Age-Related Differences in Movement Patterns Used by Toddlers to Rise From a Supine Position to Erect Stance

Background and Purpose. Rising from the floor to a standing position is an important milestone in the development of children. The purposes of this study were (1) to describe the movement patterns (MPs) toddlers use when rising to a standing position, (2) to determine whether toddlers' MPs differ with age, and (3) to investigate whether MPs that are proposed to occur earliest in the development of this task predominate in toddlers. Subjects and Methods. Sixty children aged 15 to 47 months were videotaped performing at least six trials of rising. Data were reduced by classifying movements of the upper extremity (UE), axial region (AX), and lower extremity (LE) into categorical descriptions of the action of these body regions. The incidence of each UE, AX, and LE movement pattern was determined for each 10-month age interval and compared across age groups. Results. Two previously unidentified MPs were described for LE action. The youngest children demonstrated the highest incidence of MPs that have been predicted by other researchers to occur early in development. Conclusion and Discussion. In general, toddlers' UE and AX movements were described using previously developed MP categories. Age differences were found among toddlers in the performance of the rising task. Movement patterns of the UE and AX that have been thought to occur earliest in the developmental sequence for this task predominated in this young group. [Marsala G, VanSant AF. Age-related differences in movement patterns used by toddlers to rise from a supine position to erect stance. Phys Ther. 1998;78:149–159.]

Key Words: Kinesiology, general; Movement patterns; Movement science; Pediatrics, motor development.

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rising to a standing position by young children is an important step toward developing independence. Descriptions of movement patterns that children use to rise from a supine position to a standing position can be found in the literature. This task is assessed in motor development tests. We believe, however, that these descriptions of performance are incomplete in light of the qualitative movement analysis capabilities available today. We contend that these descriptions lack important details about upper-extremity (UE), axial region (AX), and lower-extremity (LE) movements. If incomplete descriptions are used as standards to determine whether a child is developing appropriately, we believe that this causes problems. Because standing remains an important step in the development of a child, we argue that physical therapists would benefit from a more detailed description.

Background
When a child’s ability to rise to a standing position independently is first noted, at an average age of 14
months, the body action is characterized by rotation of the head, shoulder girdle, trunk, and hips in the coronal or transverse plane. According to Schaltenbrand, around the fifth year of life, this form of rising is replaced with symmetrical flexion and extension movements of the head, shoulder girdle, trunk, and hips.

Two patterns of movement used to rise to a standing position were described originally by McGraw. In one pattern, the child moves through a quadrupedal position to erect standing. Younger children tend to roll from a supine to a prone position before pushing up to the quadrupedal position. Older children were described as sitting up from a supine position, then moving their “shoulders forward as to gain a quadrupedal position.” After studying the variability among the subjects that appeared to be age-related. Different modal patterns were found for each age group. The descriptive categories of the movement patterns for the three components were appropriate for describing children’s movements, with a few modifications and qualifiers. In the UE component, two categories were expanded from previous identified categories to include the more asymmetrical movements of the children. An additional AX movement pattern was defined, “full rotation, abdomen down,” which was

Many contemporary tests of infant motor development reference the earlier studies of McGraw and Bayley. These tests continue to use the total body approach to describe movements. In our view, the movement pattern descriptions included in these tests are incomplete and typically include limited descriptions of UE and LE patterns.

Component Approach to Describing Movement Patterns
VanSant and colleagues have been studying the task of rising from a supine to a standing position in cross-sectional studies of a wide range of age groups. Applying a method introduced by Roberton et al., VanSant utilized a component analysis of movement to formulate a developmental sequence of movement patterns for the task of rising to a standing position. This method breaks body action into three regions: UE, AX, and LE. The use of the component method rather than the total body approach was an important breakthrough in qualitative movement analysis because it allows intra-individual and inter-individual variation in the rate of development across different body regions. After studying the variation across body regions for the task of rising to a standing position, VanSant proposed a developmental sequence of the movements for each body region, which has been partially validated in cross-sectional studies of children and adults.

VanSant first tested the three proposed component developmental sequences of movement patterns for rising to a standing position in a study of 120 children. The children ranged in age from 4 to 7 years. VanSant found variability among the subjects that appeared to be age-related. Different modal patterns were found for each age group. The descriptive categories of the movement patterns for the three components were appropriate for describing children’s movements, with a few modifications and qualifiers. In the UE component, two categories were expanded from previous identified categories to include the more asymmetrical movements of the children.

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This study was approved in partial fulfillment of the requirements for Ms Marsala’s Master of Science degree.

This study was completed in partial fulfillment of the requirements for Ms Marsala’s Master of Science degree.

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observed only in 4-year-old children. A new developmental step, “jump to squat,” was also added to the LE component. This step was proposed as a developmental step, as it was observed most frequently in 4-year-olds and less frequently in the older age groups. The most common body action found across all age groups of children was an asymmetrical push of the UEs, with the trunk forward with some rotation and the LEs demonstrating an asymmetrical or wide-based squat pattern. In general, the older children used more symmetrical movement patterns than the younger children used. The development sequences of movement patterns for this task proposed by VanSant have yet to be validated for children younger than 4 years of age. To further validate the proposed developmental sequence for this task, this younger age needs to be studied. The purposes of our study were (1) to determine whether movement patterns used to describe young children rising from the floor to a standing position could be used to describe movements of toddlers, (2) to determine whether there are age-related differences in the movement patterns among toddlers, and (3) to determine whether movement patterns that are proposed to occur earliest in the developmental sequence predominated among toddlers (see Appendix).

Method

Subjects
Sixty toddlers between the ages of 15 and 47 months participated in this study (Tab. 2). The sample was one of convenience. Subjects were recruited through various day-care centers and nursery schools in Mercer County, NJ.

Informed parental consent was obtained for each child. A parent was asked to provide the child’s birthdate and to assure us that the child had no physical disabilities or medical conditions that would interfere with physical activity. To be included in the study, each child had to be able to walk alone for a few steps and rise to a standing position without assistance.

The toddlers were divided into three age groups, representing an 11-month span, to allow study of age differences across the 15- to 47-month period. Group characteristics are presented in Table 2.

Design of the Study
The study was designed as a cross-sectional survey to describe age-related differences in motor performance of this rising task.

Instrumentation
Two VHS video camcorders were used to record the children’s movements. The two cameras were located to record a side view and a foot view of each subject. One camera was placed perpendicular to the length of the mat, and the other camera was placed perpendicular to the width of the mat. Each camera was approximately 2.1 to 2.4 m (7–8 ft) away from the center of the mat. The cameras were placed on tripods, and the zoom lens (zoom power: 1X) was adjusted to maximize the size of the child yet provide a full view of the child and the mat throughout the rising movement. A board in view of each camera indicated the subject number and trial number. A VHS videotape player with stop-action capabilities and a television monitor were used to reduce the data.

Data Collection Procedures
Children were videotaped at their day-care centers or at their schools. Each child was accompanied to the data collection site by a staff member of the facility. The data collection procedure was explained in a manner appropriate for the child’s age. Any questions asked by the child were answered. The child was then asked to lie down, in a supine position, in the middle of the exercise mat. This was the starting position for each trial. Some

Table 1.
Movement Patterns for the Task of Rising From a Supine Position to a Standing Position

<table>
<thead>
<tr>
<th>Category</th>
<th>Movement Patterns</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper-extremity</td>
<td>1. Push reach to bilateral push</td>
</tr>
<tr>
<td></td>
<td>2. Push and reach</td>
</tr>
<tr>
<td></td>
<td>3. Symmetrical push</td>
</tr>
<tr>
<td></td>
<td>4. Symmetrical reach</td>
</tr>
<tr>
<td></td>
<td>5. Push and reach followed by pushing on leg</td>
</tr>
<tr>
<td></td>
<td>6. Push and reach followed by pushing on leg</td>
</tr>
<tr>
<td>Trunk categories</td>
<td>1. Full rotation, abdomen down</td>
</tr>
<tr>
<td></td>
<td>2. Full rotation, abdomen up</td>
</tr>
<tr>
<td></td>
<td>3. Partial rotation</td>
</tr>
<tr>
<td></td>
<td>4. Forward with rotation</td>
</tr>
<tr>
<td></td>
<td>5. Symmetrical</td>
</tr>
<tr>
<td>Lower-extremity</td>
<td>1. Kneel</td>
</tr>
<tr>
<td></td>
<td>2. Jump to squat</td>
</tr>
<tr>
<td></td>
<td>3. Half kneel</td>
</tr>
<tr>
<td></td>
<td>4. Asymmetrical/wide-based squat</td>
</tr>
<tr>
<td></td>
<td>5. Narrow-based squat</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Age Group (mo)</th>
<th>No. of Subjects</th>
<th>Age (mo)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15–25</td>
<td>20</td>
<td>20.5</td>
</tr>
<tr>
<td>26–36</td>
<td>19</td>
<td>30.2</td>
</tr>
<tr>
<td>37–47</td>
<td>21</td>
<td>43.5</td>
</tr>
</tbody>
</table>

VanSant’s developmental sequences have yet to be validated for children younger than 4 years of age. To further validate the proposed developmental sequence for this task, this younger age needs to be studied. The purposes of our study were (1) to determine whether movement patterns used to describe young children rising from the floor to a standing position could be used to describe movements of toddlers, (2) to determine whether there are age-related differences in the movement patterns among toddlers, and (3) to determine whether movement patterns that are proposed to occur earliest in the developmental sequence predominated among toddlers (see Appendix).

Method

Subjects
Sixty toddlers between the ages of 15 and 47 months participated in this study (Tab. 2). The sample was one of convenience. Subjects were recruited through
toddlers in the youngest age group were assisted into the starting position. The child was then asked to stand up as quickly as possible on the cue “Stand up.” Due to the young age of the subjects, the cue was modified to be more motivating, as needed. The child was given general praise after each trial. As in previous studies, an attempt was made to videotape each child for 10 consecutive trials on this task. If the child became upset during the videotaping, the data collection stopped until the child was able and ready to continue. The data collection was discontinued if the child remained upset or did not want to continue. Any child who completed at least six trials was included in the study. No data collection session lasted more than 15 minutes, regardless of the number of trials completed. Due to the repetitive nature of the data collection procedure, external motivators were used as needed. Older children were rewarded with stickers. In the two younger groups, when the children appeared to be restless with the task, they were encouraged to stand up to get a favorite toy (placed across the room) or to resume a supine position by lying down on the mat next to the doll.

Data Reduction

The process of data reduction involved viewing the videotaped performances and classifying the movements observed in each of the three components (UE, AX, and LE) into one of the movement pattern categories listed in Table 1. The movement pattern categories had been established in a previous study of 4- to 7-year-old children. The first author did all classifications. The foot-view videotape was used to classify data for all components. The side-view videotape was used for any trials in which clarification of the movement was needed to classify the action.

Upper-extremity movements were classified first. The first trial of each child was reviewed and classified. The second trial of each child was then classified. This procedure continued until the UE movements seen on the 10th trial (or the last trial of subjects who completed fewer than 10 trials) had been classified. This order was chosen to reduce within-rater bias. If the trials for each child were viewed in successive order, there may have been a bias as to which categorial description was identified. By viewing trial 1 of subject 1, trial 1 of subject 2, and so on, this bias was reduced (as there were 80 subjects). This procedure was then repeated for the AX and LE components. If a movement observed in a trial could not be classified, the movement was described in writing by the first author. After all trials of all children were reduced, the written descriptions of the unclassified trials were reviewed. If the unclassified movement patterns could not be classified by modifying the existing categories, the new movements were considered qualitatively different from existing categories. New categorical descriptions were formed to encompass these movement patterns. If a category was modified or new categories were added, all trials of that component were reclassified using the new set of categorical descriptions.

Reliability

To ensure interrater reliability, 50 randomly selected trials were classified by the second author. When there was 90% or better agreement between the two authors, the categories were considered to be reliable. Interrater reliability was determined using a Kappa statistic for these 50 randomly selected trials. The percentages of agreement between the authors and the Kappa statistics are presented in Table 3.

Data Analysis

The existing movement pattern descriptions were considered accurate if pattern descriptions were not modified, and they were considered comprehensive if new patterns were not added. If additional movement categories were identified, a suggested reordering of the developmental sequence for that component was made by both authors.

To determine whether there were age-related differences in performance among the three groups of children, the movement patterns for each component for each age group and the percentage of occurrence of each pattern within each age group were compared. In each age group, the percentage of occurrence of each movement pattern was calculated by dividing the incidence of the movement pattern by the total number of trials for that group. The percentage of occurrence of each movement pattern with respect to age was presented in graphic form for each of the three components.

To determine whether toddlers displayed movement patterns that have been proposed to occur earliest in development, the modal movement pattern for each component was determined for each age group and the order in which the movement patterns predominated was determined. This order was compared with VanSant’s original hypothesis as to the order of movement patterns. (Movement patterns are listed in developmental order in Tab. 1.)

<table>
<thead>
<tr>
<th>Movement Pattern Component</th>
<th>Kappa Reliability</th>
<th>Interrater Agreement</th>
<th>Intrarater Agreement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper extremity</td>
<td>.84</td>
<td>94%</td>
<td>96%</td>
</tr>
<tr>
<td>Axial region</td>
<td>.90</td>
<td>90%</td>
<td>86%</td>
</tr>
<tr>
<td>Lower extremity</td>
<td>.93</td>
<td>96%</td>
<td>96%</td>
</tr>
</tbody>
</table>

Table 3. Percentages of Agreement and Kappa Statistics
Table 4.
Modified Axial Region Category: Partial Rotation

<table>
<thead>
<tr>
<th>Previous Description</th>
<th>Modified Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexion and rotation bring the body to a side-facing position with the shoulders remaining above the level of the pelvis. The back extends up to the vertical, with or without accompanying rotation.</td>
<td>Flexion and rotation bring the body to a side-facing position or beyond with the shoulders remaining above the level of the pelvis. The back extends up to the vertical, with or without accompanying rotation.</td>
</tr>
</tbody>
</table>

Results

Movement Pattern Categories
The first question we addressed was whether the movement patterns used to describe young children’s movements (ages 4–7 years) were appropriate for toddlers’ movements. The UE movements of toddlers in the rising task were accurately described by movement patterns used to describe 4- to 7-year-old children’s movements. Changes were necessary, however, in the written description of the partial rotation movement of the AX component. The description was revised to reflect the greater degree of trunk rotation observed in this sample of younger children. The original and revised descriptions of categories are presented in Table 4.

The LE categories were accurate but not comprehensive for the movements of these toddlers. We created two new LE categories to describe the distinct movement patterns observed in this sample.

One pattern was termed “pike.” This movement was characterized by the position of the LEs with respect to the trunk during the process of rising. The children demonstrating this action assumed a position in which the knees were relatively extended as the hips assumed an acute angle of flexion (Fig. 1). The following is the description of this LE movement:

The LEs are flexed toward the trunk and may be rotated to one side with both knees or a knee and foot in contact with the ground. Both feet then contact the support surface. The LEs are extended to a pike position. Slight flexion of the LEs is then followed by full extension during the rise.

The other new LE category, termed “pike-jump to squat,” differed from the “pike” category in that the initial base of support described by the pike position is made smaller by a jumping action, which brings the LEs toward the hands. Standing is achieved then by extending the LEs from a squat. The “pike” category, standing is achieved by slight flexion of the LEs, followed by full extension during the rise (Fig. 2). The following is a description of the “pike-jump to squat” category:

Figure 1.
Foot view (left) and side view (right) of the most common movement pattern profile for rising from a supine position to a standing position in the 15- to 25-month-old group included the “push and reach to bilateral push” pattern of the upper-extremity component, the “full rotation, abdomen up” pattern of the axial region component, and the “pike” pattern of the lower-extremity component.

Age-Related Differences in Upper-Extremity, Axial Region, and Lower-Extremity Movement Patterns

Upper-extremity component. The most common UE category for all three age groups was “push and reach to bilateral push” (Tab. 5). Push and reach was observed more frequently in the two older groups (ages 26–36 and 37–47 months) as compared with the youngest group (ages 15–25 months). A small percentage of
children in the two older groups demonstrated the UE categories "push and reach to bilateral push followed by pushing on leg" and "push and reach followed by pushing on leg" (Fig. 3), which involve an initial push followed by a thigh push.

Axial region component. The two most common AX patterns for the two youngest groups (ages 15-25 and 26-36 months) were “full rotation, abdomen down” and “full rotation, abdomen up.” In the oldest group (ages 37-47 months), “full rotation, abdomen up” was the most prevalent pattern (Fig. 4). Twenty-five percent to 35% of the toddlers in the two oldest groups used the “partial rotation” pattern. A smaller number of children in these older groups demonstrated the “forward with rotation” pattern.

Lower-extremity component. For the LE component, each age group had a different modal movement pattern. The newly defined movement pattern, “pike” (Fig. 1), was the most prevalent pattern in the youngest group. The “kneel” pattern was most common in the middle age group. The “half kneel” pattern was most common in the oldest group. The LE patterns of “pike” and “pike-jump to squat” were seen in a small percentage of trials across the three groups. The “asymmetrical/wide-based squat” pattern was noted in a few trials in the two older groups. Figure 5 presents the incidence of LE movement patterns across the three age groups.

Discussion
The UE movement categories developed to describe young children’s and adults’ body action in rising to stand were found to provide accurate and comprehen-

Table 5.
Frequency of Occurrence of Each Movement Pattern for Each Age Group as a Percentage of Trials in Which They Occurred (Number of Trials in Each Age Group Shown in Parentheses)

<table>
<thead>
<tr>
<th>Movement Categories</th>
<th>Age Groups (mos)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>15-25 (n=186)</td>
</tr>
<tr>
<td>Upper extremity</td>
<td></td>
</tr>
<tr>
<td>Push and reach to bilateral push 92.47</td>
<td>58.58</td>
</tr>
<tr>
<td>Push and reach 4.30</td>
<td>17.16</td>
</tr>
<tr>
<td>Symmetrical push 0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Symmetrical reach 0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Asymmetrical push followed by pushing on leg 0.00</td>
<td>5.33</td>
</tr>
<tr>
<td>Push and reach to bilateral push followed by pushing on leg 3.23</td>
<td>11.83</td>
</tr>
<tr>
<td>Axial region</td>
<td></td>
</tr>
<tr>
<td>Full rotation, abdomen down 43.55</td>
<td>36.69</td>
</tr>
<tr>
<td>Full rotation, abdomen up 51.08</td>
<td>30.18</td>
</tr>
<tr>
<td>Partial rotation 5.38</td>
<td>26.63</td>
</tr>
<tr>
<td>Forward with rotation 0.00</td>
<td>5.92</td>
</tr>
<tr>
<td>Symmetrical 0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Lower extremity</td>
<td></td>
</tr>
<tr>
<td>Kneel 17.74</td>
<td>32.14</td>
</tr>
<tr>
<td>Jump to squat 0.54</td>
<td>2.38</td>
</tr>
<tr>
<td>Half kneel 8.06</td>
<td>23.81</td>
</tr>
<tr>
<td>Asymmetrical/wide-based squat 0.00</td>
<td>12.50</td>
</tr>
<tr>
<td>Narrow-based squat 0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Pike 65.59</td>
<td>18.45</td>
</tr>
<tr>
<td>Pike-jump to squat 8.06</td>
<td>10.71</td>
</tr>
</tbody>
</table>
sive descriptions of toddlers' movements. With the exception of the “partial rotation” category, the AX component patterns were also accurate and comprehensive. New categories were formed to describe LE movement patterns that were more common among toddlers.

**Upper-Extremity Movement Patterns**

Toddlers displayed two UE movement patterns, “push and reach to bilateral push followed by pushing on leg” and “push and reach followed by pushing on leg,” which were previously identified only in studies of middle-aged and older adults. These patterns had been predicted by VanSant to predominate much later in the human life span (ie, in persons in their 30s, 40s, and 50s and increasing in incidence with age). Perhaps older adults and toddlers share a common problem (ie, insufficient force or strength) that results in the appearance of these patterns among the two groups. We propose that the two groups demonstrate the same UE strategy when insufficient force is generated in the extensor muscles of the trunk and LEs.

We suggest that LE- and trunk-force production is a control variable for this task. Heriza defined a control variable as one “that shifts the movement from one form to another.” An individual may change from the “push and reach to bilateral push” pattern to the “push and reach to bilateral push by pushing on leg” pattern if a critical level of quadriceps femoris muscle, hip, or back extensor force is not produced.

The fact that the two thigh push categories were seen in toddlers suggests that these categories are not the last movement patterns to appear in the UE life-span deve-
opmental sequence for this task. This finding raises the question of whether the categories of "push and reach to bilateral push followed by pushing on leg" and "push and reach followed by pushing on leg" should be early steps in the UE developmental sequence.

We propose reordering the UE movement patterns based on the varying incidence of UE patterns we found (Tab. 6). "Push and reach to bilateral push followed by pushing on leg" is suggested as the earliest category to predominate, followed by "push and reach to bilateral push." "Push and reach followed by pushing on leg" would be the next category predominating, just prior to "push and reach." The remaining UE categories would then predominate in the order previously suggested.

Axial Region Movement Patterns
Because toddlers displayed a greater degree of axial rotation in the transverse plane than reported for older subjects, the "partial rotation" category was modified to reflect this finding. In the previous description of this category, the trunk reached a side-facing position (90° of rotation) just prior to the LE extension phase. In the younger toddlers studied, however, the degree of trunk rotation was 180 degrees just prior to the LE extension phase.

The greater degree of axial rotation with respect to the vertical axis seen in the trials of younger toddlers appeared to be a variation of the existing "partial rotation" category. Our decision not to create a new movement category to represent variations in aspects of a movement unrelated to the decision rules used to discriminate is consistent with the decision made in a previous study of young children. In that study, the "forward with rotation" category was modified to reflect the trunk movements of children that differed subtly from those of adults. Future studies of very young children could explore possible separation of these movement categories.

Lower-Extremity Movement Patterns
The decision to define new LE movement patterns was based on our belief that the patterns were substantially different from existing LE patterns. In a previous study, movement categories were broadened to include new movements that were proposed to be variations of existing categories. In our study, however, this was not possible without changing the general intent of the existing movement categories.

The characteristic feature of both the "pike" and "pike-jump to squat" categories is the acute angle that the hips form in relation to the trunk just prior to the rising phase. When we initially described the "pike" category in this study, we identified two ways to assume the pike position. The "pike" category, as it currently is described, allows a child to move the LEs in a number of different ways prior to extending the LEs to a pike position. In the majority of trials, children flexed their LEs toward the trunk while rotating them and then moved them to a position of flexion with both feet in contact with the ground. Then the LEs extended symmetrically to a pike position. In a smaller number of trials, the LEs were initially rotated to one side and flexed toward the trunk. One LE was immediately placed in contact with the support surface. The LEs then extended asynchronously to place the opposite foot in contact with the support surface. This asynchronous LE extension also resulted in the assumption of a pike position. Although these two
ways of assuming the pike position may be viewed as two distinct categories in the future, we have chosen not to separate them at this time because of the low incidence of trials in which the pike position was assumed through the asynchronous method. These seemingly different ways of coming to a pike position need to be more thoroughly studied among a larger sample of young children before additional movement categories are formed.

After we identified the new movement pattern categories, we proposed a new developmental sequence for the LE movement patterns. We determined the order of the categories by examining the relationship of each LE movement pattern with age. We placed the "pike" category first in the sequence because it predominated in the youngest group and declined sharply in incidence in the two older groups. The developmental position of the "pike-jump to squat" category is more problematic because it appeared in a small percentage of trials for all age groups. The "pike-jump to squat" movement pattern may exemplify the LE sequence of toddlers who had mastered the "pike" movement pattern but were not ready to move to the next developmental step, "kneel." If the "pike-jump to squat" pattern is recognized as an advanced modification of the "pike" pattern, it follows that the "pike-jump to squat" pattern would be seen after the "pike" pattern in the LE sequence. The previously identified LE movement pattern categories would follow the "pike-jump to squat" pattern in the order previously predicted of "kneel," "jump to squat," "half kneel," "asymmetrical/wide-based squat," and "narrow-based squat" (Tab. 7).

Movement Patterns as Developmental Steps

The most common UE movement pattern in toddlers aged 15 to 47 months was a "push and reach to bilateral push" pattern. This movement pattern was noted most frequently in the youngest group, and its frequency declined slightly in the two older groups. This was the earliest pattern predicted to occur in the UE developmental sequence. The data gathered in our study support this prediction of "push and reach to bilateral push" as an early-occurring pattern in life-span development.

In the AX component, the two most common movement patterns were "full rotation, abdomen down" and "full rotation, abdomen up." These movement patterns represent the first and second steps, respectively, in the developmental sequence for the AX component for this task. The "full rotation, abdomen down" pattern was noted most frequently in the youngest group (refer to Tab. 5 for percentages of each movement pattern across each age group). The frequency of the pattern declined slightly in the middle age group and dropped sharply in the oldest group. The "full rotation, abdomen up" pattern was also common in the youngest group. This pattern declined slightly in the middle age group and was again common in the older group. These findings support the hypothesis that toddlers would demonstrate an increased frequency of the movement patterns predicted to occur earliest in the developmental sequence.

In the LE component, the first predicted step of the sequence, "kneel," was seen in each of the three age groups. It was most prevalent in the middle age group, as noted in 30% of the trials in this group. The "jump to squat" pattern was noted in a small percentage of the children across all age groups, gradually increasing in the oldest group. The data gathered, however, do not support or negate the position of these patterns in the developmental sequence. The "half kneel" pattern showed a gradual increase over the three age groups to a high of 42.93% of the trials in the oldest group. The most common LE pattern, however, was the newly described category "pike." A similar movement pattern had been observed in a study of 4- to 7-year-old children, but a descriptive category was not formed due to the small incidence. The predominance of this new pattern led to a proposed reordering of the LE categories (Tab. 7). There was a tendency in the two older groups of toddlers to use patterns that predominate in the older children, especially in the AX and LE components. These results also corroborate the findings of previous studies of 4- to 7-year-old children in which movement.
patterns proposed as early steps were more common among young children and movement patterns proposed as later steps were more common among older children. The results of our study of toddlers help to support the hypothesis that developmental sequences for this task can describe movement patterns over the life span.

**Clinical Relevance and Conclusions**

Heriza has suggested that although the use of developmental tests that mark developmental milestones may be useful in some circumstances, there is a need to develop evaluation tools that look at the "process of movement change." Developmental milestones do not typically portray the movement patterns used to accomplish a task. The process of movement change is more likely to be detected by using a component analysis.

The sensitivity of some developmental tests currently in use may not be adequate to evaluate the process of change. The criteria in these tests do not fully describe body action, nor do they address variability in action across body components. The test criteria imply that the variability of children's movement patterns is not important. Our study indicates that toddlers' movement patterns in the rising task can vary greatly across body regions. We contend that when using test criteria that incompletely describe children's movement patterns in a particular task, reliability of scores is jeopardized. The categorical descriptions of component movement patterns in the rising task have shown promising intertester reliability. More complete descriptions of movement patterns should increase reliability and bring us closer to documenting the process of movement pattern change.

The component method of studying movement patterns is easy to apply in the clinic. The method is relatively inexpensive, and the technical equipment necessary (ie, a camcorder and a television monitor) are readily available in many facilities. In a short period of time, physical therapists could familiarize themselves with the categories of movement for this task of rising to a standing position. This method would greatly increase information on movement pattern performance available to physical therapists. To date, however, reports of how this method has been applied to clinical practice and patient management have not appeared in the literature.

**References**

Upper-Extremity Movement Categories

1—Push and Reach to Bilateral Push
One hand is placed on the support surface beside the pelvis. The other arm reaches across the body, and the hand is placed on the surface. Both hands push against the surface to an extended elbow position. The arms are then lifted and used for balance.

2—Push and Reach
One or both arms are used to push against the support surface. If both arms are used, there is an asymmetry or asynchrony in the pushing action or a symmetrical push gives way to a single push pattern.

3—Symmetrical Push
Both hands are placed on the surface. Both hands push symmetrically against the surface prior to the point when the arms are lifted synchronously and used to assist with balance.

4—Symmetrical Reach
The arms reach forward, leading the trunk, and are used as balance assistance throughout the movement.

5—Push and Reach Followed by Pushing on Leg
One or both arms are used to push against the support surface or to reach forward. Pushing and reaching movements give way to a single arm push against the support surface. One or both hands are placed on the knee, and then the arms are lifted and used for balance.

6—Push and Reach to Bilateral Push Followed by Pushing on Leg
One or both hands are placed on the supporting surface beside the pelvis. After an initial push, one arm reaches across the body and the hand is placed on the surface. Both hands push against the surface to an extended arm position. One or both hands are placed on the knee, and then the arms are lifted and used for balance.

Revised Axial Movement Categories

1—Full Rotation, Abdomen Down
The head and trunk flex and rotate until the ventral surface of the trunk contacts the support surface. The pelvis is then elevated to or above the level of the shoulder girdle. The back extends up to the vertical, with or without accompanying rotation of the trunk.

2—Full Rotation, Abdomen Up
The head and trunk flex and/or rotate until the ventral surface of the trunk faces, but does not contact, the support surface. The pelvis is then elevated to or above the level of the shoulder girdle. The back extends from this position up to the vertical, with or without accompanying rotation of the trunk.

3—Partial Rotation
Flexion and rotation bring the body to a side-facing position or beyond with the shoulders remaining above the level of the pelvis. The back extends up to the vertical, with or without accompanying rotation.

4—Forward With Rotation
The head and trunk flex forward with or without a slight degree of rotation. Symmetrical flexion is then interrupted by rotation or extension with rotation. Flexion with slight rotation is corrected by counter-rotation in the opposite direction. One or more changes in the direction of the rotation occur. A front or slightly diagonal facing is achieved before the back extends to the vertical.

5—Symmetrical
The head and trunk move symmetrically forward past the vertical; the back then extends symmetrically to the upright position.

Revised Lower-Extremity Movement Categories

1—Pike
The legs are flexed toward the trunk and may be rotated to one side with knees or a knee and foot in contact with the ground. Both feet then contact the support surface. The legs are fully extended to a pike position. Slight flexion of the legs is followed by full extension during the rise.

2—Pike-Jump to Squat
The legs are flexed toward the trunk with both knees contacting the support surface. The feet are then placed in contact with the support surface while the legs remain flexed. Next the legs are fully extended to the pike position. Both feet are then lifted simultaneously off the support surface. The feet land back on the support surface in closer proximity to the hands, with the hips and knees flexing to a squat position. The legs are then extended during the rise.

3—Kneel
The legs are flexed toward the trunk and rotated to one side with both knees contacting the support surface. Half kneeling may be assumed, or a squat pattern. When the legs extend, one or more balance steps may be taken.

4—Jump to Squat
The legs are flexed and/or rotated to one side. Both legs are then lifted simultaneously off the support surface and may be de-rotated. The feet land back on the support surface with the hips and knees flexing to a squat or semi-squat position. The legs then extend to the vertical.

5—Half Kneel
Both legs are flexed toward the trunk as one or both legs are rotated to one side. Either a kneeling or half-kneeling pattern is assumed. If kneeling occurs, one leg is then flexed forward to assume half kneeling. The forward leg pushes into extension as the opposite leg moves forward and extends.

6—Asymmetrical/Wide-Based Squat
One or both legs are flexed toward the trunk, assuming an asymmetrical, crossed-leg, or wide-based squat. The legs push into an extended position. Crossing or asymmetries may be corrected during extension by stepping action.

7—Narrow-Based Symmetrical Squat
The legs are brought into flexion with the heels approximating the buttocks in a narrow-based squat. Stepping action may be seen during assumption of the squat, or balance steps (or hops) may follow the symmetrical rise.