Foreword

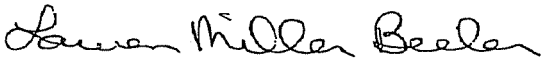
This monograph is an indispensable guide for clinicians at all levels. Lois Bly is an internationally recognized master clinician, educator, and author, renowned for her expertise in the Neuro-Developmental Treatment Approach for infants and children with neuromotor problems. Her gifts for movement observation and analysis were initially developed through her work with Mary Quinton and Elsbeth Kong, M.D. in Bern Switzerland, and have been honed through her years of practice and teaching.

Ms. Bly presents complex material on typical and atypical development in a step by step fashion, artfully leading the reader to a greater understanding of the multifaceted problems that children with movement dysfunction experience. Clinicians and educators alike will increase their understanding of essential posture and movement components that contribute to overall function and participation, as well as common problems that infants and children develop as a consequence of utilizing compensatory strategies.

Knowledge of optimal and atypical development serves to support identification and intervention of children with posture and movement challenges who need services. Detailed movement analysis is the foundation for understanding how to optimize biomechanical alignment needed for functional skills in infants and children with special needs from the multidisciplinary perspectives of occupational and physical therapy and speech language pathology. Addressing and improving biomechanical alignment during functional activities is important for prevention and minimizing the development of secondary problems in children with neuromotor challenges.

The concepts introduced in this monograph were introduced in the manual *Components of Normal Movement during the First Year of Life and Abnormal Motor Development,* originally written in 1983.These components have been the basis of interventions researched and supported by Girolami in 1994[1] and Arndt in 2008.[2]

Readers who are interested in further refining their observation skills should read Ms. Bly's book *Motor Skills Acquisition in the First Year* (1994) and the screening tool based on this book, the *Motor Skills Checklist*. Therapists looking to expand their treatment repertoire will want to read Ms. Bly's other books *Baby Treatment Based on NDT Principles* and *Facilitation Techniques Based on NDT Principles,* which was co-authored with Allison Whiteside.



– Lauren Miller Beeler, 2011

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[1] Girolami GL, Campbell SK. Efficacy of a neuro-developmental treatment program to improve motor control in infants born prematurely. *Pediatr Phys Ther.* 1994; 6: 175-184.

[2] Arndt SW, Chandler LS, Sweeney JK, Sharkey MA, McElroy JJ. Effects of a neurodevelopmental treatment based protocol for infants with posture and movement dysfunction. *Pediatr Phys Ther.* 2008; 20: 11-22.

Components of Typical Motor Development During the First Year

INTRODUCTION

The milestones of typical motor development have been well documented by several authors.[1-3] Specific motor components (kinesiological details) utilized to achieve these milestones are discussed in *Motor Skills Acquisition in the First Year*[4] and the *Motor Skills Acquisition Checklist*.[5]

The purpose of this monograph is to **highlight** some of the major components that are required to achieve the milestones in a **qualitative** manner. The "quality" or the precision of early movements is important because they are the foundation for future movements. According to Sahrmann,[6 (p 193)] "…alterations in the precision of movement result in the development of compensatory movements".

Typical is a difficult word to define. In terms of movement, typical means complexity and variability. That is the definition I will use for typical throughout this monograph.

Motor development is described as sensory-motor development. Considerable sensory input contributes to development. All of the sensory systems are involved - visual, vestibular, and somatosensory (proprioception and tactile).[7] Typical babies are very active. They repeat all movements over and over and thus develop an awareness of the sensation of the movements.

A basic characteristic of motor development is the ability to move and to make transitions. Movement implies a weight shift or a redistribution of weight. Therefore, it is important to look at and understand directions and results of weight shifting. Weight shifting provides the sensory stimulus for postural reactions and balance reactions.[8] Postural responses and balance responses can be learned and anticipated.[9] Historically, these responses were identified as righting and equilibrium reactions.[10] Today they are often referred to as balance reactions as well as righting reactions.

During motor development, the trunk muscles begin to work in numerous and various ways. As synergistic muscle control develops, muscle groups balance each other. It is especially important that antigravity axial (trunk) flexor muscles balance antigravity (trunk) extensor muscles. In Figure A, the baby is using trunk and hip extensors while the pectoral muscles and the abdominal muscles balance the extensors to create body segment alignment and stability. Synergistic balance of the trunk muscles influences the development of head control, upper extremity control, and lower extremity control.

Trunk movements develop in each of the three planes (sagittal, frontal and transverse). The trunk muscles provide synergistic stability for distal muscles to move distal segments. Trunk control and trunk movements also influence the movement and control of the head and extremities. [8,11]

The baby's trunk control progresses from sagittal plane to frontal and transverse planes. Trunk movements on each plane influence extremity movements on each plane. Trunk extension and flexion (sagittal plane) help to facilitate upper extremity and lower extremity extension and flexion (Figure A). Trunk lateral flexion (frontal plane) helps to facilitate shoulder and hip abduction and adduction (Figure B). Trunk rotation (transverse plane) helps to facilitate shoulder and hip rotation (Figure C).

Figure A: Trunk extension (sagittal plane) helps to facilitate (sagittal plane) shoulder flexion and elbow extension and hip, knee extension and ankle plantar flexion.

Figure B: Trunk lateral flexion (frontal plane) helps to facilitate shoulder and hip abduction (frontal plane).

Figure C: Trunk rotation (transverse plane) to the left helps to facilitate left hip external rotation (transverse plane).

When the baby can assume and maintain sitting and standing postures, muscle coordination enables the baby to continue to practice movement on all three planes. The baby can flex and extend, rotate, and laterally flex and shift weight in sitting and standing. This enables the baby to make transitions. Transitions enable the baby to move from one position to another, e.g. move from sitting to quadruped, quadruped to kneeling and half kneeling, half-kneeling to stand, and to walk. Babies with developmental delays have great difficulty with transitions.

The components of movement that are presented in this monograph emphasize the typical full term baby's progressive development and integration of antigravity muscular control in all typical positions in the first twelve months of life.

TYPICAL MOTOR DEVELOPMENT DURING THE FIRST YEAR

Neonate: 1 - 10 Days

The full term neonate demonstrates physiological flexor activity in the ankles, knees, hips, and elbows. This is illustrated by the flexor recoil that occurs when these joints are passively extended.[12]

Flexion is seen in both prone and supine. In **prone**, hip flexion causes weight to be shifted forward onto the baby's face, which is turned to the side (Figure 0.1). Although "physiological flexion" is dominant, the neonate is able to lift his head (extend against gravity) and turn it to the opposite side (rotation). As the baby lifts his head, the weight that was on his face is shifted backwards onto his shoulders. Marked lower extremity kicking usually accompanies this activity. (Head lifting is an early step in the development of antigravity extension and weight shifting).

Figure 0.1 Neonate: Physiological Flexion

In **supine**, the neonate demonstrates "physiological flexion" in the extremities, but antigravity control of the neck flexors is not present. Therefore, the baby can briefly bring his head to midline,[13] but he usually keeps it rotated to the side. Although it is typical for the baby's head to be rotated to the side, it is also important that the baby can briefly bring the head to the midline. Lack of ability to bring the head to midline may indicate a motor problem.

Lack of antigravity flexor control is well illustrated when the baby is pulled to sit. Although most full term newborns may attempt to initiate head flexion, resulting in an observable visible contraction of the neck flexor muscles, they lack the muscle control to lift the head against gravity. (Physiological flexion is not synonymous with antigravity flexion, and the development of antigravity extension precedes the development of antigravity flexion.)

It should be noted that the baby's attempt to lift the head when **pulled to sit** indicates that the baby has received sensory feedback (visual, vestibular, and/or proprioceptive) to indicate that the head position is incorrect.[4]

The neonate's **sitting** posture demonstrates lack of truck muscular control. If lightly supported, the baby leans all of the way forward from his hips. His back is round and his head drops forward. However, the neonate may momentarily lift his head and then drop it again.

In **standing**, the neonate demonstrates his most remarkable capabilities. They are primary standing and automatic walking.[12,14] These "skills" gradually fade out in the fourth to sixth weeks.[1]

Two Months

The second month is often characterized by semi-hypotonia (low tone),[12] decreased flexion, and increased extension and asymmetry. Physiological flexion has been reduced by gravity and the increased extensor activity. Antigravity extension has not yet been balanced by active antigravity flexion. Therefore, in gross motor activities the baby may seem to have less control than he had in previous months.[4]

In **supine**, gravity plays a major role in increasing the range of head rotation, shoulder external rotation, and hip external rotation.

The head rotates further to the side because of gravity and increased unilateral activity of neck extensors without equal counter-balance of neck flexors. As the head rotates further to the side, there is increased possibility for stimulation of an asymmetrical tonic neck reaction (ATNR) (Figure 2.1). This is the classic reaction of extension of the arm on the face side and flexion of the arm on the skull side of the head.[10] An ATNR may

ATYPICAL DEVELOPMENT IN BODY REGIONS: HEAD AND NECK CONTROL

This discussion is divided into two sections:

- NECK HYPEREXTENSION
- HEAD AND NECK ASYMMETRY

NECK HYPEREXTENSION

Typical

In typical motor development, the newborn can lift and turn his head against gravity in prone. In supine, the baby can bring his head to midline and briefly maintain it there.[13] Symmetrical **flexion** of the head with sustained tucking of the chin is not typically observed until three to four months of life.

Head lifting in prone is usually accomplished with asymmetry and neck hyperextension until three to four months of age. By four months of age, the baby can maintain his head in midline during prone forearm weight bearing.[4] The head and neck can be maintained in symmetry when the head and neck flexor muscles balance the head and neck extensor muscles.

Combined and reciprocal action of the head and neck extensor muscles and flexor muscles is necessary for typical development of head control. (See Typical Motor Development (TMD) Figures 3.1, 3.2, 4.1, 4.2 and 4.2b)

Atypical

In atypical motor development, neither the head/neck extensor muscles nor the head/neck flexor muscles achieve symmetrical activation. Consequently, the baby cannot bring his head to the midline and hold it there and he cannot tuck his chin in supine and/or prone forearm propping. It seems to be especially difficult for the baby to flex the head and neck.

The baby may use strong asymmetrical head/neck extension to initiate movements in all positions (supine, prone, sitting and standing). He lacks ability to chin-tuck (capital flexion) during head lifting.

Older children with cerebral palsy continue to lift their head with asymmetrical head and neck hyperextension. (Figure AMD 1)

Figure AMD 1: Neck Hyperextension

Compensations

If a baby does not have a balance of head/neck extensor and flexor muscles, he must use a compensatory strategy to stabilize his head. The most common compensation used to stabilize the head and neck is shoulder (scapular) elevation. Shoulder girdle elevation stabilizes the head but prevents typical head/neck movements and exaggerates the hyperextension (Figure AMD 2).

If the shoulders can be depressed, the child's lack of antigravity flexion control becomes obvious (Figure AMD 3). Often the muscles that elevate the shoulder girdle are very tight and cannot be manually depressed. If the shoulders cannot be manually depressed the child will also be unable to actively depress the shoulders. Specific therapy is needed to enable the child to depress the shoulders and simultaneously develop head/neck control. Over time, if a baby or child uses shoulder elevation to compensate for poor head control, many additional components will become involved. (See "Compensations" below.)

- Align and control trunk rotation in both directions while reaching and using both upper extremities
- In addition, upper extremity symmetrical use, body exploration and ocular convergence and tracking should be facilitated

The goal of early treatment is to prevent hip subluxation and hip dislocation. But if the hip has dislocated, it must be treated surgically. Every child should be monitored by an orthopedist.

If the child has had a dislocated hip that was repaired surgically, the child's head, neck, and spinal alignment and mobility must be continually addressed. Remember the hip may have become dislocated as a **consequence** of the asymmetrical head posture and subsequent spinal rotation and asymmetry. Treat the primary impairment or the hip may dislocate again.

ATYPICAL DEVELOPMENT IN BODY REGIONS: SHOULDER AND UPPER EXTREMITY CONTROL

Typical

In typical motor development, development of shoulder and upper extremity control is closely related to trunk alignment and the development of scapular mobility and control. In very early development, the baby's scapulae are frequently elevated, adducted, rotated downward and tipped forward (Figure TMD 0.1). This causes the humeri to extend, adduct and internally rotate. This is especially noted in prone. By the fifth month of life, the baby has developed more control of the scapular muscles in prone and supine and can depress, abduct, upwardly rotate and tilt the scapulae backward. Control of the scapular muscles is coupled with increased control of humeral muscles. By the fifth month of age, the baby can flex the shoulders overhead and reach in prone, and reach hands to knees and hands to feet in supine. (See TMD Figures 4.3, Figure 5.1, Figure 6.1 and Figure 6.3.)

In prone, the baby can typically assume and maintain forearm weight bearing by four months, extended arm weigh bearing by six months, and forearm lateral weight shifts by five months. These actions require stability of the scapulae on the trunk, elongation of the muscles between the scapula and humerus and dissociation of the humerus from the scapula. Dissociation and selective control of the elbow, wrist and hand continue as the baby practices movement of the hand in various positions and grasps a variety of objects.

In sitting and standing, the baby learns to move the arms against gravity. The control of the upper extremities in sitting and standing is closely related to the baby's alignment and control from the base of support – the pelvis in sitting and the feet in standing. Further development of upper extremity control is also dependent on trunk alignment and control.

Atypical

In atypical motor development, scapular stability does not develop. The baby's scapulae often remain elevated, adducted, downwardly rotated and tipped forward. The baby has difficulty with control of the scapulae on the thorax.

Therefore, forearm weight bearing and extended arm weight bearing are difficult or not possible. The baby's attempts at forearm weight bearing are accomplished with scapular winging because the scapulae are not stabilized on the thorax. Lack of scapular stability prevents the development of independent, dissociated humeral movements such as full humeral external rotation, flexion, and horizontal adduction. The muscles between the scapula and humerus are not elongated and scapulo-humeral dissociation does not occur. This makes selective control of each of the upper extremity joints difficult.

If the baby has difficulty with scapulo-humeral control and scapulo-humeral movements in prone

ATYPICAL DEVELOPMENT IN BODY REGIONS: PELVIC AND LOWER EXTREMITY CONTROL

This discussion is divided into two sections:

- LOW TONE: ANTERIOR PELVIC TILT
- HIGH TONE: POSTERIOR TILT.

LOW TONE: ANTERIOR PELVIC TILT

Typical

In typical motor development at three and four month of age, babies begin to actively play with anterior and posterior pelvic tilting in prone and supine. Synchronous lower extremity movements accompany the pelvic movements. The lower extremities flex with the anterior pelvic tilt and the lower extremities extend with the posterior pelvic tilt. These initial active pelvic-lower extremity movements are sagittal plane movements.

Anterior pelvic tilting is accomplished with lumbar extension and bilateral hip flexion, abduction, and external rotation (TMD Figure 4.2b). The knees flex and the ankles dorsiflex. This is the "frog-legged" position. This occurs in both prone and supine.

In prone, posterior pelvic tilting is accomplished with abdominal activity that produces slight lumbar flexion, and **beginning** activation of hip extension and adduction (TMD Figure 6.1). The knees extend and the ankles plantar flex. In supine, the baby achieves posterior tilting by contracting the abdominals, and flexing and adducting the hips (TMD Figure 4.3).

Practice and active alternation between anterior and posterior pelvic tilting with accompanying lower extremity movements helps the baby to develop mobility and control around each of the joints, i.e. lumbar spine, pelvis, hips, knees and ankles.

Five-month-old babies practice frontal plane movements of the pelvis when they shift the weight laterally and respond with a lateral righting reaction. The lateral righting reaction includes head, spine, and pelvic lateral flexion away from the weight-bearing surface. The weigh-bearing side elongates and the unweighted side laterally flexes. Lower extremity movements accompany lateral movement of the pelvis. The weight-bearing hip extends, adducts, and internally rotates. (Note that the hip internally rotates from the resting position of external rotation. It internally rotates to neutral.) The knee extends and the ankle may plantar flex. The unweighted leg responds with a balance reaction that includes hip flexion, abduction, and external rotation, knee flexion, and dorsiflexion. The legs move in opposite directions, resulting in interlimb dissociation. (See TMD Figure 5.2.)

Atypical

In atypical motor development, the alternating movements of the pelvis and hips do not occur. In supine, the anterior pelvic tilt with hip flexion, abduction and external rotation is never balanced with the antigravity flexion components (Figure AMD 13). The abdominals do not activate sufficiently to posteriorly tilt the pelvis or to balance and elongate the lumbar extensors. Antigravity hip flexion and adduction do not develop to balance and elongate the hip abductors. Subsequently the baby does not develop normal lower trunk/pelvic control. The lack of trunk/pelvic control prevents the baby from practicing lateral weight shifting and therefore interferes with the development of typical balance reactions.

Figure AMD 13: The "frog-legged" position increases the anterior pelvic tilt. Note the elevated and flared position of the rib cage.

- Increase active abdominal muscle activity with movement all three planes
- Increase synergistic control with the trunk flexors working with the trunk extensors. This often works best in the frontal plane (lateral flexion) and the transverse plane (rotation)
- Change the frog legged position to neutral lower extremity alignment in all positions
- **Increase active hip extension**

Babies that maintain a frog-legged position cannot shift the pelvis, thus cannot shift the weight laterally. Therefore:

- Work on lateral weight shifts in all positions, making sure that the entire weight bearing side elongates during weigh shifts
- The unweighted side should laterally right
- Work on these components in prone, sitting, quadruped, kneeling, and standing and all transitions in and out of these positions
- Remember to work on these components in functional contexts

If the child has developed additional compensations in standing, these compensations must be treated as well as the original problem:

- Work on typical mobility and control at the pelvis, hips, knees, and ankles in standing
- Work on weight shift at the feet. The baby must learn to transfer weight to the lateral borders of the feet
- Provide neutrally aligned orthotics to control the base of support
- Remember to work on these components in functional contexts

HIGH TONE: POSTERIOR PELVIC TILT

Typical

In typical development, the baby demonstrates strong knee extension in the fourth month. This knee extension is usually accompanied by hip extension and adduction and ankle plantar flexion (See TMD Figure 6.1). In typical motor development, this synchronous extension is balanced by synchronous flexion of the legs (See TMD Figure 6.3). The baby moves from synchronous extension and flexion of both legs to alternating movements of the two legs. One leg flexes and one extends; the legs move with dissociated movements (See TMD Figure 5.2). Strong knee extension is also balanced by active knee flexion in prone.

Atypical

Babies with high tone (marked extension) manifest an atypical motor developmental process that is different from that of the baby with low tone. From an early age, they demonstrate strong/unbalanced extension of the head and neck, scapular adduction, followed by strong hip, knee, and ankle extension (Figure AMD 26).

Figure AMD 26: Baby with strong extension from the head to the ankles.

In babies with high tone, lower extremity extension is not followed by flexion. The legs do not move with alternating movements and they do not demonstrate dissociated movements. Because the baby does not practice active flexion, abduction, or external rotation of the lower extremities, the extensor and adductor muscles are never balanced or elongated. Active hip, knee, and ankle movements and mobility are limited and this leads to muscle and joint tightness and contractures.