Development of Prone Extension Postures in Healthy Infants

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The purposes of this study were to 1) investigate the sequence of development of head, upper extremity, and lower extremity extension in the prone extension posture in healthy infants; 2) identify the variations in the sequence; and 3) compare these postures within the sequence with the development of prone-on-elbows and prone-on-hands postures. Twenty healthy, full-term infants were observed longitudinally from 8 to 28 weeks of age. Two of the infants could not complete the study, and two infants never used the prone extension posture. The data from 16 of the infants, therefore, were analyzed. The results indicate that the sequence of development of the prone extension posture consists of head extension, followed by lower extremity extension, and then upper extremity extension. The results also indicate that upper extremity extension in the prone extension posture does not appear to be a prerequisite for the prone-on-elbows or prone-on-hands postures. These findings suggest that infants may use different strategies for developing motor control in the head and lower extremities than in the upper extremities. This information adds to our knowledge of the normal developmental process and may have significance in the planning of physical therapy programs.

Key Words: Child development; Pediatrics, development; Physical therapy.

Many approaches to therapeutic exercise are based on the theory that patients with central nervous system deficits recapitulate the developmental sequence in recovery.1-3 Milestones in the developmental process are used in the evaluation and treatment of these patients, based on the assumption that facilitation of important components of the developmental sequence will improve motor function.

One component of the developmental sequence considered to be important for the acquisition of normal motor control is the development of postural stability, which Stockmeyer divided into static and dynamic components.1 Stockmeyer proposed that infants achieve motor skills by first developing static stability, or the ability to fixate one part of the body, and then by achieving dynamic stability, or the ability to superimpose movement on static stability.1 Static stability is developed, in part, by strengthening the tonic muscles of the neck, trunk, shoulders, and hips. Some researchers have theorized that infants strengthen these tonic muscles by positioning their bodies so that these muscles are in a shortened position and are held against gravity for extended periods of time.1,2 For the tonic flexor muscles of the trunk, infants use the posture of supine flexion; for the tonic extensor muscles, they use prone extension. The prone extension and the supine flexion postures, therefore, are assumed to be precursors for the development of the ability to hold such weight-bearing positions as prone-on-elbows, prone-on-hands, quadruped, and sitting.4

Dynamic stability, the ability to move in a smoothly coordinated fashion while maintaining a stable posture, is achieved after the infant is able to maintain weight-bearing postures. This stability at various developmental stages enables the child to reach while positioned prone on elbows or on hands or to creep from the quadruped position without losing postural fixation. Because the prone extension posture may have an essential role in achieving static stability, it may be one of the important components of the developmental sequence that must be recapitulated during therapeutic intervention.

Although achievement of the ability to assume the prone extension posture is considered to be a developmental milestone, little research has been conducted documenting the acquisition of the posture or relating the posture to other developmental milestones, especially the acquisition of weight-bearing postures. McGraw described the movements within the prone extension posture as swimming movements and considered them to be a part of the development of creeping.5 Others have described the posture as being a result of the labyrinthine righting and optical righting reflexes.6,7 The neck and trunk extension that occurs after labyrinthine and optical input has been labeled the symmetrical chain reflex because neck extension appears to cause extension of the upper trunk and arms, which in turn causes extension of the lower trunk and legs.8 This reaction has been described as beginning at 3 months of age and peaking at about 6 months of age.6

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Many studies have reported the average age for acquisition of various motor milestones. Much of this research, however, viewed each milestone as a separate entity and did not attempt to relate the achievement of one motor skill to the achievement of another.\textsuperscript{8,9} One exception is Wolanski and Zdanska-Brincken who followed the development of infants longitudinally for one year.\textsuperscript{10} They analyzed the data by clustering various motor skills that seemed to be related to each other into four separate groups. In each group, the items were noted to have been achieved sequentially. That is, the first skill was achieved before the second one occurred. Because scores of each of the four groups did not correlate highly with the scores in the other groups, Wolanski and Zdanska-Brincken concluded that attainment of skills in one group did not depend on attainment of skills in the other group. Unfortunately, they did not include the prone extension position in their analysis of motor skills.

The purposes of this study were to 1) observe the sequence of development of head, upper extremity (UE), and lower extremity (LE) extension in the prone extension posture in healthy infants; 2) identify the variations in the sequence; and 3) relate the various limb and head positions in the prone extension posture with the acquisition of prone-on-elbows and prone-on-hands postures.

The hypotheses of the study were 1) a sequence of positions of the head and limbs exists within the prone extension posture that emerges in a cephalocaudal direction and 2) a relationship exists between the acquisition of head, UE, and LE extension in the prone position and the acquisition of prone-on-elbows and prone-on-hands postures.

**Operational Definitions**

1. **Prone extension.** Extension of the head, UE, and trunk and LE in the shortened range while in the prone position.

   - **Head extension:**
     - Head down. Any part of the head is in contact with the floor.
     - Head partially extended. The entire head is off the ground, but the face is not perpendicular to the floor.
     - Head extended. The face is perpendicular to the floor.

   - **Upper extremity extension:**
     - Upper extremity down. The entire UE is in contact with the floor, or the infant is supporting himself on his elbows or hands.
     - Upper extremity partially extended. The upper arm, elbow, and forearm are lifted off the floor, but the hand or the upper trunk is still in contact with the floor.
     - Upper extremity extended. The entire UE, including the hand and upper trunk, are lifted off the floor.

   - **Lower extremity extension:**
     - Lower extremity down. The entire LE is in contact with the floor.
     - Lower extremity partially extended. The hip is extended forcibly so that the knee and part of the thigh are lifted off the floor, and the knee is partially flexed.
     - Lower extremity extended. Both the hip and knee are extended forcibly so that the entire LE is lifted off the floor.

2. **Prone-on-elbows posture.** The child appears to be bearing his body weight on his elbows and forearms. The child's elbows are flexed to about 90 degrees, and they are directly under the head of the humerus.

3. **Prone-on-hands posture.** The child is bearing weight on his hands. The child's hands are directly under the head of the humerus, his elbows are extended fully, and his entire chest is lifted off the floor.

**METHOD**

**Subjects**

Twenty healthy, full-term infants were selected to participate in the study. The infants were recruited from families known by the investigators (L.H. and N.S.) or from the university community. We screened the infants by administering a telephone questionnaire to one of the infant's parents. Infants were accepted for participation in the study only if they had no known medical difficulties before, during, or after birth. The infants were either first- or second-born children and were living at home with their natural parents. Their families were white, middle class, and living in the greater Boston (Mass) area. Any infant who was not observed for two consecutive visits or who missed a total of three visits was eliminated from the study.

Of the original 20 subjects, 2 did not complete the study. Two additional infants never demonstrated either the full-pivot prone posture or the UE or LE extended components of the prone extension posture. The intent of this study was to document the sequence of acquisition of the individual components of the posture, rather than the frequency or existence of the posture. The data for the two infants who did not perform the posture, therefore, were not included in the statistical analysis. Data were analyzed for the remaining 16 infants (10 boys, 6 girls).

**Procedure**

After the initial screening procedure, each infant was assigned to one of the two examiners who observed that child for the duration of the study. The infants were observed in their own homes once every two weeks from 8 weeks of age until 28 weeks of age, for a total of 11 observations. At the initial visit, one of the infant's parents reviewed and signed an informed consent statement that was approved by the university's Clinical Research Review Committee.

Before each observation session, each infant was rated on an alertness scale with scores ranging from 1 to 5. If the child was quietly or actively alert (a score of 3 or 4 on the scale, respectively), the observation session was begun. If the infant was asleep (rated 1), awake but drowsy (rated 2), or agitated or crying (rated 5), the session was postponed. The examiners attempted to schedule visits to coincide with the child's active, alert periods and did not observe a child who was tired or hungry.

We observed each infant in the prone and supine positions for three minutes to document prone extension and other motor behaviors. The order of positions used in the observations was randomized to avoid any influences that one posture may have had on another. If the child's state changed during the observation period (eg, if the child began to cry), the observation was continued for the remaining period of time. The parent was allowed to speak to the child, but could not touch or handle the child during the observation periods. The parent, however, was allowed to hold and provide comfort to the child between observations.

The examiner positioned each infant prone on the floor with a toy placed 6 in* in front of the infant's face. The parent

\* 1 in = 2.54 cm.
the spontaneous behavior of the child and recorded whether to the child with a stopwatch and noted on a check list the data for the study. Each of the two examiners simultaneously assume the quadruped position, roll, creep, crawl, or pull the child’s head and limb positions every 30 seconds. At each 30-second interval, the examiner noted whether the child’s head and limbs were down, partially extended, or fully extended. At the end of each observation period, the examiner noted and limbs were ranked based on the age when only one UE or one LE was fully extended for the first time. In the second rating scale, the infant’s head and limbs were ranked based on the age when both UEs or LEs were extended simultaneously for the first time.

The results of the rank ordering based on only one LE or one UE fully extended are shown in Table 2. The order of achievement of the fully extended posture for individual body parts was head, LE, and UE. The rankings of body parts were significant at the .01 level.

The results of the rank ordering based on both UEs or both LEs extending simultaneously are given in Table 3. The differences between the rankings of the body parts based on full extension of both limbs simultaneously were even more significant ($p < .001$) than those based on full extension of one limb. The order of achievement of the fully extended posture for individual body parts was head, LEs, and UEs.

**Data Analysis**

The data were analyzed using a Friedman two-way analysis of variance to determine the rank order of different sequences and timing of acquisition of the fully extended position for head, UEs, and LEs; a chi-square analysis to determine sig-
Dedicated human researchers found the extended arm’s development was not significantly correlated with UE or LE extension in the prone extension posture or the fully extended position in the legs or UEs during development because the arms are not mature enough to inhibit these vigorous movements, but the legs are not. Dubowitz and Dubowitz observed that premature infants develop extension of their legs and lower spine before they develop extension of their shoulders and upper spine.11 Furthermore, Sainte-Anne Dargassies reported that the development of muscle tone in premature infants begins with the feet and progresses cephalad.12 Coryell and Cardinalli documented that the asymmetrical tonic neck reflex in healthy infants appears first in the LEs before emerging in the UEs.13

This study did not support the hypothesis that components of prone extension are related to the achievement of prone-on-elbows and prone-on-hands postures. The emergence of the prone-on-elbows posture is related to the order of achievement of extension of the head and LEs, but not to extension of the UEs. In this study, the average age for the onset of the prone-on-elbows posture was 15.8 weeks, although the infants did not fully extend their arms. Based on our operational definition, therefore, they did not fully extend their upper trunk until an average age of 19.3 weeks. We also observed that many of the infants who were recorded as UE down were in a partial prone-on-elbows position even earlier than we could record in our data collection. These findings contradict the theory advanced by Stockmeyer, who hypothesized that performing a maintained muscle contraction in the shortened range against gravity was a prerequisite for weight-bearing on elbows.1 Our results, however, do concur with those of Rues who observed the development of head control and propping on elbows in six healthy infants and found that the face- vertical posture, not prone extension of the UEs, is the prerequisite activity for the prone-on-elbows posture.14

In this study, the prone-on-hands posture was not significantly associated with UE or LE extension in the prone position. Wolanski and Zdanska-Brincken’s model for development hypothesized that a lack of correlation between two developmental activities indicated that one activity had no influence on the development of the other.10 Little or no relationship, therefore, may exist between either UE extension in the prone position or the full prone extension position and the achievement of the prone-on-hands position. The results of this study indicate that the infant’s head and LE begin to extend earlier than the UE. The LEs also possibly extend sooner than the UEs during development because the arms are not used for long-duration weight-bearing activities and, therefore, are not required in much preliminary extension behavior.

These findings are supported by the work of Lawrence and Kuipers who discuss motor control in terms of two distinct systems: 1) a ventromedial system that is responsible primarily for “stability” movements and 2) a lateral system that is responsible primarily for “mobility” movements.15 These two systems have different locations within the CNS. Gilfoyle et al proposed that the trunk and legs primarily may be part of the body’s stability system, whereas the arms are used for mobility and skilled movement.3 In older children and adults, the legs and trunk are most involved in weight-bearing and other postural functions. The arms rarely engage in this activity, but are used primarily for reach and grasp. The legs and trunk, therefore, must perform more tonic postural holding during early development than the arms in preparation for the functional role they will assume later.

Two of the infants in the study never used the full prone extension posture or the fully extended position in the legs or arms. These infants appeared to dislike the prone position.
and were most content in a supported sitting position. We have followed, informally, all of the subjects since the study was completed, and all have developed normally with no observable developmental delays or abnormalities. The full prone extension posture, therefore, may not always be a prerequisite for the development of normal muscle tone, postural stability, or motor skills. The use of different strategies to achieve stability may be an area of interest for further research.

Many of the authors who have investigated normal development have used a cross-sectional rather than a longitudinal approach.6.8.9 The cross-sectional approach may result in a loss of information concerning the variability of timing and sequence for the development of the components of a motor milestone. The infants in our study showed variability in the age of acquisition of a skill and in the amount of time they used a skill before reaching a more mature developmental level. This variability also should be investigated further.

This study contained several methodological weaknesses that should be controlled in future research. First, the activity of the trunk muscles could not be recorded independent of the UE or LE movements because of a lack of videotape or electromyographic equipment available at the time of this study. Second, this study did not attempt to determine how long the infants maintained the various components of the prone extension posture. Third, the partially extended position of the limbs must be defined more precisely to allow for reliable statistical analysis of this data. Finally, the results of this study indicate that by 8 weeks of age, most of the infants already were exhibiting some prone extension activity. Most of the infants continued to exhibit this activity at 7 months of age when the study was discontinued. No clear onset or termination points for the development of the activity, therefore, could be determined. These factors should be investigated further by beginning the study at an earlier age and continuing until each child has completed the activity. The sample size also should be increased and selected more randomly before any inferences on the sequence of the development of the pivot prone position can be made.

Clinical Implications

The results of this study raise some questions about parts of the theoretical framework used in the development of some neuromuscular treatment approaches. The results of our study indicate that all development may not be in a cephalocaudal direction. The UEs may have a different developmental sequence than the head, trunk, and LEs. This concept might be used in treatment when attempting to recapitulate normal development. Therapists might consider spending more treatment time working on dynamic activities involving the arms and more time working on static holding activities involving the trunk and legs.

Another interesting finding in this study was that two of the children did not use the prone extension posture to develop normal stability. This alternate mode of development should be of interest to therapists. Investigations into how these children develop stability could be helpful in the treatment of many patients who do not like to be placed in the prone position.

CONCLUSIONS

This study investigated the sequence of development of head, UE, and LE extension in the prone extension posture among 18 healthy infants over a period of 20 weeks beginning at 8 weeks of age. Data for two of the infants were not analyzed because they did not demonstrate the postural components. Analysis of the observations of the remaining 16 subjects indicated that the sequence of acquisition of components of the prone extension posture was extension of the head, followed by extension of the LEs with the UEs extending last. The prone extension posture of the UEs, therefore, may not be a prerequisite for weight-bearing on the elbows or the hands in the prone position. These results suggest that the concept of sequential cephalocaudal development of prone extension and the presumed need for an infant to perform prone extension with the UEs should be examined further.

We propose that the extension of the UEs may be part of a different motor developmental sequence than the LEs and the trunk and that full extension of the LEs in the prone position may not always be an important component in the development of prone extension or postural stability. These findings may have significance for the planning of physical therapy or occupational therapy programs for children and adults with motor handicaps.

Research should be conducted on a larger sample of infants and with a larger representation of the general population. In addition, more refined techniques, such as electromyography and the use of videotapes, should be used to enable a closer examination of the development of this posture.

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