The Effect of an Inhibitive Weight-Bearing Splint on Tone and Function: A Single-Case Study

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Objective. This single-case study was designed to duplicate Smelt's (1989) study of the effects of the application of an inhibitive weight-bearing splint on upper-extremity muscle tone and function in a child with cerebral palsy.

Method. Data on tone were collected by tracing the hand when weight bearing in the extended arm posture. Data on function were collected by observing block play for active grasp and voluntary release and ball play.

Results. Results indicate that after the application of an inhibitive weight-bearing splint, tone changed minimally, fine motor functional task changes were variable, and arm-hand position improved. Subjective reports by family and other caregivers, however, suggest that tone decreased and function increased.

Conclusion. The results of this study suggest the need to find more accurate means of measuring changes of tone and function in children with cerebral palsy. Selection criteria for suitable candidates for the weight-bearing splint are presented.

Occupational therapists in pediatric settings frequently work with children who have cerebral palsy. Manske (1990) indicated that spasticity is the most frequently observed manifestation of abnormality in this population. The typical pattern of spasticity in the upper extremities may include internal rotation at the shoulder, flexion at the elbow with the forearm in pronation, ulnar deviation, flexion at the wrist, and adduction and flexion of the thumb. The child who has cerebral palsy and who manifests spasticity in the upper extremities may not develop appropriate upper-extremity weight bearing, particularly when the child maintains this typical pattern of spasticity. Erhardt (1982) stressed the importance of weight bearing on the hand in normal infant development. In addition, proponents of both the neurodevelopmental treatment (NDT) approach (Bobath, 1980, Boehme, 1988) and the developmental treatment approach (Erhardt, 1982) promote the use of weight bearing as a treatment strategy to reduce tone.

Other strategies that occupational therapists use to manage increased tone are splinting or casting. Explanations for their effectiveness are found in biomechanical theory and neurophysiological theory. Gossman, Sahrman, and Rose (1982) indicated that a muscle forced into passive lengthening will alter biomechanically, anatomically, and physiologically. For example, a spastic muscle changes anatomically by adding sarcomeres to the muscle fiber and by stretching the connective tissue elements. A neurophysiological explanation for casting is that it inhibits motoneuron excitability most likely through...
prolonged stretch and possibly through weight bearing (Carlson, 1984). The effects are thought to be on the muscle spindles, Golgi tendon organs, cutaneous receptors, and joint receptors.

In their single-case studies, Smith and Harris (1985) and Cruickshank and O'Neill (1990) reported on the use of upper-extremity casting at the elbows. Both stated that a relationship exists between the application of casts and prevention of further elbow contractures. Smith and Harris reported that their subject achieved functional improvements, such as ease of handling and positioning, but they did not describe specific measures of change.

In a case study of a child with right hemiplegia, Yasukawa (1990) used three phases of casting—long arm casting (i.e., elbow, wrist, hand, fingers) and short arm casting (i.e., wrist, hand, fingers)—in conjunction with NOT and reported improvements in upper-extremity strength and control without describing her measures of change. Law et al. (1991) demonstrated that children with cerebral palsy who had been casted at the wrist and forearm (thumb and fingers not included) and had received at least weekly NOT showed considerably improved quality of movement and range of motion at the wrist. Analysis of Law and colleagues’ results for hand function with the Peabody Developmental Motor Scales and Activity Cards (Folio, Fewell, & Dubose, 1983) suggested that in conjunction with casting, twice weekly (labeled “intensive”) therapy with 30 min of daily home programming improved hand function more than intensive therapy alone or weekly (labeled “regular”) therapy with 15 min of home programming three times weekly. Although weight bearing was not discussed in either report, it is an integral component of NOT.

Weight bearing as a separate component of treatment both with and without casting or splinting has also been investigated. Smelt (1989) studied the effects of an inhibitive weight-bearing splint on a 17-month-old boy with left spastic hemiplegia who did not spontaneously use his left arm. Results indicated that positive changes accrued in passive range of motion, increased weight-bearing surface area of the hand, and functional performance (described as the number of times the affected arm was used in ball play). In a more recent study, Chakerian and Larson (1993) concluded that upper-extremity weight bearing promoted improvements in hand-opening and grasp–release patterns in 10 children with spastic cerebral palsy. The purpose of our study was to replicate Smelt’s study. That is, we investigated the effects of an upper-extremity weight-bearing splint on muscle tone and functional hand skills in a child with cerebral palsy.

Method

Subject

A 20-month-old boy with spastic quadriplegia (right-side involvement was greater than left) served as the subject. He was selected because (a) in terms of motoric involvement and his chronological age, he resembled the description of Smelt’s (1989) subject, and (b) his parents indicated that the use of his more spastic right hand was a major concern. Informed consent was obtained from the family. The subject tended to hold his right arm in the typical spastic posture described by Manske (1990), even though weight bearing through the involved arm had been included regularly during therapy and at home. The subject had been in treatment (weekly conjoint occupational therapy, physical therapy, and speech therapy along with daily programming with a rehabilitation aide) since he was 12 months old. Each treatment session was 1 hour.

Instrument

Hand tracing. A tracing of the hand while weight bearing in side sitting to the right was used to measure the presence of tone and changes in tone. To determine an increase in hand contact with a surface, the subject’s hand was outlined before engagement in the therapy protocol (preactivity) and again at the end of the therapy session (postactivity). The length of the line was then measured with a cartographer’s wheel and recorded in inches.

Arm–hand posture. The subject tended to hold his arm in a general pattern of flexion and required physical assistance to place his right hand and arm into a weight-bearing position. Therefore, a 15-point observation rating scale was used to rate initial elbow and hand position when initially placed in weight-bearing positions (0 = elbow flexed, hand fisted; 15 = elbow extended, hand open).

Functional activities. Two fine motor activities were used to measure changes in hand function after weight bearing: (a) The child was presented with a 1-in. block cube three times and encouraged to actively grasp it with his right hand. If active grasp was not achieved, the block was placed in his right hand, and he was directed to release it onto the table. Although voluntary grasp occurs before release, both measures were included as a reflection of our general optimism toward a positive outcome. (b) A 12-in. diameter ball was rolled to the subject 10 times, and the number of times he used his right arm in a batting or trapping action was measured.
Materials

An inhibition weight-bearing splint was made of moldable plastic, lined with sticky-backed foam, and held in place with soft foam straps (see Figure 1). This design is a departure from the plaster and wood splint that Smelt (1989) used. Moldable plastic was used to ensure speed and ease of manufacture of the splint and was judged to hold the hand in good alignment with appropriate palmar arches and weight distribution (see Figure 2).

Procedure

The study was conducted during the 15-min to 20-min occupational therapy portion of the subject's weekly treatment session. Following Smelt's (1989) ABA study design, data were collected over 24 weeks, with each phase lasting 8 weeks. During baseline and withdrawal (A phases), the right hand was traced first. The subject was then placed in three weight-bearing positions (side sitting to the right, four point over the therapist's leg, and prone propped over a wedge) and allowed to perform "easy" play activities. The time the subject held the position was measured. Because he did not initially tolerate the positions well, he was placed in each position for only 1 to 2 min. Later, although his tolerance had increased, the original times were maintained to ensure consistency. The subject was then given the blocks while in supported sitting at a table. The 12-in. ball was rolled to him while he was positioned in long sitting on the floor with the therapist supporting him from behind. Support was initially provided because the subject had poor sitting balance. Later, as his sitting balance improved, the subject tended to intentionally fall backward without warning. The right hand was traced again at the end of the 15-min to 20-min period.

During the intervention (B phase), the weight-bearing splint was applied to the right hand. All other procedures remained the same. To maintain elbow extension in the weight-bearing position, support at the elbow was supplied by the therapist (see Figure 2). The amount of support required varied but was not recorded. Again, time in each position was limited to 1 to 2 min because of the subject's initial low tolerance and because data collection was limited to the occupational therapy portion of the treatment session.

During the 24 weeks of this study, occupational therapy programming was conducted in the home by family members and the rehabilitation aide. However, the splint remained with the occupational therapist as prescribed by Smelt's (1989) protocol. Both speech therapy and physical therapy were continued during the 24 weeks because the subject's family lived 60 miles from the rehabilitation facility. The physical therapist continued using an NDT approach with inhibitory techniques.
but refrained from activities specifically requiring weight bearing through the right arm.

Data Analysis

Data points were recorded for each measurement: hand tracing preactivity and postactivity, the score for arm-hand position when placed in upper-extremity weight bearing, the number of times the right hand was used to bat a ball, and the number of times the right hand voluntarily released a block. The subject did not voluntarily grasp a block with his right hand; therefore, data points were not recorded for this activity. The data were visually inspected initially, but because of the wide variability in the baseline data, the standard deviation band (SD band) and the C statistic were determined to be the most appropriate methods of analysis. These were also used in Smelt's (1989) study.

Results

Hand Tracing

Preactivity changes in hand tracing reflected long-term effects of the intervention. No significant effects of individual treatments were observed in hand tracing data (see Figure 3). The C statistic and the SD band reflected minimal changes across all phases. Postactivity changes in hand surface reflected short-term effects of the intervention. Again, no significant effects of treatment were noted with the SD band method of analysis. The C statistic

Figure 3. Changes in hand surface—preactivity.
indicated slight increases in hand surface across all phases (see Figure 4). Subjective reporting of family members and other caregivers seemed to suggest a reduction of tone in the involved limb after treatment sessions.

**Arm-Hand Position**

During each phase, the readiness of the right arm and hand to take weight as the subject was placed in the side-sitting position was recorded. No significant effect of treatment was noted with the SD band method of analysis. The C statistic revealed improved arm-hand position across all phases, with the greatest improvements occurring in the baseline phase (see Figure 5).

**Functional Activities**

Very little change was noted across the phases in response to ball play. With SD band analysis, no significant changes were revealed (see Figure 6). For the voluntary release of the block, significant results were noted in two consecutive sessions of the intervention phase, but they did not persist throughout this phase (see Figure 7). Failure to demonstrate voluntary grasp during data collection is discussed in the next section. Elbow position and voluntary elbow extension during release were not measured.

**Discussion**

**Hand Tracing**

Our results indicate that after the application of a weight-bearing splint, changes in hand tracing (a measure used to reflect the presence of tone) from preactivity and postactivity were minimal (see Figures 3 and 4). This finding implies that weight bearing had minimal effects on tone.
Our results, therefore, do not support Smelt's (1989) findings of significant changes in tone. Smelt (1989) used a planimeter to determine the surface area of a hand tracing. Although we used a cartographer's wheel to measure hand surface area, our measure was based on the same principle. Thus, we believe that a comparison of test results is accurate. The difference between Smelt's findings and our own might be explained by the weight-bearing position used. Additionally, the position we chose when tracing the hand may have been more challenging than that used by Smelt, which is not described in her study.

Chakerian and Larson (1993) used a computerized system for hand tracing and calculation of hand surface area while their subjects were seated as opposed to weight bearing. A computerized system may be a more reliable measure; however, the absence of weight bearing during measurement may lead to significantly different measures of tone. Furthermore, the cost of this system may be prohibitive for many clinical settings. We see a need to (a) develop more accurate, reliable, and clinically accessible measures for tone or the effects of tone and (b) compare the difference between taking measurements while seated (without weight bearing) and while weight bearing in different positions.

**Arm-Hand Position**

The gradual improvement rated in the arm-hand position throughout all phases (see Figure 5) was the result of the subject's increased readiness to assume weight through the right arm. This measured readiness may be a reflection of reduced tone and increased voluntary movement at the right elbow and shoulder.

**Functional Activities**

In the two play activities (active release of a block and batting a ball), the subject demonstrated no changes throughout all three phases. Again, our findings do not support...
Smed's (1989) findings of significant changes in ball play after intervention. Release of a block on two consecutive occasions during the intervention phase appears specifically related to application of the weight-bearing splint. The reason that active release was not sustained throughout the intervention phase is not clear. Our findings do, in part, reflect those of Chakerian and Larson (1993) who used reach, active grasp, and release of specific objects as a functional measure of prehension. They also found that reach appeared to be unchanged, whereas grasp patterns and release appeared to be improved.

In our study, family members reported that the subject used his right hand more throughout the 24 weeks of the study than he did before the study. However, we did not record when these family reports occurred and cannot indicate during which phase (baseline, intervention, or withdrawal) they began. The treating therapist casually observed during a hospitalization when the subject had an intravenous drip in his left (dominant) hand that he was actively reaching and grasping with his right hand and then voluntarily releasing a small brightly colored toy into his mother's open hand while being held on his mother's lap. It is possible then that our results are only a reflection of the subject's lack of motivation to play with the ball and blocks, a dislike of the clinical setting, or both.

In selecting candidates for upper-extremity casting, Yasukawa (1990) stressed that the amount of voluntary control at the joints to be casted is an important indicator. She stated that prognosis is best for those children who use the involved arm as a gross functional assist for reach, grasp-and-release, weight-bearing, and bilateral tasks. On the basis of these guidelines, our subject was perhaps initially too limited in ability to be an appropriate candidate for a weight-bearing splint. However, family member anecdotal reports indicate improvements in function not measured in the clinical setting. Yasukawa added that age, motivation, and intelligence of the child; sensation of the

Figure 6. Functional motor task—ball play.
involved limb; as well as expectations of family members all need to be considered during the selection process. The variable response of our subject at home and in the clinical setting, however, demonstrates the difficulty of applying these criteria accurately.

Conclusion

Our replication of Smelt's (1989) study did not support her conclusion that the inhibitive weight-bearing splint has positive effects on tone and function in a child with spastic cerebral palsy. However, our findings do indicate several areas for consideration and study. First, to establish appropriate outcome measures and accurate results, we need to establish agreed-upon descriptions of function. In the literature reviewed, function was described in such variable terms as strength and control (Yasukawa, 1990), increased ease of handling and positioning (Smith & Harris, 1985), prehension components and release (Chakerian & Larson, 1993), and ability to trap or hit a ball (Smelt, 1989). Second, it may be beneficial to expand data collection beyond the clinical setting. The family members in our study reported anecdotally that the subject had reduced tone and improved hand use (e.g., spontaneous reach, grasp and release of toys, holding his bottle) at home. Such variations of performance could be included in data analysis through the use of objective questionnaires for families and caregivers. Finally, measures of change in tone in the hand need to be developed further with low technology methods to allow for (a) their use in clinical settings without incurring great expense and (b) measures that are meaningful to the families involved (e.g., greater ease in putting on mitts or washing the hand).

This study of the effect of an inhibitive weight-bearing splint on tone and function as a treatment technique was conducted during regular treatment appointments. Such research in clinical settings is important and can be less costly than formal studies.
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References


