

APPENDIX 2

Motor Control Intervention Protocol

The dynamic systems approach underlying motor control intervention is based on the premise that interdependent body systems (e.g. musculoskeletal, motor, sensory, and cognitive status) shape movement characteristics. The primary objective was to change the *spontaneous* gait pattern in a child at the preschool stage of cognitive development. By repeatedly inducing the child to cope with situations near his or her limits of ability to manage the center of mass over the feet, the strategies were expected to gradually expand mid-stance control during gait. To effectively manage a child's movements, the therapist attended to biomechanical attributes (body symmetry, segment alignment, and weight distribution) and provided verbal and physical cues to guide correct activity execution. Home instructions were based on clinic session successes, and intended to give the parent alternatives to verbal directions to "stop toe walking".

To comply with the cleanliness policy of the clinic and avoid footwear variations, children were barefoot for all clinic sessions except while using roller skates or Moon Shoes. (Moon Shoes are a shoebox like apparatus for each foot, with rubber bands suspending a platform, creating a miniature trampoline.) Whenever possible the child was given the opportunity to choose play activities during the strategies outlined below. Every session began with strategy 1, "stair-step standing" to engage plantar weight shifts with at least neutral ankle (0 degrees). The sequence of the remaining strategies varied and elements of these strategies were blended in obstacle course activities. Strategies were progressed within and across sessions according to the child's activity tolerance.

Intervention Strategies

Strategy 1: “Stair-step standing” is shown in Figure 6. After 2 sessions or when the child could maintain heel contact without genu recurvatum, a compliant 10-degree wedge was added on the lower step. The therapist provided the following: 1) verbal direction not to lean on the table; 2) manual cues (stabilizing calcaneus and/or tibia) as needed to assist adaptive foot positions; 3) verbal cues for leg and foot position (feet perpendicular to step-stool) and neutral knee position (“soft knees” rather than genu recurvatum); 4) assistance (light manual cues at contralateral mid-thorax and/or ipsilateral pelvis) if needed to bring body weight over the extended support leg; and 5) verbal instruction to the child to indicate leg fatigue. Either the child (indicating leg fatigue) or therapist (after 3 minutes) initiated a change to a contralateral stair step pattern. Following child-initiated change, the therapist either initiated subsequent changes after the same length of time or biased the situation for greater time on the weaker leg in cases with asymmetry. Multiple alternations were carried out for a total session goal of 15 minutes, but the strategy was concluded sooner if a statement or behavior indicated fatigue. The goal was to improve and control for each extremity, a) ability to attain balanced upper body alignment and postural control over the extended support leg; b) knee extension without recurvatum; and c) calcaneus aligned within 0- 5 degrees of eversion.



Figure 6. Stair step standing. The child stood on a step-stool with 9" step height, solid and level step surfaces. The figure shows the optional compliant wedge on the lower step. Behind the child, the therapist assisted stance alignment with the entire sole on the support surface and calcaneus within 5 degrees of neutral, while in front a table was used for a game.

Strategy 2: Standing-balance activities with a stable base of support (BOS) situation were introduced at the first session. During simple upper body activities such as beanbag toss or pantomime, symmetrical standing with both feet was confined to a 10" inch colored (e.g. "red") Spot Marker in an open space (Spot Markers are flat discs in the Figure 9 path). The therapist a) directed the child: "Keep your feet glued on red"; and b) used verbal attention (praise and correction) to assist the child to stay in position. The goal was to enhance ability to stand with feet in place for at least 60 seconds without taking steps during an upper body activity. In subsequent sessions, additional methods to confine BOS standing balance included a bench, a 4"

wide board, or tactile Step-N-Stones (Figure 7). The therapist provided light physical support if needed for balance. When the child displayed ability to manage double stance for 60 seconds, single limb balance challenges on a stable surface and double limb balance challenges on unstable surfaces replaced the double stance activity. Examples of unstable surfaces were standing on a balance board (Figure 8), on Moon Shoes, or on top of a therapy ball held in place against a mirrored wall. While balance activities were initiated as described above, they were generally combined with strategies 3 and 4.



Figure 7. Standing balance activity example (stable but challenging surface). Tactile Step-N-Stones required light balance assist at hips to help the child maintain symmetrical static standing during upper body play with a streamer.



Figure 8. Standing balance activity example (unstable support surface). To teach voluntary body weight shifts, the therapist assisted the child to position ankles over the frontal axis of a balance board blocked to allow 5 degrees each of dorsiflexion and plantarflexion. The child held forward or backward positions for 1-2 seconds while engaging in toss and catch.

Strategy 3: Stooping and transition activities were introduced at the first session with the child positioned for standing balance on a Spot Marker. To elicit stooping, the therapist a) rolled a playground-size ball to the child's feet; b) directed him or her to keep feet in place, to pick the ball up, stand and toss it back; c) gave verbal cues if needed to elicit knee flexion; and d) assessed stooping ability and adjusted ball size if needed. Heels were not required to remain in contact with the support surface. The ball roll routine was carried out in bouts of 10, repeated up to 3 times. At this time the therapist explained to the child the therapy rule: "stay on your feet" (stoop), rather than semi-sit to get items from the floor. In subsequent sessions, stooping was integrated into the construction and pick up of a "Spot Marker path". The child stood on one

marker and stooped to place the next on the floor for a series of 6-12 markers. Additional stooping activities were integrated with controlled stepping activities. For example: step on a marker in the path, stoop to pick up a piece for the puzzle. When the child dropped to kneeling or a semi-sit position to obtain items from the floor, the therapist pointed out “sit down” occurrences with humor, and gave direction such as “Trick or treat, stay on your feet!” The target was greater than 50 repetitions of stooping within a one-hour session.

Strategy 4. Controlled stepping and heel-toe practice progressed from simple to high challenge tasks according to ability, integrating games with stooping, stops, starts, and elevation changes. The set-up incorporated walking obstacle courses with incentives (e.g. the slide or “take mom a toy”), with introduction of a simple Spot Marker path by the third session (Figure 9). When the child demonstrated control to accurately step on individual markers, additional stability challenges were introduced. Examples included a) stepping on tactile Step-N-Stones or a 2x4 balance beam; b) stepping over objects without disturbance (cardboard bricks, stuffed toys); c) reciprocal leg stair ascent (verbal cues; and if needed, isolated practice with the weaker leg); and d) controlled walking down a 15-degree incline. With these activities, the therapist used the rubber tubing described with Figure 9 for “just enough” physical support for lower extremity control. When the child demonstrated controlled pace while walking down the incline, instruction for heel strike began as described with Figure 10. To further advance single limb stance demands, supervised walking with “Moon Shoes” or roller-skating was also incorporated. ** Goals of these activities were to a) control cadence and increase step length; b) develop stance accommodation to various surface characteristics and center of mass changes; and c) develop concentric and eccentric lower extremity strength for postural challenges.

* Both Moon Shoes and roller skates present safety concerns, and a gait belt was used. For safety with young children, parents were directed not to use Moon Shoes at home.



Figure 9. Obstacle course example (Spot Marker path). The child stepped on each marker, with a goal of 0.5 seconds per marker. Foot flat placement was not required, but when the child dashed the therapist gave verbal direction to slow down. When needed to assist speed control or balance, she walked alongside holding a short piece of flexible tubing for the child to grasp.



Figure 10. Heel-strike instruction. Verbal instruction (“toes up”) to use a heel-strike was introduced with descent of the incline. Most children required at least 7 sessions before readiness for instruction. Home practice was assigned, such as walking down a slope or on level surface counting 100 “heel-strikes”.

Strategy 5: Sensory and intrinsic foot activities. Besides intrinsic foot movement awareness goals, activities presented with this strategy provided a rest break from large motor activities. An example using playdough is depicted in Figure 11. Another option was to engage active ankle dorsiflexion (“toes up”), plantarflexion (“toes down”), inversion (“feet look together”), eversion (“feet look away”) with therapist assistance as needed. During this time (up to 5 minutes per session), the therapist directed attention to foot motion (“see how your muscles [tendons] work”). The goals were to a) increase the variety and range of active foot movements; b) reduce reactions to tactile contact for children who have tactile hypersensitivity; and c) provide intermittent joint compression without stressing foot joints.



Figure 11s. Sensory play example. Sitting on a chair with foot to floor contact, play began with rolling feet forward/backward over a rolling pin while the therapist provided light resistance for control. Playdough was added, with feet on the rolling pin to roll out a “pancake”. Then as pictured, playdough was rolled directly by feet to create a “snake”. Another option to assist foot movement awareness was creation of playdough “heel print cookies”.

Strategy 6: Age-appropriate motivation methods were used to support engagement with challenges beyond the child’s natural inclination. The therapist refrained from focusing attention on toe-walking and asked parents to follow the same guideline. She gave intermittent, verbal and body language acknowledgement of approximations such as “Wow, look how you are balancing”, “You are a great worker.” At the first session the therapist stated: “You are the boss of your body and can tell me when you need to do something different,” to give the child permission to request activity changes. Body language (e.g. increased shifting, or a statement “I

don't want to play this ... any more") was closely observed and interpreted as a cue to change an activity. The goal was to evoke the best and most positive work from the child and model strategies for parents.

Strategy 7: Information for parents. A one-page synopsis about toe walking and intervention included the following topics: toe walking in children over 2½ years of age, foot structures, 2 stages of intervention, commonly associated behaviors, and footwear options. Verbal information and discussion with the therapist about their child's gait pattern was available at each session according to parent inclination.

Strategy 8: Home activities to support carry-over to daily living were adapted to developmental levels and session responses. All parents were asked to observe for spontaneous opportunities to encourage stooping and to provide the verbal cue "stay on your feet". Brief structured practice was requested for home activities. During the initial 3 weeks of intervention and for children with persistent stance control difficulties, double stance standing with limitation from taking steps, stooping for object retrieval, single limb standing with assistance, and backwards walk while pulling a loaded clothes-basket were assigned. If a child used "step-to" stair ascent, practice on the non-preferred side was assigned. After 3 weeks for those with sufficient advancement, controlled stepping activities (such as an obstacle path between jump ropes placed 5-8" apart on floor, stepping over objects, step from one stool to another), walking drill for 100 heel strikes, and reciprocal stair descent for children who used "step-to" pattern was assigned. For children able to control weight shift on the tip board, practice of forward and backward "ankle sways" with feet on floor was assigned.