NDTA Network

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PEDIATRIC ORTHOPEDICS

Developmental Orthopedics, Part IIIb

FRONTAL-PLANE DEVELOPMENTAL CHANGES IN THE TORSO AND HIPS

By Beverly Cusick, PT, MS, COF

In Part 1 of this series [*Network*, March/April 2006], we reviewed the influences of normal, strain—inducing, mechanical loads on developing bone geometry and joints. In Part II [*Network*, July/August 2006], we examined the connective and muscle tissues in similar contexts, with a discussion of the relationship between the history of muscle recruitment and clinical evidence of muscle imbalances and soft tissue transformation. In Part IIIA [*Network*, March/April 2007], we examined musculoskeletal changes in the spine and lower extremities as they emerge in the sagittal plane.

This segment addresses comparable changes in the frontal plane—the plane that divides any part of the body into front and back segments. We appreciate frontal-plane postural features and movements by looking at the front or backsides of the body. In this article, I've organized the discussion of frontal-plane skeletal modeling events to follow developmental postural and functional changes in order to better illuminate the modeling process.

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HOW TO TEACH NDT

Teaching NDT in the Entry-Level Professional Curriculum

WHEN AND HOW TO PROVIDE FEEDBACK

Robert Wellmon, PT, PhD, NCS

Almost all entry-level curricula that prepare students for professional practice include an introduction to principles of Neuro-Developmental Treatment (NDT). Devoting sufficient time to the exploration of those principles, however, particularly the hands-on psychomotor applications, is a challenge for faculty working in the academic setting. An ever-expanding scientific knowledge base, which determines the amount of content that must be covered and the need to prepare students to practice in a variety of settings, limits the time available for teaching any one particular treatment approach. Using NDT effectively in the clinic requires both extended practice and mentorship. Entry-level students can have difficulty understanding how to apply NDT principles in both the classroom and clinical setting for a variety of reasons. When questioned, students easily demonstrate a basic academic or cognitive familiarity with NDT principles. But translation to clinical practice and the acquisition of the psychomotor and clinical decision-making skill are elusive. This may be due to students' relative lack of experience working with more complex patients, such as those who have neurological dysfunction. In the clinical setting, students attempt the implementation of handling skills that are neither fully explored nor mastered. Additional processing time is required to identify primary patient problems based on observations of patient performance and the evaluation of clinical data from the examination.

> **Students easily demonstrate a basic familiarity with NDT principles, but translation to clinical practice with psychomotor and clinical decision-making skills are elusive.**

Entry-level students do not yet possess the highly honed clinical decision-making skills to appropriately adapt and scale interventions "in the moment" in response to patient performance, which is an important part of using NDT effectively. Finally, students have difficulty providing feedback to patients, frequently relying on highly detailed, movement-specific verbal explanations. Inadequate time is allowed for the patient to process the feedback and there is little attention paid to the systematic follow-up evaluation of the patient's use of the information provided.

This article will highlight three potential areas for fostering growth and provide some suggestions on how to teach NDT to entry-level professional

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INSIDE THE NETWORK:

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The elements of this discussion that pertain to the acquisition of antigravity movement skills in infancy are based upon the work and writings of Lois Bly.[1]

FRONTAL-PLANE NOMENCLATURE

Frontal-plane motions are typically described using the Latin prefixes ab (away from) and ad (toward), and pertain most often to the shoulder and hip joints (think jumping jacks). At the foot, however, frontal-plane motions are described as inversion and eversion—turning or deviating toward (in) or away from (e) the body midline.

The adjectives used to describe lower extremity (LE) alignment and bone geometry are these: vara, varum, varus, valga, valgum and valgus. Vara pertains to an alignment feature in which the inferior aspect of a bone or joint is deviated medially toward the midsagittal plane of the body. Valga is a condition of lateral deviation of the inferior aspect away from the midsagittal plane.[2] The Latin suffix "um" assigns the feminine, and "us" the masculine gender to the object described by the term. So you may choose a gender for the proximal femur (coxa valga), the knee joint (genu valga), the tibiofibular segment (tibial vara), the calcaneus (subtalar valga), the forefoot (vara or valga), and the hallux (valga), if you wish. Tip to remember which is which: va**L**ga is **L**ateral.

THE FRONTAL-PLANE TRUNK AND PELVIS: ANTIGRAVITY SKILLS EMERGE

Supine and Prone: By age 2 months, spinal mobility increases as a result of the mechanical influences of handling, positioning, and gravity, combined with normal muscle weakness. Central nervous system (CNS) maturation adds an asymmetric tonic neck reflex (ATNR) in response to head turning, featuring face-side elbow, hip, and knee extension and skull-side flexion of the same joints. These gravitational, mechanical, and neuromotor factors bring about a transient period of generalized hypotonia, with an associated, flexible and variable frontal-plane postural asymmetry. However, the spine at 2 months remains relatively immobile in the frontal plane (Fig.1). Frontal-plane truncal asymmetry diminishes in the third month (Fig. 2), and resolves to symmetry in the fourth month (Fig. 3).

Next, neck lateral flexion emerges as a head turn toward the face-side of the skull, "reaching" with the eyes toward an object of interest (Fig. 4). This face-side neck "flexion" –actually a predominantly unilateral neck extension—leads to face-side lateral trunk "flexion" and loads the upper limb on the face side.

The "ingredients" of bilateral, symmetrical, antigravity trunk and neck extension and flexion then combine to produce antigravity lateral neck and trunk flexion (Fig. 5). The skull-side weight shift emerges as a means of unloading—and reaching out to play with—the face-side arm and hand. The more distal consequence of this head displacement backward and laterally is a lateral displacement of the center of mass (COM)—located in the lumbar region at this age—toward the skull side as well, and a shift of weight to the ipsilateral side of the pelvis.

Fig. 1

Fig. 2

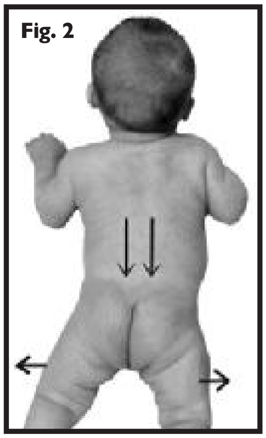

Fig. 1. Age 2 months.

Fig. 2. Age 3 months.

Fig. 3

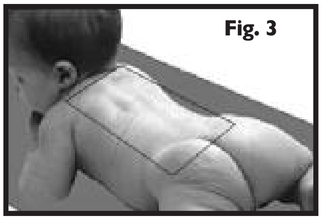

Fig. 3. Age 4 months. Frontal-plane symmetry. **Fig. 4.** Age 5 months: Face-side weight shift. **Fig. 5.** Age 6 months: Skull-side weight shift. **Fig. 6.** Key to locomotion: a skull-side weight shift toward the left side. Right hip adduction will be used to move into quadruped.

Fig. 4a

Fig. 4B

Fig. 5

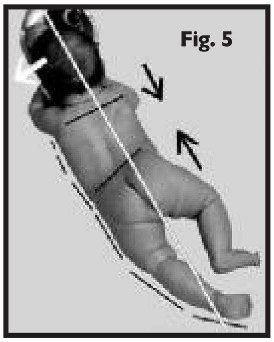

Fig. 6

The *skull-side weight shift in prone* activates the righting reaction that calls in the trunk flexors on the face side, promoting and producing a concavity of the unloaded side of the spine with flexion of the unloaded (face-side) lower limb. This movement pattern manifests the first integration of extension and flexion and is a *necessary precursor to successful locomotion.* By removing a measure of body weight from the face-side limbs, the face-side arm is freed for play or for locomotion, and the lower extremity flexes and

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Fig. 7

Fig. 8

Fig. 7. Antigravity neck and trunk flexion appear in rolling prone to supine, and initiate from supine to prone. **Fig. 8.** Age 26 months, born prematurely, **Fig. 9.** No skull-side weight shift skill → drag crawling.

Fig. 9a

Fig. 9b

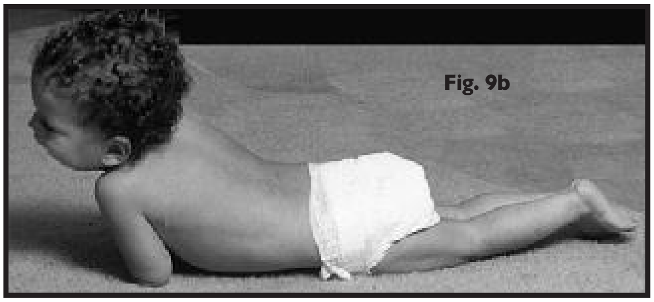

Fig. 10

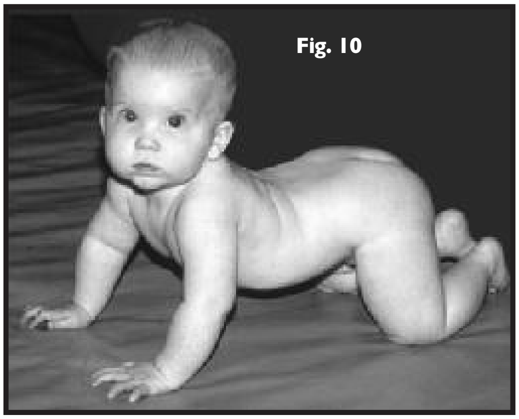

Fig. 10. Normal early quadruped with wide BOS.

abducts to assume the position required for propulsion, as in belly-crawling, and for assuming the hands-and-knees and sitting positions (Fig. 6). These positional transitions and locomotion skills typically develop between ages 6 and 8 months.

Though the period of belly-crawling is brief—typically beginning in reverse-locomotion, then lasting from a few days to two weeks—the achievement of frontal-plane trunk and neck movement presents an opportunity for the unloaded hip and knee joints to engage in weight (i.e. floor)-resisted extension, abduction and lateral rotation. Full term gestation in classic fetal position causes the hip abductors and lateral rotators to begin to work against resistance while aligned in shortened position. Coincidentally, the underlying lower-extremity bones and joints endure the dynamic modeling loads of compression, tension and lateral torque.

Around age 6 months, head lifting in supine and side-lying position – true lateral neck flexion against gravity—emerges with the transition from side-lying and supine to prone (Fig. 7).

Clinical implications of failure to achieve lateral weight shifts in prone position:

Example (at left): *Nicholas, age 26 months, exhibits hydrocephalus and moderate quadriplegic CP. He was born prematurely, before gaining normal, full-term LE soft-tissue constraints and joint alignment—the biomechanical base for acquiring bilateral, symmetrical antigravity trunk extension. He recruits neck and lower extremity extensors, in part to manage his oversized head while viewing his environment (Fig. 8).*

Lacking the essential movement ingredients of antigravity trunk extension and flexion, he does not execute a skull-side weight shift in prone. So, he must drag crawl, relying primarily on his shoulder extensors and adductors for propulsion (Fig. 9).

Sitting: At ~6 months, the infant gains positional stability by "ring-sitting"—a LE posture featuring hip and knee flexion with hip abduction and lateral rotation. The soles of the feet approximate each other. Between ages 6 and 10 months, the wide base of support (BOS) narrows, accommodating a more dynamic stability. Lateral weight shifts emerge over the vertical pelvis and are magnified by the reduction in the width of the BOS. Extension and flexion components are gradually integrated into frontal-plane righting reactions, and equilibrium responses appear in the torso and lower extremities.

Quadruped (at left): Between ages 7 and 9 months, the infant assumes the hands and knees position from prone lying, via a skull-side weight shift leading to flexion of the face side lower limb (Fig. 6). Adduction over the flexed hip becomes a significant contributor to the acquisition of the all fours position for play, and later, for locomotion. The hip abductors and adductors coactivate with the hip joints in flexion, abduction, and lateral rotation – beginning again on a wide BOS that reduces the range of movements possible to the sagittal plane (Fig. 10).

Transitions to Upright Postures: Between ages 8 and 12 months, most infants can kneel-stand with hand

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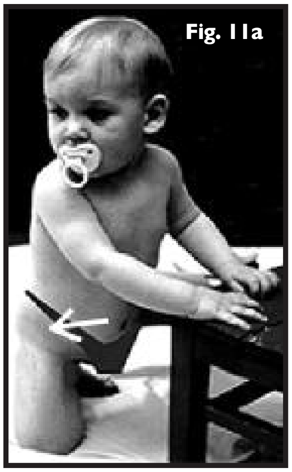
Fig. 11a

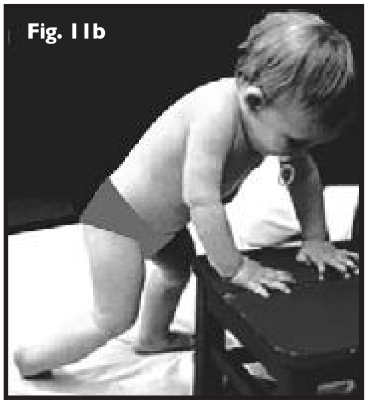
Fig. 11b

Fig. 11. Weight shifts → half-kneeling → rising over the forward limb. **Fig. 12.** Pelvic alignment at ages 4 and 12 months. Spine is straight and vertical. **Fig. 13.** Normal standing pelvic alignment: ≤ 2°.

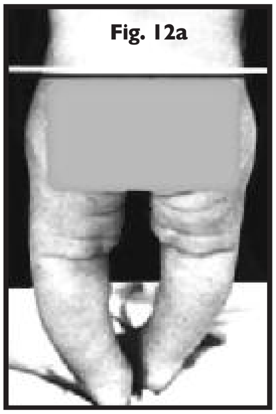
Fig. 12a

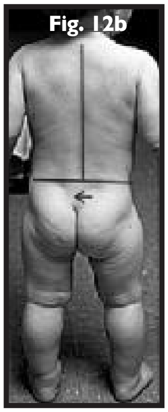
Fig. 12b

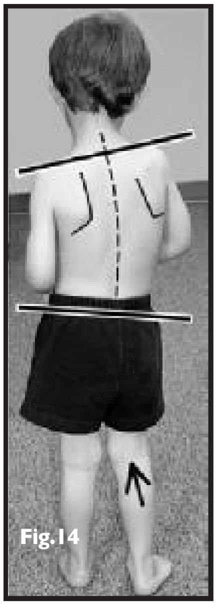
Fig.14

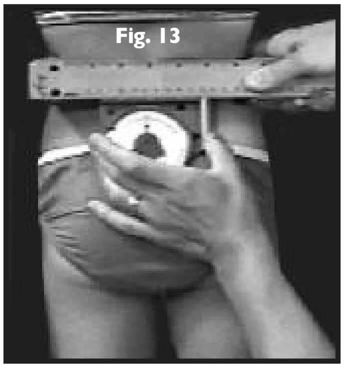
Fig. 13

Fig. 14. 4-year-old boy with left hemiplegic CP. Left LE is shorter. **Fig. 15.** Pelvic obliquity = 6°, left side higher.

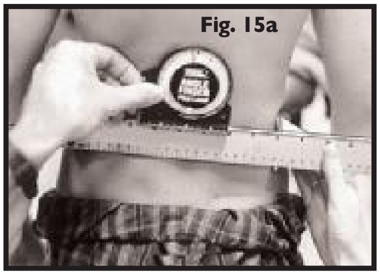
Fig. 15a

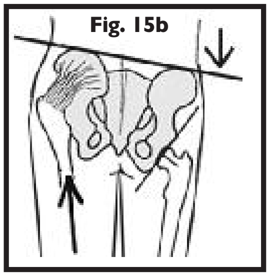
Fig. 15b

support on furniture and can stand up by extending both lower limbs simultaneously. They later shift weight laterally and backward to load one knee, allowing the unloaded limb to flex, placing the foot on the floor into half-kneeling to rise to stand (Fig. 11).

Upright Postures (at left): Infants normally try to, and then successfully do, maintain a vertical face and torso when positioned upright. From age ~4 months on, the spine is perpendicular to the plane of the superior iliac crests, and the pelvis is predominantly level in the frontal plane in standing position (Fig. 12). In the absence of ligament integrity problems, a pelvic alignment of ≤2° is both common and ideal, as the level pelvis can be expected to sustain the optimum angle of extension (AOE) of 90° +/- 2° (Fig. 13).[3]

Clinical implications: effect of pelvic obliquity at the spine:

The sacrum and the lumbosacral joint must follow a frontal-plane pelvic tilt. Intervertebral ligaments and vertebral processes sustain the spinal column, so the spine proximal to the lumbosacral joint must follow suit (Fig. 14).

Clinical implications of pelvic deviation / obliquity at the hips:

A pelvic obliquity of >2° in standing position disrupts the ideal 90° AOE (Fig. 15). It is important to rule out true limb length discrepancy as a contributing factor. Radiologic imaging is the most accurate mechanism of assessing bone lengths. In standing, a pelvic lateral deviation or obliquity is most commonly caused by either leg length discrepancy—the longer LE under the higher side—or hip abductor muscle weakness on the higher side, or both.

The load-bearing hip joint on the higher side loses proximal stability afforded by the acetabular "roof". The stabilizing musculature, capsule and ligamentum teres elongate on the higher side, losing tensile and contractile strength (Fig. 15).

In the case of hip abductor weakness in the child with left hemiplegia in Figure 14, the LE on the high side of the obliquity is shorter than the opposite LE. The more affected LE has historically taken less body weight than the sounder limb while the more affected hip musculature has been less effectively recruited.

ON LIFTING THE SHORTER SIDE TO LEVEL THE PELVIS

Asymmetrical growth in length on the more affected side is a known event in children with hemiplegic CP, more often occurring in the leg segment than in the femur.[4] The logic of connecting the skeletal modeling influence of compressive strain on bone growth rate is easily applied to the problem of true limb length discrepancy (LLD) in children with hemiplegia whose onset occurs before skeletal growth is complete, and in significant brachial plexus injury at birth (obstetric BPI or OBPI), and in children with asymmetric diplegia. With skeletal growth in the future, the decision to let a "small" LLD go unattended places the

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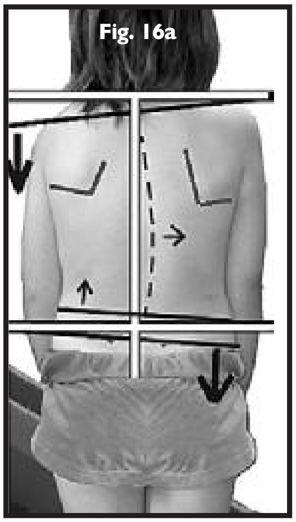
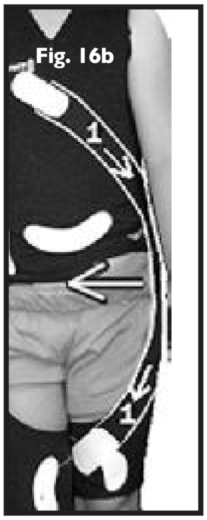
shorter limb at risk for developing a greater length deficit later on.

In the neuromotor-intact population, the impact of LLD on gait pattern symmetry might be minimal because of unspecified "functional adaptations".[5] Yet, if the pelvis is chronically oblique, or if other joints in the longer limb have successfully compensated for the discrepancy by collapsing, the resulting "clinically-acceptable" load-bearing joint malalignments can be expected to hasten the onset of degenerative joint disease (DJD) at the hip and/or knee on the longer side, or foster hip subluxation on the higher side in adulthood.[6,7,8] Perhaps clinicians who are interested in evaluating predisposing factors to hip and knee joint DJD—with ensuing hip or knee replacement surgery—will study the incidence of coexistence of "acceptable" or "normal" LLD "in these adults.

Rather than allow my clients to risk developing pain as a likely outcome of chronic pathomechanical alignment, I take the modeling mechanism, the presence of asymmetrical function, and the expectation of a level pelvis at all ages into account when I evaluate a child for LLD. I request radiologic confirmation and proceed to intervene with a leveling heel wedge placed in the shoe on the shorter side.

If, as in the case of the child in Figure 14, the shorter limb is under the higher side of the pelvis, a lift on the affected side would be contraindicated without first providing hip joint stabilization, strengthening the abductors in the closed chain, and providing the long bones of the same limb a stable proximal joint contact so that compression loads can be delivered to the epiphyses of the bones, rather than to the process of subluxing the hip. Then, lifting can proceed in small increments as strengthening and muscle re-education continue. Try to enlist the help of a pediatric orthopedist who is interested in deformity prevention to monitor this process radiologically.





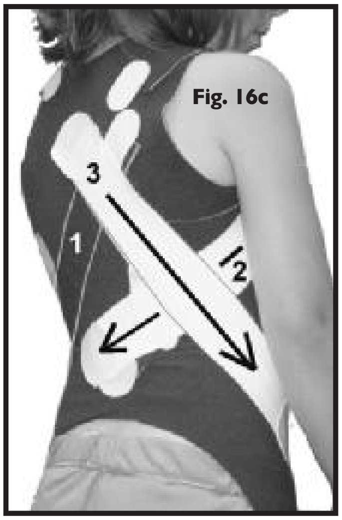
THERATOGS APPLICATIONS TO PROMOTE FRONTAL-PLANE SPINAL AND PELVIC ALIGNMENT

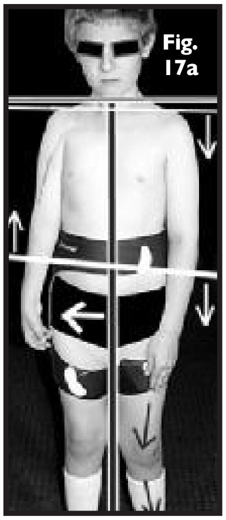
TheraTogs™ garments, with appropriately selected and positioned straps, maintain postural correction that the therapist can elicit manually without force. The children who actively respond to manual facilitation cues are excellent TheraTogs candidates. After first addressing the issue of LLD, the therapist effects a postural convexity correction and draws elastic straps over the shortened muscles and soft tissues. Sensory awareness of the strapped muscle and tissues is immediately increased. Since elastic strapping, unlike plastic and metal alternatives, cannot passively brace the underlying joints, the newly shortened muscles activate at the newly reduced length, assisted by the strapping.

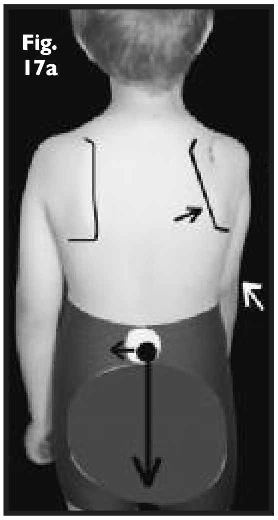
Examples: *Figures 16a, b, and c: A 5-year-old girl with a left OBPI at birth exhibits residual postural compensations for limited left shoulder flexion and forearm supination. A history of thousands of these compensatory deviations have evidently resulted in longer left LE long bones (due to excess compression strains), pelvic obliquity, and a compensatory right convex spinal curve. The sequence of intervention to reduce these postural convexities began with the introduction of a pelvis-leveling wedge under the right heel in the*

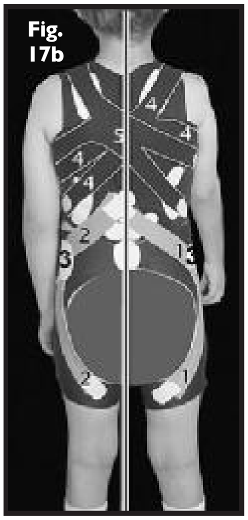
(continued on page 20)

Fig. 16a. 5-year-old girl with L OBPI. **Fig. 16b.** Split strap #1 for pelvic alignment. **Fig. 16c.** Stretch straps derotate and reduce the right convexity. **Fig. 17a.** 9-year-old boy with R OBPI, numerous postural deviations, and sensory processing disorder (SPD). **Fig. 17b.** 2 Split straps align the pelvis and reduce extraneous movements. **Fig. 17c.** Lower abdominal Strap #3









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shoe. The mechanical reduction of pelvic obliquity was necessary to render the application of split strap #1 effective in reducing pelvic deviation toward the left (Fig. 16b). Straps #2 and #3 were applied across the manually reduced right thoracic convexity (Fig.16c). Strap #3 also applies a rotation reduction vector.

Figures 17a, b, and c: A 9-year-old boy with right OBPI occurring at birth exhibits generalized hypotonia, sensory processing disorder (SPD) with difficulty standing still, and frontal-plane malalignments in the torso and scapulae (Fig. 17a). Again, with clinical evidence of a true LE length discrepancy, the first step was to insert a pelvis-leveling lift under the left heel in his shoe. Then, split straps #1 and 2 were applied over abducted hips, applying deep proprioceptive and tactile input to assist in centering the body weight and standing still (Fig. 17b). Straight strap #3 shortens and alerts the lower transverse abdominus for more "centering" body awareness (Fig. 17c). Split straps #4 and #5 reduce bilateral scapular abduction and right scapular upward rotation, anchoring the scapulae against arm motions that otherwise occur without separation from the scapula (Fig. 17b).

Hip Abduction ROM – Developmental Aspects

Neonatal hip abduction ROM averages 79.3°, (+/- 4.34, range = 63-86) with the hips in 90° of flexion (Fig. 18).[9] Tested in the position of available hip extension (commonly about -30° from 0°), abduction ROM averages 39° (+/- 5.11, range: 27° to 58°) (Fig.19).[71] The shortened iliopsoas (IP) muscle, which limits hip extension and medial rotation, also limits neonatal abduction ROM in extension.[10] Abduction ROM in hip extension increases rapidly to a median of 55° at age 1 year, ~50° between ages 2.5-6 years, and ~45° at age 7 years (Fig. 20).[11] Young children show no normal "first catch" when assessing passive hip abduction ROM in hip extension. Nine studies of adult hip abduction ROM produced means that range from 39° to 46°.[12]

The abundance of available hip abduction ROM with hips flexed in early infancy contributes to the acquisition of sagittal-plane trunk control by providing a wide BOS. For example, the abducted hips serve as an anchor in prone at 4 months, in ring-sitting (soles of feet contacting) at ~6 months, and in standing unsupported at 12 months. The added positional stability reduces the degrees of freedom of movement at the trunk, favoring the acquisition of sagittal-plane antigravity control. Furthermore, the abducted position holds the lateral hip musculature in shortened state during this period of stability acquisition.

The wide BOS diminishes with improved frontal-plane balance and control in the torso, favoring greater excursions of the COM in lateral directions and building lateral righting reactions and equilibrium in prone, sitting, all fours, kneel-sitting, kneel-standing, and standing positions.

In gait, the (massive and many) hip adductors initiate each weight shift onto the stance limb and contribute to hip joint stability by coactivating with the lateral hip stabilizing musculature. As the BOS diminishes by age 2 years, the hip abduction ROM increases, indicating that the adductors are not tonically recruited in upright function.


Fig. 18

Fig. 18. Neonatal hip abduction in flexion. **Fig. 19.** Neonatal hip abduction ROM at available hip extension. **Fig. 20.** Ideal hip abduction ROM and evidence of functional strength between ages 3 and 5 years. **Fig. 21.** Hip abduction ROM procedure in hip extension.

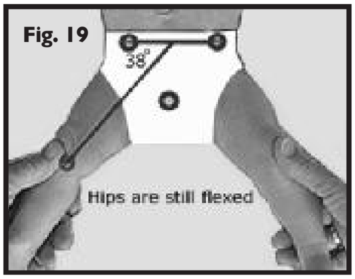
Fig. 19

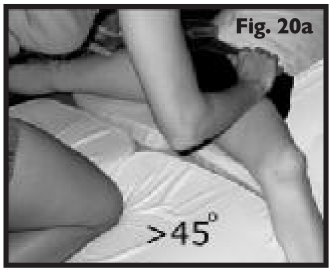
Fig. 20a


Fig. 20b

Assessing Hip Abduction ROM

The frontal-plane hip joint axis is located in the center of the femoral head. A measurement of hip abduction that uses the tangent of the left and right ASIS as the proximal reference arm and the test-side ASIS-to-mid-knee as the distal reference arm misrepresents the anatomical angle of the hip joint. Therefore, in the procedure described here, the distal reference arm has been realigned to fall through the center of the distance from the test-side ASIS and the symphysis pubis (orthopedic assessments described in this article and many others are reviewed in detail my DVD: *Legs & Feet: A Review of Musculoskeletal Assessments, 3rd edition. 2005. Available via* ***www.gaitways.com****)*. The resulting distal reference arm will approximate the (continued on page 21)

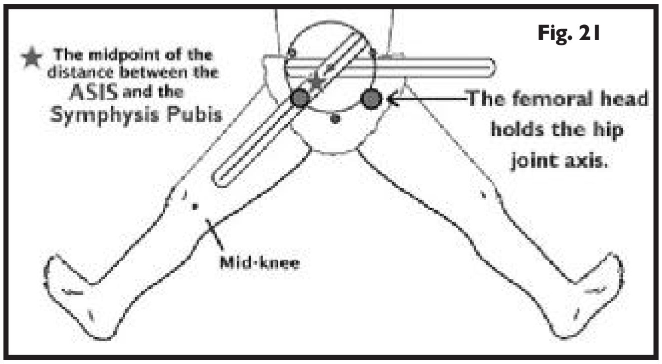
Fig. 21

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femoral bisection, including the joint axis (Fig. 21).

The procedure, with the child lying comfortably in supine position is as follows (thanks to orthopedic surgeon Richard Schwend, MD, for sharing this procedure with me).

- Abduct both hips simultaneously to R1 end range.
- Align the proximal border of the *undermost* UG arm adjacent to both ASIS.
- Align the *uppermost* UG arm parallel to a line connecting the following two landmarks (*as illustrated in Fig. 21):*
  - The midpoint between the test-side ASIS and the symphysis pubis.
  - The ML knee joint bisection (even if laterally rotated).

Clinical implications of dominant, shortened, hip adductor muscles: *Chronic, tonic recruitment of the hip adductors at the expense of the abductors results in mechanical transformation with shortening of the muscle and surrounding soft tissues, including proliferated connective tissue, nerves, blood vessels, and skin (Fig. 22).*[13] *The resulting loss of adductor muscle extensibility prohibits the acquisition of locomotion-promoting postures, such as those that occur with skull-side shifts. Squatting with hips adducted strains the medial forefeet, maintains elongated gluteal muscles, and fails to promote hip abductor and strengthening (Fig. 23).*

At its most severe, adductor dominance presents as "scissoring" of the lower extremities (Fig.24). In my experience, true scissoring occurs with increased severity of involvement—i.e., GMFCS Levels IV and V—and is linked to poor trunk control. Strapping with TheraTogs to reduce scissoring in these cases is often of limited value, as the focus of intervention should be on the torso, beginning with anti-gravity extension assist. The more competent the trunk musculature, the less compensatory extremity muscle recruitment is needed.

TheraTogs Strapping to Shorten and Assist Hip Abductors

The principles of intervention proposed by Sahrmann (Section II of this series) suggest that in the presence of a muscle imbalance—in this case, the hip adductors dominating over the abductors—elongating the shortened, dominant muscle group would simply reduce the force of the existing recruitment strategy. Without first providing a better strategy, the dominant adductors are likely to shorten again (Fig. 25).[14] TheraTogs strapping targets the under-recruited, functionally long hip abductors. First, *we shorten them by abducting the hip with the torso either vertical or leaning toward the targeted hip*. Then, we draw elastic strapping, under tension, over the underused muscles, alerting them via the sensory system and assisting them to function in shortened state (Figures 26-28). Any strapping application must be evaluated for optimum effectiveness, and moving attachments or changing lengths is common practice.

ACQUISITION OF FRONTAL-PLANE WEIGHT SHIFTING SKILLS

The standing infant practices lateral weight shifts over the feet with the hip joints abducted and abductor muscles in shortened position, recruiting the adductors to initiate the shifts (Fig. 29-a). While cruising or playing at furniture, if the child stands with minimal out-toed foot alignment—for example the toddler in Figure 29-b—he can displace the COM past the loaded foot, elongating the

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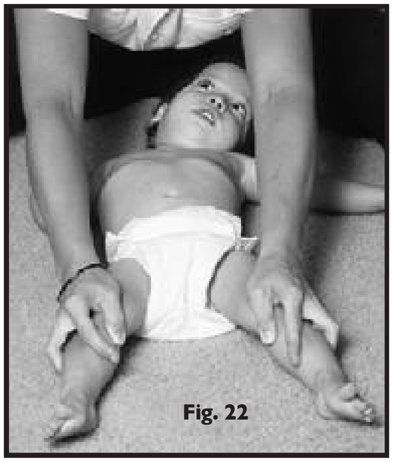
Fig. 22

Fig. 22. Dominant hip adductors → contracture. **Fig. 23.** Hip adductors over-recruited.
Fig. 24. "Scissoring" **Fig. 25.** Dominant adductors in functional context: the known recruitment strategy.


Fig. 22a


Fig. 23

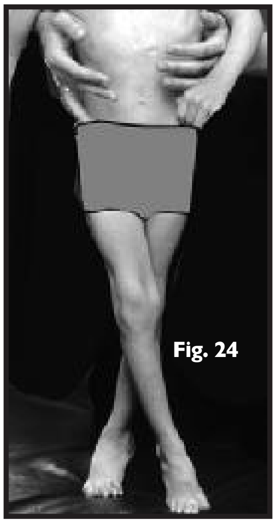
Fig. 24


Fig. 25

(**Developmental Orthopedics** *continued from page 21*)

abductors while decelerating the weight shift (eccentric action), and contracting the same muscles in elongated position to restore the COM to midline. An out-toed foot limits the lateral COM shift (Fig. 29-c).

Gait: The developing child devotes several months of weight shifting practice over a gradually diminishing frontal-plane BOS and outward foot rotation. In the pre-walking, cruising stage, the infant experiences a myriad of weight shifts over her feet, as many as 1100/waking hour (Fig. 30).[14]

When the primary means of locomotion is walking, the step frequency approaches 10,000/day and ideally persists throughout life. However, adults more commonly take ~4,000 to 5,000 steps/day. Toddlers actively lift the pelvis on the swing side, momentarily tilting the acetabulum over the loaded femoral head.[11]

Early, wide-based walking, with swing-side pelvic hiking, therefore operates to deepen the acetabulum (Fig. 31). In addition, the TFL and gluteus medius and minimus on the loaded side shorten while the hip adductors are recruited to help to hold the pelvis over the loaded femoral head. By age 2 years, the BOS has narrowed, and with the concentric activation of the hip adductors, the COM is brought over the *lateral* foot in midstance, placing added stabilization demand on the slightly elongated stance-side hip abductors (Fig. 32). Between ages 5 and 7 years, the swing-side pelvis lowers normally, ~4°, in gait (Figs. 33 and 34).[11]

Clinical implications of excessive hip abduction ROM or posture: *Though a period of positional stability is a normal developmental phase for each new level of movement skill, lateral weight shifts are mechanically hindered by a persistently wide BOS (Figures 38 and 39). Large positional bases are common in children with problems such as hypotonia and developmental delay, ligament laxity, pronated, out-toed feet, and cerebellar ataxia. I've used Hip Helpers—adapted shorts designed to constrain the hips against abducting excessively—successfully in children for whom hip or leg rotation problems are not a concern. For info, contact www.Hiphelpers.com for more information.*

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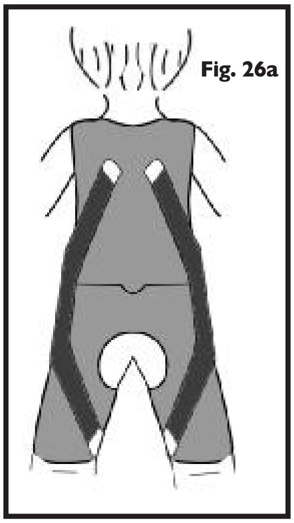
Fig. 26a


Fig. 26b


Fig. 27

Fig. 26. Split strap assists the dominated iliotibial band (ITB) complex and the deeper Gluteus Medius and Minimus. B: Same child in Fig. 25. **Fig. 27.** Double split strapping expands the intervention region and adds magnitude to the force vector.

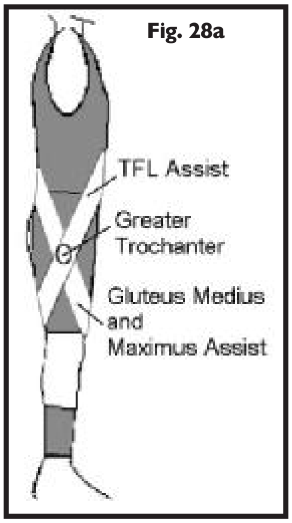
Fig. 28a


Fig. 28b


Fig. 28c

Fig. 28. Straight Stretch Straps are applied to mimic the tensor fasciae latae (TFL)/ITB/Gluteus maximus complex. Like all hip abduction assist strapping, the lateral musculature is physically shortened before applying the straps under tension. They cross over the greater trochanter. For added effect, you might place a half-sphere of firm foam under the crossed straps to add leverage. **Fig.29.** Lateral weight shifts at 12 (a), 15 (b), and 36 (c) months.


Fig. 29a

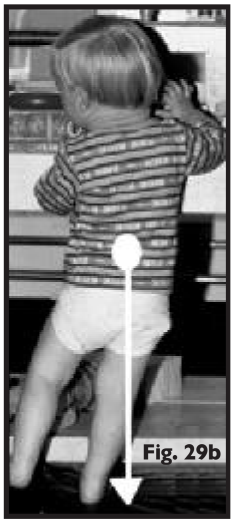
Fig. 29b


Fig. 29c

(**Developmental Orthopedics** continued from page 22)

THERATOGS APPLICATIONS FOR REDUCING THE BOS

Clinical implications of failure to master lateral weight shifts in standing position: *Liao et al (1997) used a force plate with a visual biofeedback feature to determine that in children with CP, comparing static standing balance with lateral weight shift skill—i.e., controlled COM displacement,—the latter was associated with higher levels of ambulatory function.*[15] *Inadequate achievement of lateral weight shift skill reflects the lack of achievement of integrated, antigravity trunk extension and flexion control.*[1]

In the upright position, pathomechanical factors that contribute to the failure to achieve lateral weight shifts include the closed chain influences of persistent foot pronation and excessive medial femoral torsion (Fig.37). Both problems promote hip muscle imbalances favoring the chronic recruitment of the adductors and diminishing the activation of the abductors.

The ITB inserts at the lateral knee joint by wrapping anteriorly around it. Excessive medial femoral torsion produces a medially-rotated knee joint axis that draws the distal ITB anterior to its normal vector, moving the TFL toward the anterior hip joint where it gains function as a hip flexor and loses function as a lateral hip and pelvic stabilizer during the stance phase of gait (Fig. 38).[14]

A positive Trendelenburg sign (Figure 38) reveals weakness of the ITB complex in the role of pelvic stabilization during stance on the same LE. The normal pelvic drop on the swing side is exaggerated.[16] *When pelvic obliquity combines with immature coxa valga and a history of inadequate recruitment of the hip*

(continued on page 24)

Fig. 30. Cruising. **Fig. 31.** First steps, age ~14 mos. **Fig. 32.** Age 2 yrs. **Fig. 33.** Age 5 yrs. **Fig. 34.** Mature pelvic drop. **Fig. 35.** Both underdeveloped anti-gravity extension and a wide BOS impede the emergence of a skull-side weight shift in prone.


Fig. 30


Fig. 31


Fig. 32

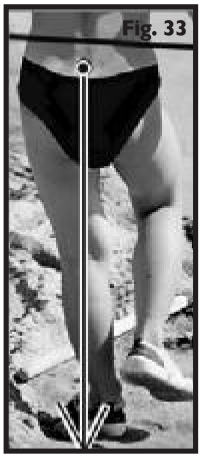
Fig. 33

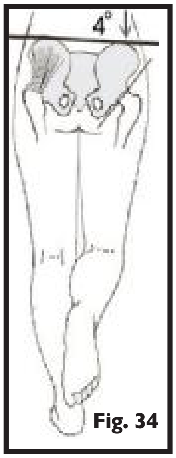

Fig. 34


Fig. 35a


Fig. 35b


Fig. 35c

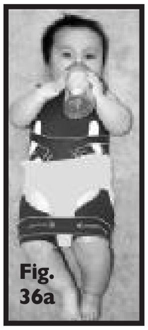
Fig. 36a

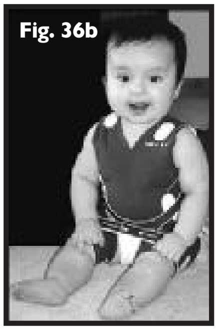
Fig. 36b


Fig. 36c


Fig. 36d

Fig. 36. A split strap alerts and assists the abdominals. Hip abduction and LR-reduction strap reduces the BOS. Trunk musculature is more active and frontal-plane weight shifts in kneel-standing and standing position are greater in magnitude and more dynamic. **Fig. 37.** Diplegic CP: pronated feet and increased femoral torsion mechanically impede lateral shifts. **Fig. 38.** Positive Trendelenburg – excessive drop on the swing side. **Fig. 39.** 7-year-old boy, 1 year S/P selective dorsal rhizotomy. Left hip subluxation with coxa valga, capsular laxity, and weakness of the hip abductors. Pelvic obliquity findings: 18° to 23°.

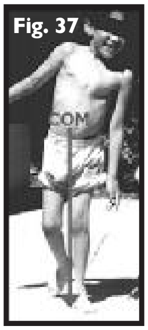

Fig. 37

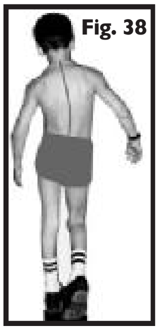
Fig. 38


Fig. 39a

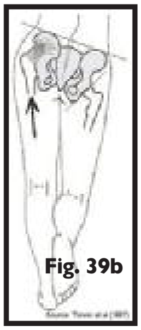
Fig. 39b

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and pelvic stabilizing muscles, subluxation is likely (Fig. 39).

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FOOTNOTES

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