The interactive effects of neuro-developmental treatment and inhibitive ankle-height orthoses on gait were examined via a single-subject research design. Knee flexion during gait at initial contact, mid-stance, heel-off, and mid-swing were measured in a 2-year-old girl with diplegia by use of a goniometer and freeze-frame videography. During the treatment and treatment/orthoses phases, a decrease in excessive knee flexion was noted. Changes in trend over time were greater in the 3-week treatment phase than in the 3-week treatment/orthoses phase. Changes in level at the initiation of the treatment/orthoses phase were greater than in the treatment phase. The described neuro-developmental treatment activities were conducted correctly 92% of the time according to an independent observer. The intrarater reliability of goniometric data measured by videography was .93 using intraclass correlation coefficients. The results of this study suggest that both methods of treatment can be used to decrease excessive knee flexion during gait in a child with diplegia. [Embrey DG, Yates L, Mott DH. Effects of neuro-developmental treatment and orthoses on knee flexion during gait: a single-subject design. Phys Ther. 1990;70:626–637.]

Key Words: Gait; Kinesiology/biomechanics, gait analysis; Neurodevelopmental treatment; Orthotics/splints/casts, lower extremity.

Children with neurological handicaps frequently receive neuro-developmental treatment (NDT) from physical therapists and occupational therapists to reduce the problems of impaired movement and coordination.1–5 Considerable controversy exists regarding the effectiveness of such treatment. Denhoff6 reported the benefits of intervention programs for at-risk and handicapped children clearly outweighed the disadvantages. Conversely, Ferry5 concluded no valid scientific evidence existed to support the use of NDT for altering neurologically development in high-risk or neurologically handicapped children. Although some studies6–8 reported that NDT made little change in the children studied, other studies9–11 reported NDT was effective in improving the functional ability of children.

Ottenbacher et al12 provided a quantitative analysis of nine NDT studies, representing a total of 371 subjects. They reported that "subjects who received NDT performed slightly better [in functional activities on the variables studied] than the control-comparison subjects who did not receive the intervention."12(p1095)

Neuro-developmental treatment is based on an individual intervention plan designed to remediate specific problems of an individual with neurological impairment. Evaluation of
Single-subject research designs have been used to document the effectiveness of orthoses. Harris and Riffle used a single-subject design to document the effects of inhibitive ankle-foot orthoses on standing balance in a child with cerebral palsy. The effects of the orthoses were studied with a child who received physical therapy and occupational therapy routinely. Consequently, the effects of the orthotic intervention were not separated from the effects of the therapy. A single-subject design was also used to evaluate the effects of tone-reducing and standard plaster casts. The authors of this study determined that “tone-reducing casts were more effective than standard immobilization casts” based on stride-length data.

Several authors have described the use of lower extremity orthoses or “inhibitive casts” as an adjunct to therapy for children with cerebral palsy. Carlson provided a neurophysiological analysis of inhibitive casts as a component of therapeutic intervention in cerebral palsy. Cusick and Sussman described the role of short leg casts in the management of children with cerebral palsy.

Inhibitive ankle-height orthoses have been used at Children’s Therapy Unit of Good Samaritan Hospital (Puyallup, Wash). We believe these inhibitive orthoses improved the functional ambulation of children with neurological impairment. The purpose of this study was to evaluate the effectiveness of inhibitive ankle-height orthoses used in conjunction with NDT and the effectiveness of NDT used in isolation to decrease what we considered to be excessive knee flexion during gait.

**Method**

**Subject**

The subject, who was referred for physical therapy by a pediatric neurologist, was a 2-year–8-month-old girl with the following characteristics: diplegia, mild to moderate trunk hypotonia, limb hypotonia with hyperextensible joints, poorly integrated and poorly graded movement, decreased shoulder co-contraction with diminished proximal stability, 1 to 2+ deep tendon reflexes in the upper extremities, and 2+ deep tendon reflexes in the lower extremities. The child demonstrated a positive plantar grasp bilaterally with toe clawing during standing. No limitation in range of motion was noted in the lower extremities.

The subject ambulated independently for all daily activities, although the walking pattern showed increased knee flexion during all phases of the gait cycle based on visual observation. Increased flexion of the hips, knees, and ankles was accompanied by increased hip adduction and internal rotation. In addition, according to the parent’s report, the subject would fall 6 to 10 times per day when ambulating on flat surfaces. Informed consent was obtained from the subject’s parents prior to participation in the study.

**Research Design**

Seven data-collection sessions were conducted during each of the five phases (A-B-A-BC-A) in order to obtain sufficient data for analysis. Each phase was 3 weeks in duration.

During the baseline phases (A), data were collected while neither treatment nor orthoses were provided. Data-collection sessions required approximately 20 minutes to complete. During the treatment phase (B), the child received 30 minutes of NDT three times per week by the same therapist. During the treatment/orthoses phase (BC), the child received NDT combined with orthotic intervention. During the treatment and treatment/orthoses phases, data-collection sessions immediately followed treatment.

**Neuro-Developmental Treatment**

The NDT protocol was developed and administered by a physical therapist certified in pediatrics (DGE). Therapy was conducted following an assessment to determine treatment activities and goals. The same therapist who developed the treatment protocol also videotaped the first session. Ten activities were chosen (Appendix), and photographs were taken of 10 freeze-frame sections of the videotape. The 10 activities were selected by the treating therapist as the most beneficial for remedying the abnormal motor patterns causing the excessive flexion in the lower extremities. Each activity was illustrated with line drawings, and descriptions of correct and incorrect movements were provided for the independent observer (LY). These treatment activities were used during the intervention phases and to establish whether the treatment procedures were performed according to the established guidelines. Therapy was conducted in three 30-minute sessions per week for 3 weeks during the treatment and treatment/orthoses phases.

**Orthoses**

The orthoses prescribed for this child were bilateral inhibitive ankle-height orthoses manufactured by a certified prosthetist. Based on the need for medial-lateral control without limiting plantar flexion and dorsiflexion, the orthoses were made from polypropylene, U-cut posteriorly, with an anterior ankle strap (Fig. 1). The child’s
ankle and foot were positioned in neutral subtalar alignment in each orthosis based on clinical observation during standing. To inhibit plantar grasp, her toes were elevated approximately 10 degrees. Leather was placed under the full length of the toes to allow for the normal push-off needed in the terminal stance phase of gait. The orthoses allowed full ankle dorsiflexion and plantar flexion while maintaining medial and lateral control of the subtalar joint. During the treatment/orthoses phase, the subject wore the orthoses during all daily activities, except for bathing.

**Procedure**

**Treatment replication.** To determine whether the treatments were given in a replicable fashion, an NDT pediatric-certified occupational therapist (LY) reviewed the photographs and descriptions twice during each of the treatment and treatment/orthoses phases of the study. The treating therapist was unaware of the observations, which were conducted through a one-way mirror.

Treatment activities were assessed at 10-second intervals throughout each treatment session and recorded as “correct,” “incorrect,” or “no activity.” The observer was given a cue from a tape-recorded message when to observe and when to record data. The order and length of the treatment activities were not monitored.

The percentage of correct movements was calculated by dividing the number of correct movements by the total number of activities observed. Billingsley et al.\(^1\) report that failure to assess the repeatability of procedures in experimental conditions poses a threat to both the internal and external validity of single-subject research.

**Videographic analysis.** Videographic analysis was used to obtain data regarding knee flexion during gait. Knee flexion was chosen as the dependent variable for evaluating improvement of the gait pattern because excessive knee flexion during gait is a common problem in cerebral palsy.\(^2\) Knee flexion was averaged for the right and left lower extremities because both extremities were affected and a goal of intervention was to decrease the excessive knee flexion bilaterally.

Videographic data were collected with an RCA video camera* with an automatic focus. The child was asked to walk approximately 15 m across the room to pick up a small toy and return it to her mother. Emphasis was placed on the child obtaining the toy and not on the quality of her walking. The child wore a shirt, shorts, socks, and shoes for all recordings. In addition, during the treatment/orthoses phase, the child also wore the orthoses. The camera was held 6 m perpendicular to the walkway by the principal investigator (DGE) in order to collect sagittal plane data. This procedure was repeated three times to ensure collecting data for at least two acceptable right and left gait cycles. The first two trials were selected for data collection unless one of the trials was unacceptable. An unacceptable trial was defined as any walking trial during which the child stopped or turned toward the camera. The full image of the child was projected onto the video screen.

**Data reduction.** The video data were analyzed using a four-head Mitsubishi VHS cassette recorder.\(^3\) The camera recorded data at 30 frames per second. The videotape was advanced frame by frame to determine the following gait events:

1. **Initial contact**—the point at which the child’s foot first contacted the ground.
2. **Mid-stance**—the point at which the opposite knee was obscured by the ipsilateral knee.
3. **Heel-off**—the point at which the heel first lifted off the ground.
4. **Mid-swing**—the point at which the swinging knee first crossed in front of the opposite knee.

Once the specific point in the gait cycle was identified, a 15.24-cm, clear plastic goniometer with 1-degree increments was used to measure knee flexion. The center of the knee joint was used for placement of the axis of the goniometer. The midshaft of the upper leg dictated the correct placement of the stationary arm of the goniometer, and the midshaft of the lower leg was the placement for the moveable arm. No markers were used in this study for three reasons. First, marker placement would have increased the duration of each data-collection session by 5 to 10 minutes. Because of the child’s age and short attention span, this additional amount of time may have hindered her cooperation with the data collection. Compliance with data collection was considered more important than marker placement. Second, the accuracy of marker placement could not have been ensured throughout the 35 different measurement trials. Third, the knee joint axis changes during the flexion and extension of the knee.\(^4\) Furthermore, marker placement on the skin would not accurately depict the actual movement of the joint alignment. Therefore, assigning a specific point to measure the axis of the knee during walking could introduce systematic error. Consequently, only the knee axis and midshaft of the upper leg and the lower leg were used for goniometric measurements. These same landmarks were used in establishing the interrater reliability for this study.

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*Model CLR200, RCA Corp, 30 Rockefeller Plaza, New York, NY 10020.

\(^1\)Model HC-359UR, Mitsubishi International Corp, 277 Park Ave, New York, NY 10027.

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Physical Therapy/Volume 70, Number 10/October 1990
Table 1. Two-Way Analysis-of-Variance Results for Interrater Reliability

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
</tr>
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<tbody>
<tr>
<td>Main effects</td>
<td>8</td>
<td>214767.7</td>
<td>26846.0</td>
<td>417.38</td>
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<tr>
<td>Treatment phase</td>
<td>4</td>
<td>1044.0</td>
<td>261.0</td>
<td>4.06</td>
</tr>
<tr>
<td>Rater</td>
<td>1</td>
<td>72.2</td>
<td>72.2</td>
<td>1.12</td>
</tr>
<tr>
<td>Gait phase</td>
<td>3</td>
<td>213651.6</td>
<td>71217.2</td>
<td>1107.24</td>
</tr>
<tr>
<td>Interaction</td>
<td>19</td>
<td>4045.9</td>
<td>212.9</td>
<td>3.31</td>
</tr>
<tr>
<td>Treatment phase x rater</td>
<td>4</td>
<td>8.9</td>
<td>2.2</td>
<td>0.03</td>
</tr>
<tr>
<td>Treatment phase x gait phase</td>
<td>12</td>
<td>3988.4</td>
<td>332.4</td>
<td>5.17</td>
</tr>
<tr>
<td>Rater x gait phase</td>
<td>3</td>
<td>48.7</td>
<td>16.2</td>
<td>0.25</td>
</tr>
</tbody>
</table>

Eight knee flexion measurements, representing measurements for both lower extremities during two complete gait cycles, were taken during each data-collection session. The eight knee flexion measurements were averaged to provide the mean knee flexion for that session. Seven data-collection sessions were needed for the five phases, which yielded a total of 280 measurements for initial contact, mid-stance, heel-off, and mid-swing.

**Interrater reliability.** Interrater reliability of determination of knee motion was performed by the principal investigator and by an independent physical therapist with 10 years' pediatric experience who independently scored one randomly selected session of each intervention and baseline phase. An intraclass correlation coefficient (ICC) was calculated using the (2,1) formula. An analysis of variance (ANOVA) was performed with knee flexion as the dependent variable and with rater, treatment phase, and gait phase as the independent variables. A t test was performed to determine standard error of measurement for repeated trials of initial contact, mid-stance, heel-off, and mid-swing.

**Plotting data.** Knee flexion for each session was plotted, and the split-middle line was calculated to determine the level and trend values. Using the split-middle line, the initial value for the phase, the slope, and the final value were derived.

The "change in level" of one phase compared with the previous phase was calculated by subtracting the initial value of the trend line of one phase from the final value of the trend line of the previous phase. Level changes refer to the shift or discontinuity of performance from the end of one phase to the beginning of the next phase. A level change indicates the initiation or withdrawal of intervention has caused a difference in performance of the subject.

"Trend change" was calculated by comparing the values of consecutive slopes. If the slope values were in the same direction, the values were subtracted. If the slopes were in opposite directions, the trend changes were added. Trend changes are the tendency for the data to show systematic increases or decreases in level of behavior over time. A trend change indicates a change in performance as the subject improves or regresses in performance during a treatment or baseline phase.

**Experimental Results**

Decreased knee flexion at initial contact of the gait cycle illustrated positive level changes at the beginning of both the treatment and the treatment/orthoses phases. In addition, the trend changes occurring over the 3-week treatment and treatment/orthoses phases suggest improved knee flexion (Fig. 2). Each of the baseline phases showed negative level and trend changes with increased knee flexion.

Knee flexion at mid-stance was reduced. The data indicated positive level changes and trend changes for treatment and treatment/orthoses phases (Fig. 3). The baseline phase following the treatment phase showed negative level and trend changes. The baseline phase following the treatment/orthoses phase showed a negative trend change.

**Results**

**Interrater Reliability**

The two-way ANOVA revealed an intrerrater ICC of .934. The standard error of measurement was 1.78 degrees for initial contact, 2.42 degrees for mid-stance, 2.52 degrees for heel-off, and 1.97 degrees for mid-swing. The results of the two-way ANOVA for interrater reliability are presented in Table 1.
Knee flexion at mid-swing demonstrated interesting information (Fig. 5). Little change in level or trend occurred during the first three phases (baseline, treatment, baseline). Then a level change upward occurred at the initiation of the treatment/orthoses phase, followed by a downward trend change. The downward trend continued into the final baseline phase. The knee angle at the end of the final baseline phase was approximately at the same level as the initial three phases.

A summary of the data for initial contact, mid-stance, heel-off, and mid-swing is provided in Table 2. The treatment and treatment/orthoses phases generally showed positive changes (decreased knee flexion) in both the level and the trend data.

Of the 16 level and trend values listed in Table 2 for the treatment and treatment/orthoses phases, 13 were positive, 2 showed no change, and only 1 showed a negative value. Of the 16 level and trend values for the baseline phases, 13 were negative and 3 were positive. No statistical analysis was performed with these data because such an analysis did not appear to be warranted for this single-subject design.

**Discussion**

This study evaluated the effect of NDT and the interactive effects of NDT combined with inhibitive ankle-height orthoses on knee flexion during gait in a 2-year-old girl with diplegia. Excessive knee flexion during gait was decreased at initial contact, mid-stance, and heel-off. The use of NDT in isolation was effective in producing a decrease in knee flexion for this subject. The greater improvement in trend values for the treatment phase compared with the treatment/orthoses phase suggests that NDT intervention in isolation was more effective than the NDT and orthotic interventions combined for decreasing excessive knee flexion over time.

The NDT intervention used in conjunction with orthoses was also effective in providing a decrease in knee flexion for this subject. The combined intervention, however, provided more immediate level value changes than the use of NDT in isolation.
In addition to the data that illustrated change, the subjective reporting of information was helpful in determining the functional improvement in the subject's motor performance in the home environment. The mother reported at the end of the first week of treatment that she could see a positive difference in the walking pattern and balance of her child. At the end of the third week of the treatment, the mother reported that her child was falling only once or twice a day compared with 6 to 10 times a day when the study began. She also reported that the initial reaction of the child to wearing the orthoses was negative because her daughter was more "clumsy and awkward." After her daughter became accustomed to wearing the orthoses, the mother noted that her child's gait had improved markedly and that she seldom fell when walking on level surfaces.

Numerous steps were taken to minimize the threat of bias in this study. Repeatability of the NDT procedures was measured by an independent observer. The subject did not appear to consciously walk differently across the 35 individual data-collection sessions or the five phases of the study.

The measurement procedure used could have been a source of error in this study. Specifically, the video- graphic method evaluated movement in the sagittal plane and did not assess the rotational component of movement in the transverse plane. Based on clinical observation, it may be argued that, because this child had increased internal rotation at the hip, knee flexion measurements may have been partially a component of internal rotation at the hip. More precise data could be obtained by a computer-assisted, three-dimensional motion analysis system.

Another limitation of the study was the similarity of the subject's performance during mid-stance and mid-swing in both the treatment and baseline phases. This similarity may be explained by a review of the gait cycle. During gait, the lower extremities need to be the most stable when the subject's weight is transferred from one foot to the other during double-limb support. Initial contact begins double-limb support, and heel-off begins the push-off phase of gait. The data show this is where the most consistent improvement occurred. Conversely, less-consistent improvement occurred during the mid-swing phase.
of gait, when the foot is not on the ground, and during mid-stance, when the body is gliding over the fixed foot.

The overall treatment effects may appear to be in question when reviewing the data presented in Figures 2 through 5. Specifically, the subject's walking pattern did not appear dramatically better at the end of the study than during the initial baseline phase. Two explanations exist for this apparent lack of improvement. First, the study ended with a baseline phase in which no intervention was provided for the child. Had the study ended after the treatment/orthoses phase, the data would have demonstrated a greater improvement for all phases of the gait cycle. Second, 3 weeks of intervention should not be expected to produce long-term changes in the gait of a child with diplegia. The long-term effects of NDT and orthotic intervention were not evaluated in this study.

The activities used with this child were based on NDT principles. The freedom to elaborate and modify treatment as the child responded was not available in this study. Although the therapist was able to adapt the same 10 movements as the child was able to respond to greater challenges in handling, the treatment was nevertheless limited by the research design. Greater improvements perhaps might have occurred without the rigors of the research limitations.

**Conclusion**

This single-subject study evaluated the short-term effects of NDT and inhibitive ankle-height orthoses on the gait of a child with diplegia. Freeze-frame videography was used to evaluate knee flexion during gait at initial contact, mid-stance, heel-off, and mid-swing. Videographic data illustrated that NDT used in isolation was effective in decreasing excessive knee flexion during the 3-week treatment phase. Videographic data also showed that inhibitive ankle-height orthoses used in conjunction with NDT provided a more immediate effect on decreasing excessive knee flexion than using NDT in isolation. This study demonstrated that both NDT and the use of inhibitive ankle-height orthoses were effective in decreasing excessive knee flexion in the subject studied.
**Figure 5.** Knee flexion at mid-swing of gait cycle. Asterisk (*) indicates split-middle line values (initial value, slope, final value); double asterisk (**) indicates change in phase values (level change, trend change).

**Table 2.** Summary of Gait Cycle Data (in Degrees)

<table>
<thead>
<tr>
<th>Event</th>
<th>Treatment</th>
<th>Baseline</th>
<th>Treatment and Orthoses</th>
<th>Baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Level</td>
<td>Trend</td>
<td>Level</td>
<td>Trend</td>
</tr>
<tr>
<td>Initial contact</td>
<td>+7</td>
<td>+8</td>
<td>-5</td>
<td>-5</td>
</tr>
<tr>
<td>Mid-stance</td>
<td>+2</td>
<td>+3</td>
<td>-11</td>
<td>-13</td>
</tr>
<tr>
<td>Heel-off</td>
<td>+6</td>
<td>+14</td>
<td>-8</td>
<td>-12</td>
</tr>
<tr>
<td>Mid-swing</td>
<td>0</td>
<td>0</td>
<td>-1</td>
<td>+4</td>
</tr>
</tbody>
</table>
Appendix. Neuro-developmental Treatment Activities

Extension with Rotation Reaching Up

Purpose: To achieve thoracic rotation (upper trunk) with weight-bearing on one arm while reaching up with the other arm.

Correct Movement: 1. Begin with child sitting facing you and straddling your waist with her legs.
2. Have the child rotate her body sideways to play with a toy elevated to her shoulder height.
3. Have child support her body with one arm while reaching up with the other arm.
4. Ensure the upper trunk is twisted.
5. Head should remain in line with the body.

Incorrect Movement: 1. Do not allow child to let her trunk sag. Provide support, if needed, at the lower trunk by holding the abdomen.
2. Do not allow child to rotate only the lower trunk. Assist in rotation of upper trunk, if needed, by bringing the upward trunk forward as illustrated.
3. Do not allow the child to lock the elbow of the supporting arm.
4. Do not allow the child to let her head sag.
5. Do not allow the child to stiffen her legs.

Extension with Rotation Reaching Down

Purpose: To achieve thoracic rotation (upper trunk) with weight-bearing on one arm while reaching down with the other arm.

Correct Movement: 1. Begin with child facing you and straddling your waist with her legs.
2. Have the child rotate her body sideways to play with a toy at ground level.
3. Have the child support her body with one arm while playing with a toy on the floor with the other hand.
4. Ensure the upper trunk is twisted.

Incorrect Movement: 1. Do not allow the child to let her trunk sag. Provide support, if needed, at the lower trunk by holding the abdomen.
2. Do not allow the child to rotate only the lower trunk. Assist in rotation of the upper trunk, if needed.
3. Do not allow the child to lock the elbow of the supporting arm.
4. Do not allow the child to let her head sag.
5. Do not allow the child to stiffen her legs.

Trunk Flexion Against Gravity

Purpose: To achieve abdominal tone and trunk flexion.

Correct Movement: 1. With child sitting on a therapy ball or on your lap, ensure her legs are apart and rotated outward.
2. Assist the child in shifting her weight backward.
3. The head should remain slightly forward.

Incorrect Movement: 1. Do not allow the child to collapse into full flexion. Assist, as needed, by supporting lower trunk and lower rib cage as pictured.
2. Do not allow child to collapse her head forward or throw it backward.
3. Do not allow child to pull strongly with her leg muscles to hold her body up.

(Continued)
**Appendix. (Continued)**

### Flexion with Rotation

**Purpose:** To achieve abdominal tone and trunk flexion with rotation.

**Correct Movement:**
1. With child sitting on a therapy ball or your lap, ensure her legs are apart and rotated outward.
2. Assist the child in shifting her weight backward and to the side. The shoulders should be behind the hips and rotated away from the hips.
3. The head should remain slightly forward and rotated.
4. Assist the child in moving alternately away from midline and back toward midline.

**Incorrect Movement:**
1. Do not allow the child to collapse in the lower trunk.
2. Do not allow the child to support a major portion of her body weight with her arms.
3. Do not allow the child to pull strongly with her leg muscles to hold her body up.

### High Kneeling

**Purpose:** To achieve pelvic stability with active hip extension and abdominal control.

**Correct Movement:**
1. Assist the child into kneeling. Child may hold a supporting surface for balance, if needed.
2. The head, shoulders, hips, and knees should be in a vertical position.
3. Knees should be shoulder-width apart, and lower legs should be parallel.
4. Assist pelvic control, as needed, to achieve correct alignment.
5. Shift weight laterally to facilitate hip abductor muscles.

**Incorrect Movement:**
1. Do not allow hip flexion posture to persist. Hip flexion may be encouraged to reach down to pick up a toy, but child should return to kneeling with hip extension.
2. Do not allow hip extension beyond neutral.
3. Do not allow child to lean on supporting surface or your hands.

### Half Kneeling

**Purpose:** To achieve pelvic stability with active hip extension and abdominal control with lateral weight shift.

**Correct Movement:**
1. From a high-kneeling position, assist child in coming to a half-kneeling position by bringing the center of gravity to the side and back slightly to facilitate bringing up the opposite leg. Child may grasp a supporting surface for balance if needed.
2. The head, shoulder, hips, and supporting knee should be in a vertical line in the half-kneeling position.
3. The trunk should be laterally shifted over the supported knee.

**Incorrect Movement:**
1. Do not allow hip flexion on the supporting knee.
2. Do not allow hip extension beyond neutral on the supporting knee.
3. Do not allow the raised knee to drift inward toward the body.
4. Do not allow the child to lean on the supporting surface or your hands.

(Continued)
Appendix. (Continued)

Squat Balance
Purpose: To achieve better balance while developing quadriceps femoris, hip abductor, and hip extensor muscles.
Correct Movement: 1. Hold the child's feet shoulder-width apart with feet parallel.
2. Provide a toy that will encourage the child to squat down to pick it up and then stand back up.
3. Allow the child to sit on your knees as shown in order to keep the knees from going beyond 90 degrees.
4. Keep the weight forward in order to keep the shoulders directly over the feet.
5. Assist the ankles from rolling inward. Support the ankles, as needed, with your hands.
Incorrect Movement: 1. Do not allow the feet to be spread widely apart.
2. Do not allow the knees to turn inward.
3. Do not allow the child to push up with her hands on the knees or throw the shoulders or head backward.

Stretch Stance
Purpose: To achieve pelvic control on forward leg with quadriceps femoris and hip extensor muscles while achieving hip extension and abdominal control with the other leg and trunk.
Correct Movement: 1. Begin with the child standing while holding onto a supporting surface.
2. Shift the child's weight sideways to lift up the opposite leg.
3. Lift the foot and leg off the ground and bring them backward.
4. Keep the shoulders parallel with the supporting surface while rotating the pelvis backward.
5. Keep the upper trunk straight.
Incorrect Movement: 1. Do not allow the supporting leg to lock into extension.
2. Do not allow the stomach to sag.
3. Do not allow the supporting leg to turn inward.

Standing Weight Shift
Purpose: To facilitate the hips and lower leg muscles to work more efficiently (ie, stronger and quicker).
Correct Movement: 1. Allow the child to support her weight in standing by grasping a table at waist height while playing with a toy.
2. Shift the child's weight backward slightly until she lifts her toes up, but not so far that she steps backward.
3. Shift the child's weight sideways slightly until the inside of her foot raises slightly, but not so far that she steps sideways.
Incorrect Movement: 1. Do not allow the child to lean into the table.
2. Do not allow the child to let her stomach sag or arch her back.
3. Do not allow the child to stiffen her shoulders or arms.
(Continued)
Appendix. (Continued)

### Half Standing

**Purpose:** To achieve pelvic stability while weight-bearing asymmetrically.

**Correct Movement:**
1. Begin with the child standing near a waist-high table.
2. Provide a short stool onto which the child can step.
3. Assist the child in shifting the weight sideways before she steps up with the other foot.

**Incorrect Movement:**
1. Do not allow the child to lean against the table.
2. Do not allow the child to lock the supporting (back) leg into extension.
3. Do not allow the front leg to turn inward.
4. Do not allow the shoulders to become stiff.

### Acknowledgments

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### References