Effects of Inhibitive Ankle-Foot Orthoses on Standing Balance in a Child with Cerebral Palsy

A Single-Subject Design

SUSAN R. HARRIS and KATHY RIFFLE

A single-subject, alternating treatments design was conducted to evaluate the effects of inhibitive ankle-foot orthoses on standing balance in a 4.5-year-old boy with moderate spastic quadriplegia who had been wearing an initial pair of inhibitive orthoses for one year. Before introducing the subject to a newly fabricated but similarly designed pair of orthoses, we collected baseline data on the duration of standing balance without orthoses during five sessions over a two-week period. The new orthoses then were applied, and we collected data for standing balance for another two weeks (five sessions) under two treatment conditions: with and without orthoses. We also noted qualitative differences in symmetry of stance pattern and ease of maintaining standing balance for both conditions. Improvements were noted in duration of standing balance, symmetry of stance, and ease of maintaining standing balance during the “with-orthoses” condition. Although these results support the efficacy of inhibitive orthoses for children with cerebral palsy, further, systematic, single-subject research is indicated.

Key Words: Ankle, Cerebral palsy, Foot, Orthotic devices, Physical therapy.

Several reports have appeared recently in the medical literature describing the use of inhibitive casting for children with cerebral palsy. Inhibitive casts have been recommended specifically by Sussman as an adjunct to the neurodevelopmental treatment approach, with the goals being to reduce extensor muscle thrust and to facilitate supported or independent standing, cruising, and walking. Duncan and Mott have commented that inhibitive casting appears to reduce reflex-induced foot deformities and hypertonus in children with cerebral palsy. Recently, it has been suggested that when the child begins to ambulate independently, the inhibitive casts should be replaced by polypropylene ankle-foot orthoses. The advantages of using an inhibitive plastic splint rather than an inhibitive plaster cast are that the splint material is flexible and lightweight and that it can be used with regular, low-cut shoes. We believe that the splints are as effective as the casts in providing stability at the forefoot and ankle and inhibition of hypertonus. A disadvantage is that the splints cost two to three times the amount needed to produce the casts.

Only one published report has described specifically the use of tone-inhibiting orthoses in improving patient performance. In that case report, the patient was a 25-year-old man who had sustained brain damage as a result of a head injury. Treatment began with tone-inhibiting casts, which subsequently were replaced by a tone-inhibiting AFO for the right lower extremity. Gait analysis revealed specific improvements, including decreased positive support reaction and increased heel strike, when the patient began ambulating with the AFO. Because this was a case report, without the systematic collection of repeated measures for assessing gait objectively, definitive conclusions that the tone-inhibiting AFO was responsible for the reported gait improvements are impossible.

Because both inhibitive casting and inhibitive orthoses have gained increased use as adjuncts to the physical therapy of children with cerebral palsy, we decided to examine the effectiveness of inhibitive orthoses in improving standing balance in a child with spastic quadriplegia. To rule out possible effects of normal maturation on improving this child’s standing balance, we used an alternating treatments, single-subject design in which measurements were taken for a two-week period without orthoses (Phase 1) followed by a two-week period in which measurements were taken both with and without orthoses during five different sessions (Phase 2). To control for possible order effects and practice effects, we randomly assigned the two types of treatment conditions (with orthoses vs without orthoses) so that the sequence varied from day to day. During Phase 2, the duration of standing balance was measured first with orthoses on three of the measurement days, whereas on the other two days, the measurements were taken first when the child was without orthoses. The purpose of this single-subject, alternating treatments design was to examine the effects of inhibitive orthoses on both quantitative and qualitative aspects of independent standing for this subject.

METHOD

Subject

The subject in this case study was a 4.5-year-old boy with a diagnosis of moderate spastic quadriplegia who had greater...
involvement on his left side than his right side. Cerebral palsy was diagnosed at 10 months of age; developmental therapy was initiated one month later at the Easter Seal Children's Clinic and Preschool in Seattle, Wash. At 18 months of age, the subject began participating in a once-weekly play group at the clinic, in addition to his therapy program. He entered the clinic's preschool at the age of 3 years and continues in that program five days a week. Currently, he receives both physical and occupational therapy as part of his preschool program. His cognitive and communication skills, as measured by standardized psychological and language tests, are within normal limits for a 4.5-year-old child.

Developmentally, when the study began the subject was able to sit independently, knee-walk, pull-to-stand by half-kneeling over the right foot, and stand independently for 10 seconds. He was able to cruise, more easily toward the right than toward the left, and could creep asymmetrically. These activities were accomplished without orthoses.

The subject was fitted for inhibitive casts initially at the age of 18 months and continued to wear a series of bivalved casts until the age of 3.5 years when he was fitted for his first pair of inhibitive orthoses, which were similar in design to his current pair (Fig. 1). We noted immediate improvements in the ease and symmetry with which the child could stand while he was wearing the orthoses. Recently, the subject received a new pair of orthoses (Fig. 1) because he had outgrown his original pair. Based on our clinical experience with inhibitive casts and orthoses, we hypothesized that wearing the inhibitive AFOs would improve this subject's standing balance, both quantitatively and qualitatively.

Procedures

A signed consent form for participation in the study was obtained from the subject's parents. We explained that the additional procedures of the study would not interfere with the duration or the frequency of the subject's scheduled therapy sessions.

Before the subject received his new set of inhibitive orthoses, we collected baseline data on independent standing during five sessions over a two-week period (after the discontinuation of the original set of orthoses). Data were collected while the subject was attending his preschool class or immediately before the scheduled physical therapy sessions. Phase 2 of the study was initiated one week after the subject began wearing the new splints to allow him a chance to become comfortable with them.

During Phase 2, the subject's standing balance was measured during each of two conditions: with orthoses and without orthoses. On each of the five measurement sessions during Phase 2, the order of the two treatment conditions was assigned randomly. On three of the five days, the duration of standing balance was measured first with orthoses. On the other two days, independent standing was measured first without orthoses. The five measurement sessions for Phase 2 were conducted over a two-week period.

Five trials of independent standing balance were timed for each of the baseline sessions (Phase 1). The subject was barefoot and standing on a firm, carpeted surface (Fig. 2). For Phase 2, 5 timed trials were recorded for each of the two conditions so that a total of 10 timed trials were conducted during each session of Phase 2. The subject began each trial by standing while holding onto his physical therapist for support. He was instructed to let go of the therapist when he felt secure in his balance and to remain standing for as long as possible. He was very cooperative and seemed eager to show his best performance. Each trial was timed with a stopwatch by the physical therapist. Timing began when the subject let go of the therapist; the trial was stopped when he began to fall forward or to catch himself.
Reliability of Procedure

Interobserver reliability was assessed on four of the measurement days (two sessions during Phase 1 and two sessions during Phase 2). Each session during Phase 1 consisted of 5 timed trials, and each session during Phase 2 consisted of 10 timed trials; therefore, two raters independently timed and recorded the duration of standing in seconds for a total of 30 timed trials. The subject's occupational therapist served as the second rater and separately recorded her duration of standing data. The two raters agreed (to the whole second) on 29 of the reliability trials for an agreement of 96.7%. Disagreement on the one trial involved only a one-second difference (80 vs 81 seconds).

Data Analysis

The mean and range for the 5 trials of the five measurement sessions of Phase 1 and for the 10 trials of the five measurement sessions of Phase 2 are recorded in the Table. The mean values subsequently were plotted on standard graph paper for visual analysis of level and trend

RESULTS

Figure 3 shows the definite improvement in the subject's ability to maintain independent standing while wearing the orthoses during Phase 2. Even though the order of the two treatment conditions was varied from day to day, the subject consistently demonstrated a longer duration of independent standing when wearing the inhibitive orthoses.

Although both level and trend are stable across time for the “without-orthoses” condition (during both Phase 1 and Phase 2), the subject’s ability improved sharply during the timed trials in which the orthoses were worn during Phase 2. Not only is there a difference in the levels of the plotted data for the two conditions, but a marked difference also exists in the trend of the data in favor of the “with-orthoses” condition. Level refers to the relative value of the data pattern on the dependent variable, whereas trend is defined as the direction in which the data pattern is progressing.

To examine qualitative differences between the two treatment conditions, we took photographs of the subject standing independently both with and without orthoses. The subject’s standing posture without orthoses (Fig. 2) was markedly asymmetrical, with weight bearing primarily on the right lower extremity and with the right foot pronated. The left hip was internally rotated, and the left foot was positioned in equinus. When the orthoses were in place (Fig. 4), the subject’s standing posture was visibly more symmetrical with an apparently even distribution of weight bearing. The right foot pronated less as compared with the without-orthoses condition. The left foot was flat, and the left hip no longer was positioned in as much internal rotation.

Although photographs capture the subject during only a brief moment of time, we believe that the pictures included in this article typify the standing postures used by this subject both with and without the benefit of orthoses. We took a series of photographs both with and without orthoses and chose the two included in this article (Figs. 2 and 4) as

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<th>With Orthoses</th>
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<td>Session 10</td>
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* Interrater reliability sessions (agreement = 96.7%).

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![Fig. 3. The duration of independent standing with and without orthoses.](image-url)
The subject continued to show functional gains while wearing orthoses that he does not show without them. He has outgrown the pair he wore in this study and has worn a similar, but larger, pair for the past three months. While wearing orthoses, the subject can progress independently from standing to a semisquat position and then back to standing. Without orthoses, he is able to stand only with knees fully extended with most of his weight borne over the right foot. He now is able to ambulate independently for seven steps when wearing orthoses. Without orthoses, he can take two to three steps, but his gait is very awkward.

According to the subject’s mother, he now is ambulating independently around furniture at home with orthoses and also is showing more independence in cruising around furniture. He now is able to walk independently with more control; that is, he will take a step, then stop, and maintain his balance before walking further. When walking without orthoses, he takes a few uncontrolled steps and then lunges forward. His mother reports that he now is able to walk beside her for short distances with one-handed support while wearing the orthoses. Previously, he required facilitated support at both shoulders during assisted walking.

**DISCUSSION**

This single-subject design represents the first controlled attempt to evaluate quantitatively the efficacy of inhibitive orthoses for children with cerebral palsy. The alternating treatment design offered us the opportunity to compare the effect of treatment and no treatment conditions without requiring a withdrawal of treatment, a significant benefit to clinical research in which therapeutic gains are expected as a result of a specific treatment. This design also provided control for both maturational and order effects in addition to establishing interrater reliability on the dependent measure. As Martin and Epstein have proposed, the single-subject design is particularly appropriate for evaluating treatment effectiveness in children with cerebral palsy because of the “organic and behavioral variability” of this disorder.

With the increasing use of both inhibitive casts and inhibitive orthoses for children with cerebral palsy, the clinical value of these adjunctive treatment strategies must be validated empirically. Although we have attempted to examine the effects of inhibitive AFOs on improving qualitative and quantitative aspects of standing balance, many other advantages claimed by the proponents of these modalities have yet to be demonstrated systematically and reliably. These benefits include reduction of hypertonus and foot deformity, inhibition of positive support response and plantar grasp reflex, and facilitation of improvement in motor skills. Through the careful use and interpretation of single-subject research designs, systematic documentation of the effectiveness of these modalities on a variety of dependent measures would be possible. The research responsibility of both physical therapists and orthopedists is to substantiate systematically the clinical claims they are making about the efficacy of these adjunctive treatment approaches. Future clinical studies to examine the effects of both inhibitive casts and inhibitive orthoses on a variety of dependent measures, such as gait and fine motor coordination, are needed to substantiate further the value of these modalities for children with cerebral palsy.

**CONCLUSIONS**

This single-subject research design supports the efficacy of inhibitive orthoses in improving standing balance for a child with cerebral palsy. Objective, reliable measurements of the duration of independent standing during the with-orthoses condition showed improvements in both level and trend when graphed data were analyzed visually. Subjective improvements were noted in the symmetry of the subject’s stance pattern and in the ease with which he maintained independent standing. Further research is needed to document systematically the effectiveness of this adjunctive treatment strategy on a variety of other dependent measures for children with cerebral palsy.

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