing position. Another recent development is an **ultra thin polyethylene hand brace** designed to provide flexible and precise positional support, stability and fine movement control to thenar, hypotenar, thumb/index finger web space and the dynamic palmar arches. It is designed to be worn alone or with a SPIO Lycra Glove.

FLEXIBLE COMPRESSION BRACING

Among recent dynamic bracing advances that show good promise are very flexible systems fabricated of Neoprene or heavy weight Lycra. Neoprene has an obvious advantage in providing greater external mechanical stability, but distinct disadvantages in heat retention and wear comfort. Rectangular wraps of Velcro sensitive Neoprene of various sizes have proved extremely valuable therapy tools in our Center. They can assist elbow, knee or trunk extension stability during given therapy and functional activities. By giving the therapist or parent "extra hands", they permit greater challenges and activity possibilities for more severely involved children. These and other **Neoprene bracing systems are available through BENIK, Inc., Silverdale, Wa.**

Even more recent is the availability of a wide variety of heavy weight multi-directional stretch **Lycra Compression Bracing** systems. Though they do not provide as much external mechanical stabilization, Lycra bracing systems have advantages in conforming much more precisely to the body, comfort with direct application over skin and breathability of the fabric. In addition, one particular Lycra material used by **SPIO Works in Sumner, Wa**. has very excellent memory retention characteristics which appear very helpful in movement and postural stability and balance organization.

CONTOURED FOAM SEATING AND EQUIPMENT ADAPTATION AND DEEP PIN DOT SYSTEMS

Among the inexpensive and very useful low tech systems which we have used at our Center over the past 15 years, is custom contoured 4 inch medium density polyfoam seating inserts. High chairs, strollers, wheelchairs, swing seats, wagons, and classroom seats are some of the variety of situations that have succumbed to foam and a standard electric carving knife. In addition, comfortable custom contoured long-sitters, sidelyers, pronelyers are easily fabricated using multiple layers of foam glued together. The equipment is light weight and easily transportable for parents.

Like the other systems, the foam is cut to provide maximum total contact support in a midline shoulder, trunk and hip orientation. The softness of the foam permits some movement, but tends to rebound back to a more centered position. In this way, even children with very low

or very high postural tone are softly supported in a position that allows them opportunity to explore contained movement control around a controlled mid-position. They tend to become more active in exploring the limits of this soft control and this often happens within a few minutes. As active control improves, the amount of support is gradually lowered with emphasis on maintaining a stable base of support until the child can actively maintain this by themselves. In this way, we have seen many children discover and practice balance and postural strategies which helped them achieve functional independence in sitting. In other children, where such control is not possible, a more dynamically stable base allows more possibilities for active head, upper body and arm control.

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DYNAMIC AFOs and FO

PURPOSE: Provide improved foot/ankle alignment, stability, sensory feedback, balance, movement and tone control; very flexible and thin high temp. plastics provide a flexible exoskeleton which permits small increments of movement to aid active movement control and deep pressure/proprioceptive feedback. An improved base of support should permit improvement in general movement control, stability and balance to progress more rapidly.

TYPICAL USES: Replace standard SL or articulating AFOs, UCBs or FOs in ambulatory and non-ambulatory children/adults with neuromotor and musculoskeletal difficulties.

PROTOCOL: DAFOs - supra-malleolar support which allows some movement into plantar and dorsiflexion, used with moderate to very severe high tone, fluctuating tone and severe low tone or mechanical instability. Also used successfully with L-5,S-1 MM, Arthrogryposis, some MD and SCI, HI, CVA, MS, TM.

DFOs - precise underfoot contour with varying height of medial-lateral rearfoot support/stability around and under subtalar joint, used to assist mild to moderate high tone, fluctuating tone and mild to moderate low tone or mechanical instability. Forefoot can be surrounded completely (helpful in ataxia, and marked forefoot hypermobility with reasonable ankle control). Also used successfully MS, SCI, polyarthritis of RA.

RESULTS: Immediate:

- Slight to dramatic reduction in abnormal hypertonus and tone fluctuations in lower extremities and often generalized throughout the body
- Sometimes significant sensory and movement confusion with changes in positional control
- Enhanced shoulder/trunk/hip/knee/ankle/foot stability, grading, balance and movement control in response to spatial displacements
- Apparent improvement in useable deep sensory information from BOS, displayed in decreased tripping, falling, etc. and more general awareness of body position in space.

Long Term:

- Accelerated learning curve with improved balance, stability, grading functions and improved adaptive responses to new or changing situations
- Gradual decreasing dependency on the orthotic support to manage function
- Preservation of joint and soft tissue integrity of foot and ankle; generally improved ROM into active and passive lengthening of plantarflexors; sometimes similar effect in hamstrings and hip adductors

FLEXIBLE COMPRESSION BRACING

PURPOSE: Increased sensory awareness (position-in-space; limb/trunk;body center) through deep pressure and precise touch
Increased stability; contain Degrees of Freedom
Decrease and dampen external force vectors; contain motion through increased soft tissue compression around joints; (perhaps increased internal pressures)

PROTOCOL: Always DAFOs or DFOs for more stable Base of Support
Person has movement management problems connected connected to decreased stability or decreased sensory awareness

PATIENT GROUPS with Positive Response:

Low Tone or Athetoid or Ataxic - Shoulder/Trunk/Hip Instability
High Tone: Quadriplegia, Hemi, Diplegia - Decreased Shoulder/Trunk/Hip Stability or Major Sensory Deficit forcing high tone
Autistic/PDD with major deficits in body awareness
Specific Syndromes (ie. Rett, Angelman) with major deep sensory and proprioceptive deficits
Spino-Cerebellar CNS Degenerative Diseases (ie. Friedericks Ataxia)
Post Severe Asphyxia or Head Injury - severe deficits in body awareness sensory information and head/neck/shoulder/trunk/hip instability
Transverse Myelitis and other spinal cord injuries- especially where poor stability/decreased proprioception affect function

RESULTS: Immediate:
Increased active Head/Shoulder/Trunk/Hip movement control
Increased grading and adaptation of movement, balance, etc.
Decreased hypertonus - proximal and limbs
Decreased Latency of response - sometime very dramatic!
Long Term:
Increased Learning Curve for movement/posture/balance adaptation (They like it!)
Increased functional movement control

Possible Biomechanical and Neuro Mechanisms for Flexible Compression Bracing: Food for Though!

Though the insights shared here can certainly be considered highly speculative, they are offered as possible mechanisms for the functional changes which we have observed in hopes of stimulating more thought and exploration in this area. At a wonderful 3-day course in February 1996 called "The Brain in 3-Dimensions", instructor Shelby Clayson, MS, OT casually shared some information during a break which has profoundly stimulated my thinking. My question to her was concerning any neurophysiological connection between deep pressure and proprioception. Her response both astounded and excited me! Not only were **proprioception** and **deep pressure** specific somatic inputs to an organization within the CNS designed for **environmental exploration and learning**, but this system also included **vibration** and **precise touch** as additional somatic inputs. An alternate organization designed for survival and protective functions included inputs of light touch and pain. Proprioceptive feedback deficits can be because of a primary deficit or because of inconsistent and poorly coordinated muscle activation disrupting the sensory feedback loop. Could it be that persons with these deficits are able to receive helpful information from vibratory and deep pressure receptors that enable improved functional movement control? Is this the link that makes Flexible Compression SPIO Bracing change functional control so quickly for some individuals?

If it is so, and my experience and intuition makes a strong connection to this piece of information, then one possible mechanism for the functional improvements that we have seen with Lycra is both direct deep pressure from contact with the skin and increased internal soft tissue pressure impacting both mechanical stability and pressure receptors. As the deep pressure receptors give more usable information to the Proprioceptive Feedback System, positional limb and body awareness is improved. The person is then able to direct movement and specific muscle activation more precisely. By observation, the little boy with Angelmann's Syndrome, appeared to have very little idea of where the edge of his body ended and the air began. Lycra Bracing from wrists to ankles with double compression through the trunk and across the shoulders, perhaps permitted him to better " feel and place his body in space." Increased light touch from the don of the top and bottom portion of the brace, caused a hypersensitive 'fidgety' and 'disorganized' response initially. This response was however temporary and changed quickly to a more attentive, interactive and deliberate demeanor within a few minutes. The latency response time for body righting to weight displacement on the therapy ball was reduced almost immediately from a 15-20 second average down to 5-10 seconds. With don of the SPIO, he opened his eyes wider, gave me direct visual regard and smiled. It was as if the Lycra suit "gave him better ownership of his body."

Some of the **biomechanical mechanisms** are fairly easily seen. Overstretched abdominal muscles can not contract as easily as those which are being held in a less stretched mid-range. Neoprene Cylindrical wraps around arms, legs and trunk exert a direct force against collapse from gravity in weight bearing and upright. Though the direct effect may be more subtle, Lycra also must have some dampening effect on external force vectors which are acting across joints, especially those with multiple degrees of freedom. This permits a slightly longer reaction time and contains overshooting so that the system has the possibility to become increasingly more predictable rather than less predictable.

Increased stability assisted by increased internal pressure on soft tissue structures, also in some cases probably plays a roll in the improved loading of joints which is seen. It is a well known fact that increased intraabdominal pressure provides improved anterior spinal stabilization. Abdominal muscle sets are taught for this reason to be used before and during heavy lifting to support and protect back structures. It makes sense that similar increased soft tissue pressure around shoulder and hip/pelvic girdle areas could be equally helpful in improving joint stabilization and reducing troublesome vector forces. The effect seen in the young girl with spastic diplegia in Louisiana might be an example of this mechanism. An independent walker with forearm crutches, her instable hips snapped and popped with each step. Double thickness SPIO Compression Bracing from the level of the lower ribs to her knees, immediately stopped the popping and clicking sounds and excessive hip lunation movement and improved both gait comfort and efficiency.

Another mechanism which may be contributing to the functional improvement seen, relates to the alteration of external forces. In a conversation with biomechanist, Gad Alon Ph.D., PT, he commented that among all of the force vectors acting to make life difficult for persons with movement control problems, external vector forces are probably causing the biggest problems. By dampening these forces, containing and supporting movement and force generation, persons with neuromotor control problems may be assisted in their ability to redirect force vectors more effectively into

supporting surfaces. The **more predictable and adaptive base of support** may be account for the improved functional movement control which we have observed. **Greater predictability of movement control and force generation** might allow the person more possibilities to experiment with combined muscle activation in a greater variety of combinations.. This may partially account for the initial and continued more rapid learning curve for movement, stability, control and balance seen in some children with the addition of SPIO Bracing to an already established therapy intervention program. It may also account for the observation that even though function is improved with SPIO Bracing on, improved control generalizes over time to situations without brace wear. **The dependency curve appears to lessen with wear instead of increasing.**

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MEDIUM DENSITY CONTOURED FOAM ADAPTATIONS

PURPOSE: Provide improved midline stability, allowing small increments of movement and recovery assist after displacement

TYPICAL USES: Chair adaptations, long-sitters, supine/side/prone position assist (ie. highchairs, car seats, swings, strollers, bath seats, grocery cart, etc.)

PROTOCOL: Total inability to manage sitting/positional control ----------
- beginning independent motor skill, rapid fatigue or deterioration of movement quality without support (C.P., Spina Bifida, MD, Hypotonia, Transverse Myelitis, etc.)
- Fidgety, wiggly kids (mild to minimal) - sensory or stability deficit -appears to increase attention and quiet body

RESULTS: Immediate:
- Increased active Head/Shoulder/Trunk/Hip control - increased functional play with hands, eating, swallowing
- Increased endurance - active in position
- Increased tolerance to position
- Decreased hypertonus (hamstring, adductor, full body extension or flexion)

Long Term:
- Accelerated Learning Curve with improved quality, adaptive, grading of movement, balance, etc.
- Decreased dependence upon support - gradual self maintaining of the quality of movement/posture/balance control

Mechanical Assists to Sensory Feedback: Improving Body Awareness, Postural Stability and Muscle Readiness

LOW INTENSITY THERAPEUTIC ELECTRICAL STIMULATION

Thanks to a therapist friend, Karen Karmel-Ross in Cleveland, I became interested in the use of electrical muscle stimulation in the late 1980's. Though her published work focused on improved quadriceps strength and gait in children with Spina Bifida, my interest was focused more on possibilities to assist other postural groups to activate more readily and simultaneously. Karen's shared knowledge about flexible low impedance electrodes allowing much better tolerance of the sensation of ES in younger children, was very helpful. Through a small grant, 2 Statodyn EMS2 units and enough 1 1/2 X 3 inch Encore electrodes were purchased to allow each of 6 therapists a trial each with single child during therapy sessions. The results of up to 4 site simultaneous stimulation, using bifurcation lines, were fascinating.

Messing with electrodes and wires soon took it's toll on the interest level of several of my colleagues, but the very positive results with one 2 year old boy with spastic diplegia, a 10 year old girl post selective dorsal rhisotomy, a rather cantankerous 12 year old body with hemiplegia and severe left side neglect and a 2 1/2 year old girl with T-10 Transverse Myelitis spurred my continued exploration of this therapeutic medium. Travis, the 2 year old with moderate spasticity and movement control deficits, was just beginning to attain free standing balance in therapy. Firm manual input to abdominals, gluteals and quads seemed to help him find and activate the muscle groups simultaneously, but he was unable to sustain this for longer that a few seconds on his own. Low intensity(2-2.5 on a scale of 10) ES to quads and gluteals, increased his ability to activate and sustain activity in these muscle groups to support balance, single and dual support stance many fold. Interestingly adductor spasticity faded from high moderate range to mild when the ES was turned on and I was able to challenge Travis to work his legs in much more difficult ways. Though he also needed verbal cueing, independent controlled non-propulsive steps emerged in therapy with the ES on. Over the next 2 years, Travis moved through marginal free ambulation to secure free ambulation and running. His function was so dramatically improved with the ES that I felt obligated to let him borrow a EMS2 unit for home use. Soon, thereafter, as parents were preparing to purchase more expensive EMS2 unit, we discovered that an inexpensive TENS unit worked equally well and the family purchased this for 1/10 the cost.

Deep sensory information provided by low pulse rate (30-60pps) low intensity TES supports improved muscle activation and active control, not only in the groups stimulated, but in adjacent posturally connected muscle groups. Travis described it once, "I can feel my muscles. It goes bam, bam, bam, bam!" Another older boy with moderate diplegia remarked that it made his "muscles fizz." Still others could feel nothing , but active loading over legs, balance and postural stability in upright was significantly improved with the TES.

In addition to improved deep sensation, there may also be a direct subcontractile effect which improves the readiness state of the muscle and supports continuation of active contraction for postural synergies. Persons with neuromotor control deficits appear to have more difficulties controlling eccentric (stabilizing and decelerating) muscle contractions which are common components of postural loading strategies. Concentric (movement generating) contractions appear easier, perhaps because they provide inherently more proprioceptive feedback.

Mechanical Assists (cont.)

More recent availability of the **Octostim Unit** which was designed by a man with cerebral palsy specifically for this TES function. The unit allows individual adjustment of stimulation to 8 sites and is a much more flexible TES for this use and is available form the developer, Robbie Freiler in Santa Cruz, CA, Fax: 408-475-8478.

VIBRATION AND OTHER MECHANICAL SENSORY ASSISTS

Low pulse rate (60 - 100 cps) vibration also appears to provide helpful deep sensory information as to muscle awareness and location for improved activation . The positive response of even very young children to this type of vibration, especially that with a very strong, almost obnoxious beat, has prompted our curiosity and informal exploration of sensory deficits being major contributors to motor control problems. For a long time, many manual neuromuscular treatment systems have used various types of manual inputs which produced among other things, changes in muscle and joint pressures, mechanical displacement of skin and changes in limb, joint and body alignment. Attempts to explain changes in motor activity with specific input have probably been limited at best. It may be time with our new understandings of dynamical systems organization to revisit some of these treatment modalities and try to understand how they might be contributing to any changes seen.

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THERAPEUTIC ELECTRICAL STIMULATION (our system)

PURPOSE: To promote a better Sensory/Active Stability Base for balance and movement control

PARAMETERS:
- Low Intensity; sensory (initial awareness to tolerance only); subcontractile
- Low Frequency: 40-60 pps (patient directed); continuous
- Electrodes: Low impedance, stainless steel mess, broad dispersion (Encore)

PATIENT GROUPS:
- C.P. Diplegia - Quadriceps, Gluteals (also sometimes lower abdominals and/or plantar flexion)
- Hemiplegia - Gluteals, Quadriceps or PF, arm, scapula
- Quadriplegia - Lower abdominal obliques, quadriceps, gluteals, UE (scapula or biceps or triceps)
- Transverse Myelitis - T-10 partial (hamstrings and gluteals) - 1 child
- Spina Bifida - Quadriceps or PF
- Non-Progressive Anterior Horn Cell - Hypotonia - (abdominal obligues, gluteals, quadriceps, UE triceps) - 1 child

PROTOCOL:
- Always DAFOs or DFOs to improve Base of Support
- Actively work muscle groups together in treatment to Enhance Sensory Feedback and Muscle Activation
- Some are wearing 2-4 hours/day, 4-5 days/week

RESULTS: Immediate:
- Increased awareness of muscle groups
- Increased ability to actively contract and sustain (Eccentric/Postural) contraction
- Increased endurance
- Increased muscle power
- Decreased hypertonus (sometimes in distant muscle groups)
- Increased functional movement control

Long Term:
- Accelerated Learning Curve with improved quality of movement
- Increased ability to adapt and grade movement, balance and postural control with functional gains becoming less marginal and more secure

Why hypertonus? This is an important question which is too little asked.

It is our opinion that hypertonus is primarily a compensatory phenomenon. There are at least **three primary deficits** which may be causing this response in persons with neuromotor disturbances.

a) Deficits in motor control reduce available movement and coordination options. By tensing certain muscle groups around certain joints, the person makes the movement system more predictable and useful and eliminates the need for very fine movement adjustments.

b) Where there is increased biomechanical instability from hypotonia, ligament laxity and other soft tissue systems, muscle groups can be tensed to provide improved stability.

c) Deficits in proprioception and deep sensory awareness make it very difficult for the person to "feel" limb or whole body orientation. By tensing specific muscle groups, especially very large muscles crossing multiple joints, the person gains some improved body awareness or produces more forceful loading into weight bearing surfaces.

In children with C.P., it is nearly always a complex combination of these factors. As with all of us, **emotions** whether positive or negative, **apprehension** in unpredictable or precarious situations and **anticipation** of injury can also be power contributors to increased muscle tension. If any of us very able persons were perched on the top of a 200 foot flag pole in a wind, we would immediately become quite spastic in our whole body. On an icy ski slope with limited visibility, we tend tostiffen in a way associated with spastic diplegia. If someone were to push us backwards off the edge of the Grand Canyon, we would all have a full MORO reaction. Even thinking about these situations can bring a queasy feeling in our stomach and increased emotional tension.

It is again my opinion that sensory awareness deficits comprise at least 50 % of the movement control problems in persons with C.P. For some it is as much as 95 % of the problem. Helping them to manage these sensory and stability deficits should permit for some dramatic improvements in there functional motor control.

It is our job not to give false hope but to systematically work to help them find these new movement possiblities at any age. The CNS is designed for tremendous learning and adaptability

Nancy Hylton Biographical Sketch

Nancy is an assistant NDT instructor who has studied under Dr. and Mrs. Bobath for both Adult hemi and Refresher courses, Mary Quinton and Dr. Kong for Pediatric and Baby courses, as well as, numerous other U.S. and foreign CIs for Advanced NDT courses. She has been a pediatric PT for 30 years, graduating from the Univ. of Washington in 1969 and has been actively involved in the development of inhibitive casting and dynamic orthotics over the last 28 years.

She has taught in Canada, Mexico, Finland, Germany, England, as well as, throughout the U.S. and has published articles on dynamic orthotics in the Neurology Report, Journal of Prosthetics and Orthotics, and the Finnish national PT Journal Fysioterapia. She has also authored the chapter on Lower Extremity Casting and Orthotics in the book The Practical Management of Spasticity in Children and Adults.

In 1979, she co-founded the non-profit Children's Therapy Center in Kent, Washington which now serves over 200 children and their families, as well as consultation services to some adults. Though the Center has focused on very early infant intervention, Nancy has also had considerable experience in treatment of adolescents and adults with cerebral palsy, as well as consultation for orthotics in adult HI, CVA and other neurological conditions.

As parent of an adopted son with cerebral palsy, Nancy feels that problem-solving his everyday needs has taught her a great deal about therapy follow-through and adapting daily activities for improved movement and function. Nancy has two adult daughters and is currently hosting her 14th YFU exchange student.