Comparison of Leg Movements in Preterm Infants at Term with Healthy Full-term Infants

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This study describes the differences and similarities in movement of low-risk preterm and full-term infants of comparable postgestational ages using a sensitive and quantitative measurement system, kinematic analysis. Subjects were 25 low-risk infants, 10 born at 34 to 36 weeks gestational age and 15 at term. Spontaneous leg movements were videotaped, and a 10-second segment was digitized to provide kinematic data. Data obtained were compared to evaluate the neurological maturation of preterm infants and to investigate the influence of the extraterine environment on movement. Results showed that all infants had organized movement as determined by high interjoint correlations, small phase lags, and constrained movement durations. Pause durations and joint angles differed among infants. Infant leg movements are highly organized synergies and are not influenced by extraterine environmental events. Differences in movements are attributed to dynamic interaction of elements in the motor control system. Additional studies with full-term infants may provide further insight into the constraints and supports of the immediate environment on movement outcome.

Key Words: Child development; Infant; Kinesiology/biomechanics, lower extremity; Pediatrics, development.

The traditional way to evaluate the neurological progress and integrity of preterm infants has been the comparison of neurobehavioral responses of these infants at 40 weeks postgestational age (PGA) (gestational age plus age from birth) with the responses of full-term infants. The rationale is that full-term infants provide a healthy analog from the same population. This comparison also provides a method for investigating the effects of exposure of the extraterine environment on the development of the preterm infant. Early comparisons of the behavior of full-term and preterm infants at 40 weeks PGA revealed similarities. Because these results were unexpected, they have been overemphasized. These studies, however, also included discussions of observed differences. Movement of the preterm infant at term was described as smoother than the full-term infant. This difference disappeared, however, in a few weeks. Saint-Anne Dargassies also noted that preterm infants tired more easily than full-term infants and that the duration of movement in these infants was brief.

Recent studies have also suggested that differences exist between full-term infants and preterm infants of 40 weeks PGA with respect to the amount of movement activity. Results, however, have been contradictory even when similar methods have been used. Paludetto et al, for example, using the Brazelton Neonatal Behavioral Assessment Scale, found that preterm infants had more spontaneous and elicited activity at term than full-term infants, whereas Ferrari et al reported no differences in activity level. Other studies have also supported that no differences exist in the amount of spontaneous movement of preterm and full-term infants at the same PGA. However, Booth et al, however, reported a greater frequency of movement of preterm infants at term in comparison with full-term infants during quiet and active sleep. Other studies have reported weaker spontaneous movements of preterm infants at term compared with full-term infants.

These contradictory results can be attributed to 1) different criteria for selection of infants with some studies using homogenous groupings of infants and other studies using heterogenous groupings, 2) differences in ages at which full-term infants were tested, 3) different behavioral states of the infants during movement observations, 4) different neurological tests used resulting in different classifications of movements, and 5) different reporting of results with respect to providing total scores of movement or a breakdown of individual motor items. Additionally, frequency of movement has been considered an insensitive measure of neural function. Prechtl and Nolte proposed that the coordination of movement and the speed and intensity of the movement pattern be used as measures of neural function. They hypothesized that changes in these variables of movement would precede frequency changes when the integrity of the nervous system was impaired.

No studies exist that compare the movement of preterm infants at term with full-term infants using quantitative kinematic analysis. This method of analysis has been used successfully with preterm and full-term infants. Results indicated that both preterm and full-term infants have organized movement, as indicated by coordinative structures demonstrating closely coor-
ominated joints, small phase lags, and constrained movement times.

In general, studies that have found similarities in the motor performance of preterm infants at 40 weeks PGA in comparison with full-term infants have concluded that neither intrauterine experience nor extraterine experience influence movement outcome.2,4,5,7,10 Other research reporting differences in movement between infants with identical PGAs but different ages from birth postulate that the type of environment may be an important factor in shaping these differences.5,11-14

The purpose of this study was to compare kinematic organization of leg movements of low-risk preterm infants at term with full-term infants to 1) evaluate the neurological maturation of low-risk preterm infants and 2) ascertain the influence of the extraterine environment on movement outcome. The question posed in this study was: What is the extent to which the extraterine maturation of the preterm infant parallels the intrauterine maturation of the full-term infant? That is, do differences and similarities exist in movement among infants of comparable PGAs but different ages from birth?

METHOD

Subjects

Subjects were 10 low-risk infants (4 female, 6 male) born at 34 to 36 weeks (X = 34.2 weeks) gestational age (GA) and 15 full-term infants (10 female, 5 male) delivered at 39 to 41 weeks gestational age. All infants were black and were from the same hospital population. Criteria for inclusion of preterm infants were 1) singleton birth; 2) vertex presentation at birth; 3) appropriate for size with respect to head circumference, weight, and length; 4) Apgar score of at least 4 at one minute and 7 at five minutes after birth; and 5) absence of any physical malformation. Infants exhibiting severe respiratory distress, pneumothorax, apnea, cardiac failure, convulsions, intracranial hemorrhage, hydrocephalus, perinatal asphyxia, chronic lung disease, or drug withdrawal were excluded from the study. All full-term infants were singleton, born by vaginal vertex delivery, appropriate for size, and healthy as determined by a pediatric physical examination. Gestational age estimations were made by a neonatologist using a Ballard, Kazmaier, and Driver18 assessment of GA.

Infants who met the criteria were enrolled consecutively in the study after informed consent was obtained from their parents. At the time of the study, preterm infants weighed an average of 3,300 g, and their crown-heel length averaged 51 cm; full-term infants weighed an average of 3,077 g, and their crown-heel length averaged 49 cm.

Instrumentation

Spontaneous kicking was recorded using a portable 1.27-cm cassette recorder and camera positioned at examining-table level to produce a lateral view of the infant's leg. The tapes were transferred to a 1.9-cm video recorder-editor with a 60-second frame-by-frame capability. Frame numbers were superimposed on the videotape (60 frames/sec).

Procedure

Infants were videotaped for three minutes. Preterm infants were videotaped at 40 weeks PGA; full-term infants on the third day after birth. To ensure awake infants, videotaping was conducted before feedings. The infant's clothes were removed, and the lower extremity was marked at the lateral border of the base of the fifth metatarsal head, the lateral malleolus, the lateral femoral condyle, and the lateral thigh at the hip crease with a 0.64-cm circle of dark blue tape affixed to a 1.27-cm circle of white tape (Fig. 1). The right leg of the full-term infants was videotaped until five infants of the same sex were filmed. Subsequently, the left leg of the next five full-term infants of that sex were filmed. The right leg of five male full-term infants was filmed. The right leg of all except two of the preterm infants was filmed. The left leg was filmed in two preterm infants because of the presence of an intravenous line in the right leg at the time of initial filming of these infants at birth.

After the infants were prepared for videotaping, they were allowed to kick spontaneously in the supine position for three minutes while they were videotaped. No specific stimuli were presented to the infant to elicit spontaneous kicking. The infant's head was supported in the midline position by the examiner's (C.B.H.) hand. The other hand was placed on the infant's abdomen to maintain the trunk in the midline position. During the videotaping session, the infant's arousal state was recorded every 15 seconds on a six-point scale (1 = asleep, 6 = crying)19 on an appropriate subdivision of this scale for preterm infants.20

Data Reduction

The videotapes were analyzed according to the procedure described previously.15 The three-minute videotape was analyzed for frequency of kicking, and joint angle changes for a selected 10-second segment of continuous movement were coded.

The 10-second movement segment was analyzed by digitizing the X,Y spatial coordinates of the marked hip, knee, ankle, and fifth toe for every frame (1 frame = 16½ msec). Joint angles of the hip, knee, and ankle were calculated from the coordinate data (Fig. 1). Because these joint angles reflect the relationships among body segments, they were not analogous to clinical measurements. In this study, 180 degrees was regarded as full extension at each joint (full plantar flexion of ankle). Interobserver correlations on displacement values in my previous study15 were calculated and were .960 for the hip, .946 for the knee, and .808 for the ankle, as determined by intraclass correlation coefficients (2,1).

Raw angle data were then subjected to Fourier analysis and filtered using procedures described previously.17 Joint angle and time of the start and termi-
nation of the flexion and extension movements of the kick cycle were noted according to predetermined criteria. The kick cycle was characterized by four phases. The flexion phase of the kick cycle lasted from the frame at which continuous leg movement (for at least five frames) in a horizontal plane toward the body was first noticed until the frame at which movement stopped or changed horizontal direction. The interkick pause was the time interval between the cessation of the flexion phase and the initiation of the extension phase. In the extension phase, the infant's foot moved continuously away from the body until horizontal movement ceased. The interkick pause was the time interval between the end of extension and the initiation of the next flexion phase.

The duration of each phase of the kick cycle was calculated. In addition, the phase lags between the joints were calculated and normalized. The peak velocities of both the flexion and extension movements were recorded. The joint angles at the onset and end of the flexion and extension movements were recorded and the amplitude excursion calculated.

Data Analysis

Descriptive data included frequencies, means, and standard deviations for the kinematic variables of movement. Differences between groups of infants were analyzed using t tests. Relationships between variables were analyzed using Pearson product-moment correlation coefficients.

RESULTS

Organization of Movement

Preterm infants at 40 weeks PGA showed the same close temporal and spatial synchrony between the joints as the full-term infants. All possible pairwise correlations of joints (three pairs for each infant) were significant at the .0001 level. Figure 2 shows the close synchrony of hip, knee, and ankle of a preterm infant at 40 weeks PGA and a full-term infant. Pair-wise correlations of angles of the preterm infant were: hip and knee, .986; hip and ankle, .803; and knee and ankle, .761. The full-term infant's correlations were: hip and knee, .810; hip and ankle, .849; and knee and ankle, .632.

To examine possible developmental trends in these joints, phase lags were calculated between key kinematic events in the joint movements—the onset of flexion and the point of peak flexion. Lags were calculated by subtracting knee onset or peak flexion times from hip onset or peak flexions; ankle onset or peak flexion times from hip onset or peak flexions; and ankle onset or peak flexion times from knee onset or peak flexions, normalized by dividing by the kick period. Differences between the time of hip, knee, and ankle onset and of hip, knee, and ankle peak flexion are shown in Table 1.

A small phase lag indicates the joints started moving or reached peak excursion in close temporal synchrony. A positive lag means either 1) the knee time of onset or peak was smaller than that of the hip or 2) the ankle time of onset or peak was smaller than that of the hip or knee and therefore lagged behind those movement events. A negative lag means either 1) the knee time of onset or peak was greater than that of the hip or 2) the ankle time of onset or peak was greater than that of the hip or knee and therefore led the hip or knee in those movements.

The kicking of a single leg in full-term infants showed the same topography of movement as preterm infants at 40 weeks PGA. During both flexion and extension, the ankle led the movement, followed by the hip and then the knee. The preterm infants at 40 weeks PGA showed the same relative temporal phase lags as the full-term infants. There was a tendency for the phase lags to be longer at the beginning of the flexion movement than at peak flexion.

No significant differences were found between preterm infants at 40 weeks PGA and full-term infants with respect to duration of either flexion or extension
movements or of the intrakick pause (Tab. 2). Term-equivalent infants averaged 520 msec for the flexion phase of movement and 810 msec for the extension phase compared with 490 msec and 790 msec, respectively, for the full-term infants. Full-term infants, however, paused significantly less during the interkick pauses resulting in significantly shorter kick periods and an increased frequency of kicking in 10 seconds as compared with the preterm infants. Thus, these infants appear to adjust the overall rate of kicking through adjustments in the interkick pause.

**Frequency of Kicking**

The data indicated a trend for full-term infants to kick more than preterm infants at 40 weeks PGA in three minutes. Full-term infants kicked an average of 43 times in three minutes (range = 14–92) in comparison with preterm infants at 40 weeks PGA who kicked an average of 33 times (range = 16–60). These differences, however, were not significant. The greater frequency of kicking in full-term infants is probably reflective of their shorter interkick pause.

**Amplitude of Movement**

Although preterm infants at 40 weeks PGA demonstrated greater excursion of movement at all joints than full-term infants, these differences were not significant (Tab. 3). Figure 3 shows the mean amplitude excursion of the knee (91°) of a preterm infant at 40 weeks PGA, which is similar, although greater, to that of a full-term infant (63°).

Although no significant differences were found in amplitude excursion between preterm infants at 40 weeks PGA and full-term infants, significant differences were noted between joint angles at the beginning of flexion and at peak flexion (Tab. 4). The knee and ankle joints of the preterm infants had significantly larger joint angles than full-term infants at the beginning of flexion. The ankle joints of the preterm infants were also significantly larger at peak flexion. Thus, the preterm infant at term is more extended than the full-term infant at the knee and ankle.

The position and movement of the ankle joint are of particular interest (Fig. 2). The amplitude excursions of the ankle were similar between the two infants (35° for the preterm infant at 40 weeks PGA; 28° for the full-term infant), but the movement occurred in more extension (118°-153°) for the term-equivalent

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**TABLE 1**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Preterm (n = 10)</th>
<th>Full-term (n = 15)</th>
<th>df</th>
<th>t*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kick period</td>
<td>2.365 ± .853</td>
<td>1.726 ± .607</td>
<td>23</td>
<td>-2.20b</td>
</tr>
<tr>
<td>Phase lag-knee flexion onset</td>
<td>0.030 ± .047</td>
<td>0.031 ± .042</td>
<td>23</td>
<td>0.09</td>
</tr>
<tr>
<td>Hip-knee</td>
<td>-0.022 ± .081</td>
<td>-0.003 ± .064</td>
<td>23</td>
<td>0.64</td>
</tr>
<tr>
<td>Knee-ankle</td>
<td>-0.054 ± .067</td>
<td>-0.033 ± .079</td>
<td>23</td>
<td>0.70</td>
</tr>
<tr>
<td>Hip-ankle</td>
<td>0.021 ± .032</td>
<td>0.046 ± .058</td>
<td>23</td>
<td>1.26</td>
</tr>
<tr>
<td>Knee-ankle</td>
<td>-0.005 ± .060</td>
<td>-0.013 ± .101</td>
<td>23</td>
<td>0.13</td>
</tr>
<tr>
<td>Knee-ankle</td>
<td>-0.030 ± .076</td>
<td>-0.043 ± .054</td>
<td>23</td>
<td>-0.05</td>
</tr>
</tbody>
</table>

* Independent t test.

b p < .05.

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**TABLE 2**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Preterm (n = 10)</th>
<th>Full-term (n = 15)</th>
<th>df</th>
<th>t*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of kicks/10 sec</td>
<td>3.06 ± .92</td>
<td>5.27 ± 1.84</td>
<td>23</td>
<td>2.72b</td>
</tr>
<tr>
<td>Kick phases</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flexion</td>
<td>0.52 ± .12</td>
<td>0.49 ± .15</td>
<td>23</td>
<td>-0.43</td>
</tr>
<tr>
<td>Intrakick pause</td>
<td>0.09 ± .17</td>
<td>0.12 ± .17</td>
<td>23</td>
<td>0.37</td>
</tr>
<tr>
<td>Extension</td>
<td>0.81 ± .30</td>
<td>0.79 ± .33</td>
<td>23</td>
<td>-0.20</td>
</tr>
<tr>
<td>Interkick pause</td>
<td>0.92 ± .55</td>
<td>0.30 ± .43</td>
<td>23</td>
<td>-3.16c</td>
</tr>
<tr>
<td>Kick period</td>
<td>2.36 ± .85</td>
<td>1.73 ± .61</td>
<td>23</td>
<td>-2.20b</td>
</tr>
</tbody>
</table>

* Independent t test.

b p < .05.

c p < .01.

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**TABLE 3**

<table>
<thead>
<tr>
<th>Joint</th>
<th>Preterm (n = 10)</th>
<th>Full-term (n = 15)</th>
<th>df</th>
<th>t*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hip</td>
<td>72.06 ± 18.27</td>
<td>62.02 ± 12.44</td>
<td>23</td>
<td>-1.64</td>
</tr>
<tr>
<td>Flexion</td>
<td>70.08 ± 19.43</td>
<td>59.30 ± 12.45</td>
<td>23</td>
<td>-1.70</td>
</tr>
<tr>
<td>Knee</td>
<td>73.55 ± 17.35</td>
<td>72.07 ± 12.75</td>
<td>23</td>
<td>-0.25</td>
</tr>
<tr>
<td>Flexion</td>
<td>74.19 ± 18.85</td>
<td>69.57 ± 15.10</td>
<td>23</td>
<td>-0.68</td>
</tr>
<tr>
<td>Ankle</td>
<td>32.72 ± 7.83</td>
<td>28.83 ± 7.11</td>
<td>23</td>
<td>-1.29</td>
</tr>
<tr>
<td>Flexion</td>
<td>31.06 ± 6.75</td>
<td>27.59 ± 7.98</td>
<td>23</td>
<td>-1.13</td>
</tr>
</tbody>
</table>

* All nonsignificant.

b Independent t test.
infant than for the full-term infant (90°-118°).

**Peak Velocity**

No significant differences were found in peak velocity of the flexion or extension movement of kicking between preterm infants at 40 weeks PGA and full-term infants (Tab. 5). Figure 3 shows the mean peak flexion velocity of the knee of a typical term-equivalent infant to be 216°/sec as compared with 130°/sec for the full-term infant; the mean peak extension velocity is 94°/sec for the preterm infant of 40 weeks PGA as compared with 92°/sec for the full-term infant.

**DISCUSSION**

All infants showed organized movement at comparable postgestational ages regardless of whether the infants reached term in the extrauterine environment or were born at term. Close synchrony of movement was denoted by high interjoint correlations and short phase lags. The durations of the flexion and extension phases of the kick cycle were constrained in all infants, averaging 505 msec for flexion and 800 msec for extension. These values are comparable to those reported for preterm infants at 34 to 36 weeks GA and slightly greater than for 2- and 4-week-old full-term infants.

These results suggest that the joints of one leg are organized as a coordinative structure, a group of muscles and joints that act as an elementary unit of motor control. This synergy provides order and regularity to the movement and the distinctive spatial and temporal character of early kicking. Because this movement pattern is relatively invariant in infants of comparable PGAs regardless of age at birth, this organization likely arises from neuromuscular structures constructed comparatively early in development and not influenced by extrauterine environmental events.

Although the interjoint synergy and movement durations remained stable with extrauterine experience, small differences were found between the two groups of infants. First, full-term infants spent less time than preterm infants in the interkick pause, resulting in shorter kick periods and a trend toward an increased frequency of kicking in three minutes. Paludetto et al also noted that full-term infants have a tendency to kick more than preterm infants. Second, specific joint angles at the beginning of the flexion movement and at peak flexion were smaller in full-term infants reflecting that these infants are more flexed than preterm infants who reach term-equivalent age. Others have also found that preterm infants at term are more extended than full-term infants, especially in the legs.

If the elementary unit of motor control, the coordinative structure, is similar in infants regardless of age and environmental experience, why are there differences in spontaneous kicking? Thelen and colleagues have argued that movement dynamically emerges from the confluence and interactions of many components. In this view, kicking is not the outcome of only central instructions but emerges from numerous interacting subsystems within the constraints and supports of the immediate environment. Such subsystems could include arousal level, body-build characteristics such as limb weight and length, muscle strength, and passive viscoelastic properties of muscles.

Studies have shown that the rate of kicking increases as arousal level increases. This increased frequency of kicking is reflective of short interkick pauses resulting in short kick periods. Previously, I suggested that differences in movement of preterm infants at 34 to 36 weeks GA and these same infants at 40 weeks PGA were not caused by changes in the central processes generating the movement pattern but were...
TABLE 4
Infants at 40 Weeks Postgestational Age and Full-term Infants at Three Days After Birth

<table>
<thead>
<tr>
<th>Joint</th>
<th>Preterm (n = 10)</th>
<th>Full-term (n = 15)</th>
<th>df</th>
<th>t*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>X</td>
<td>s</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hip</td>
<td>95.69</td>
<td>17.11</td>
<td>23</td>
<td>0.64</td>
</tr>
<tr>
<td>Peak</td>
<td>165.37</td>
<td>6.13</td>
<td>23</td>
<td>-1.80</td>
</tr>
<tr>
<td>Onset</td>
<td>91.64</td>
<td>15.81</td>
<td>23</td>
<td>-2.04</td>
</tr>
<tr>
<td>Knee</td>
<td>165.55</td>
<td>5.95</td>
<td>23</td>
<td>-3.66b</td>
</tr>
<tr>
<td>Ankle</td>
<td>117.83</td>
<td>16.96</td>
<td>23</td>
<td>-4.94b</td>
</tr>
<tr>
<td>Peak</td>
<td>150.72</td>
<td>14.05</td>
<td>23</td>
<td>-7.21b</td>
</tr>
</tbody>
</table>

* Independent t test.
 b p < .001.

TABLE 5
Peak Velocity (in Degrees per Second)* for Preterm Infants at 40 Weeks Postgestational Age and Full-term Infants at Three Days After Birth

<table>
<thead>
<tr>
<th>Joint</th>
<th>Preterm (n = 10)</th>
<th>Full-term (n = 15)</th>
<th>df</th>
<th>t*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>X</td>
<td>s</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hip</td>
<td>175.49</td>
<td>51.06</td>
<td>23</td>
<td>-1.69</td>
</tr>
<tr>
<td>Flexion</td>
<td>148.31</td>
<td>29.69</td>
<td>23</td>
<td>-0.68</td>
</tr>
<tr>
<td>Extension</td>
<td>102.63</td>
<td>40.23</td>
<td>23</td>
<td>0.72</td>
</tr>
<tr>
<td>Knee</td>
<td>114.29</td>
<td>45.22</td>
<td>23</td>
<td>0.12</td>
</tr>
<tr>
<td>Flexion</td>
<td>173.74</td>
<td>49.00</td>
<td>23</td>
<td>0.43</td>
</tr>
<tr>
<td>Extension</td>
<td>116.38</td>
<td>45.84</td>
<td>23</td>
<td>1.33</td>
</tr>
<tr>
<td>Ankle</td>
<td>90.33</td>
<td>46.70</td>
<td>23</td>
<td>1.33</td>
</tr>
<tr>
<td>Flexion</td>
<td>83.72</td>
<td>31.16</td>
<td>23</td>
<td>0.43</td>
</tr>
<tr>
<td>Extension</td>
<td>78.48</td>
<td>42.19</td>
<td>23</td>
<td>1.33</td>
</tr>
</tbody>
</table>

* All nonsignificant.
 b Independent t test.

attributable to parallel developmental changes in body size and composition. One possible interpretation of the results of this study, therefore, is that arousal level and body-build characteristics could explain the differences in kicking, pause durations, and joint angles between preterm infants at term and full-term infants.

Thus, the expression of kicking depends on the dynamic interaction of the coordinative structure with other developing systems, including anatomical, postural, and biomechanical systems, within the supports and constraints of the environment. The coordinative structure need not change with development but may remain as a general substrate whose details are emergent from the entire dynamic context of the infant. In this view, the uterus is just as much an environment or context for action as the postnatal world.

A limitation of this study relates to the digitization of movement in the sagittal plane. Movement outside the sagittal plane occurred in all kicking movements during the three-minute movement segment. To control for this problem, a 10-second segment was chosen in which movement outside the sagittal plane was minimal and all four markers could be observed. Thus, joint angles discussed are relative joint positions and not absolute angular measurements. Preterm infants at 40 weeks GA showed more lateral rotation of the hip than full-term infants. This lateral rotation was primarily observed during the extension phase of kicking and was accompanied by eversion of the foot. During the flexion phase of kicking, infants medially rotated toward the anatomical neutral position, with inversion and dorsiflexion of the foot. Preterm infants at 40 weeks PGA showed periods of leg extension in midair. Only one full-term infant showed this type of movement.

Clinical Implications

Leg movements in infants appear to be organized as a basic unit of movement, a coordinative structure. This unit shows close coupling of the joints and constrained movement times and is not influenced by the intrauterine or extrauterine environment.

Results of small differences in kicking among infants, attributed to nonneural variables, support a biodynamic approach to movement. Such theory purports that the final form of the movement is not the outcome of only central instructions but also of other components interacting within a particular environmental context. Physical therapists must bear in mind that arousal level, body build, muscle strength, articulator differentiation, viscoelastic properties of muscles, and other variables dynamically interact with the coordinative structure within the environment to produce the final movement pattern. Because small differences between preterm infants at 40 weeks PGA and infants born at term were noted, comparisons of movement between preterm and full-term infants of similar PGAs may not be valid. Physical therapists should consider comparing preterm infants with preterm infants and full-term infants with full-term infants of the same GA or PGA.

The need for additional studies in this area is obvious. Specifically, future research could address differences and similarities of kicking between full-term infants at birth and these same infants at 6 weeks of age to further elucidate the constraints and supports of the environment on movement.

CONCLUSIONS

This study described similarities and differences in movement of low-risk preterm and full-term infants of comparable PGAs using kinematic analysis. Results showed that all infants have organized movement, as denoted by strong interjoint correlations, small phase lags, and constrained movement durations. Differences in movement were ascribed to dynamic interactions among the elements in the motor control system. Implications for physical therapy evaluation of preterm and full-term infants and future research with full-term infants were addressed.
Acknowledgments. I wish to express my appreciation to Esther Thelen, PhD, for her guidance in the use of kinematic analysis; Thomas M. Shea, EdD, for his support throughout the study; Donald J. Baden, EdD, for his careful review of my doctoral study; William P. Ahlbrand, PhD, for his assistance with the statistical analysis; Corinne Walentik, MD, for her cooperation in providing access to patients; Cheryl Cavallo, PT, for her technical expertise; and Gloria Schwartz for her assistance in the preparation of this manuscript.

REFERENCES


15. Heriza CB: Organization of leg movements in preterm infants. Phys Ther, to be published