Forced Use of the Upper Extremity in Cerebral Palsy: A Single-Case Design

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Objective. Muscle imbalance and poor control of movement can have an impact on the daily occupational functioning of children with cerebral palsy. When one side of the body functions better than the other, children will often prefer to use the less-involved upper extremity for completion of play and self-care activities because they have learned that the other hand does not function as effectively. This study examined a method purported to overcome this learned nonuse of the affected upper extremity by directing the child’s attention to this extremity and increasing his or her motivation to use it. The research hypothesis was that restriction of the less-involved hand with a resting splint would result in increased use of the more-involved hand in a child with spastic cerebral palsy.

Method. Initially, two children with cerebral palsy participated in this single-subject, ABA design study, but only one subject complied with the splint-wearing schedule and completed the study. This subject was a 2-year-old girl with greater involvement of the right side than the left. During the experimental phase, she wore a resting splint on her less-involved hand for most of the waking hours of the day to restrict its use. Data were collected over a 7-week period (2 weeks pre-splinting, 3 weeks splinting, 2 weeks post-splinting) and at a 6-month follow-up. Use of the more-involved extremity was measured through analysis of her performance during 15-min videotaped sessions of free play, administration of items from the Peabody Developmental Fine Motor Scales, and completion of a daily finger-feeding task.

Results. An improvement in quality, quantity, and variety of use of the more-involved extremity after splinting, with some continuing improvement evident at follow-up, was found. The subject had increased voluntary control of her more-involved arm and hand and used them more spontaneously for completion of daily occupations.

Conclusions. Although the results of this single-case design are encouraging, further research with a randomized, controlled design is necessary to determine the effectiveness of the forced-use technique with a larger population.

Lack of motor control can have a serious impact on the functional abilities of the upper extremity in children with cerebral palsy (Yasukawa, 1992). Often, one upper extremity is more involved than the other, resulting in disproportionately less use of that arm for task completion (Ostendorf & Wolf, 1981). Taub (1980) termed this phenomenon learned nonuse of the involved upper extremity: The person notices that he or she is not as effective when using the more-involved extremity and, thus, learns to not use it. It would appear that directing the person’s attention to the more-involved
extremity by restricting the use of the dominant, less-involved hand could help to counteract the learned non-use of the more-involved arm and hand. This is an important area of study for occupational therapy because forced use of the more-involved extremity could lead to increased functional abilities for children with cerebral palsy.

Literature Review

**Forced Use in Animal Models**

Taub (1980) studied the effects of deafferentation of the forelimbs of monkeys, which caused a loss of sensation but did not affect motor innervation. When the deafferentation was unilateral, the monkeys made no attempt to use the deafferented extremity in a purposive fashion and would hold the limb in a stereotyped position, with the shoulder adducted and the elbow and wrist flexed (Knapp, Taub, & Berman, 1963). However, with bilateral deafferentation, the monkeys were able, in time, to use both involved extremities for grasp, ambulation, and climbing despite sensory impairments. Furthermore, with unilateral deafferentation, if the intact limb was restrained with a straitjacket, the monkeys were able to reach with the deafferented limb to drag food into the cage. When the straitjacket was removed after 1 to 2 days, there was a return of nonuse of the involved limb, but, if the monkeys wore the straitjacket for 3 days, use of the deafferented limb continued after restraint removal.

Taub (1980) explained the behavior of the monkeys by applying a learned nonuse hypothesis. He suggested that when attempts to use the limb were unsuccessful after unilateral deafferentation, the monkeys learned that they should not try to use the limb. Conversely, the monkeys with bilateral deafferentation were not effective in the laboratory environment, and motivation remained high to use the deafferented limbs. Restraint of the intact forelimb of monkeys with unilateral deafferentation increased the monkeys' motivation to try to use the deafferented limb.

More recently, Jones and Schallert (1994) presented findings that they interpreted to be evidence against the effectiveness of the forced-use technique. After inducing unilateral, electrolytic lesions in the sensorimotor cortex (SMC) of 35 adult rats, they studied the effects of forelimb restraint on functional behavior and morphological changes in the SMC. Restraint of the forelimb either ipsilateral or contralateral to the lesion was achieved immediately after surgery by placing the forelimb in a plaster of paris cast for 15 days. Measurements of sensorimotor dysfunction, made before casting and on day 16, included vibrissae-stimulated forelimb placing errors and falls made by the forelimbs while the rats walked on a grid floor. Restricting the use of the nonimpaired forelimb caused a mild decrement in bilateral sensorimotor function and did not enhance the performance of the impaired forelimb. In addition, restraint of the nonimpaired forelimb, but not of the impaired forelimb, interfered with the typical response to unilateral SMC damage—a temporary increase in dendritic branching within the SMC contralateral to the lesion. The investigators concluded that a critical period may exist after a cortical lesion for the development of compensatory strategies involving use of the noninvolved limb. They suggested that restriction of the intact limb of humans with hemiplegia, in an attempt to improve use of the involved limb, may jeopardize overall function. However, the functional importance of the temporary dendritic growth after SMC damage has not been determined. Furthermore, the period during which behavior was observed after removal of the restraint was limited to 1 day. Hence, the investigators' suggestions are highly speculative.

**Forced Use With Adults Experiencing Hemiplegia**

Ostendorf and Wolf (1981) examined the effects of forced use of the involved upper extremity of a 50-year-old woman 18 months after stroke. The researchers used an ABA study design, with 7 days per phase. In the experimental phase, the subject's intact extremity was restrained throughout the day with a shoulder sling. For evaluative purposes, the researcher used the subject's self-report of the number of purposeful movements of the involved extremity per day and a functional assessment for rating quality and time of movement. The results showed that the frequency of functional behaviors with the involved extremity increased during the experimental phase, and although these behaviors decreased during the second baseline period, they remained at a level higher than that of the initial baseline measurements. The quality of movement measurements, however, showed minimal change across the experiment, but the researchers reasoned that this could have been due to the emphasis placed on speed of movement.

Wolf, LeCraw, Barton, and Jann (1989) studied the effects of forced use on 21 subjects with hemiplegia of at least 1-year duration that was secondary to stroke (n = 16) or traumatic brain injury (n = 5). Using an experimental ABA design, the investigators initially evaluated the subjects during 6 weekly sessions to establish baseline measurements. The subjects were then required to keep their uninvolved upper extremity within a hand-enclosed sling during waking hours for 2 weeks, with postrestraint evaluations completed at 1-week, 2-week, 4-week, and 52-week follow-up periods. The results showed a significant change in the speed and force of movement during the second week of forced use, and significant improvements from the last baseline measurement were present for 19 of the 21 tasks at the 52-week follow-up evalu-
measurements of arm function were qualitative and based on observations of the researcher and the subject's mother. After the period of restraint of the less-involved arm, overall improvement was noted in the control and strength of the hemiplegic arm. Additionally, the subject used the more-involved hand during play and mobility. At the end of the study, he used his more-involved arm more spontaneously in functional tasks, particularly in bilateral manual activities. However, it is difficult to determine whether the increased use was due to the inhibitive casting, restriction of use of the less-involved extremity, or a combination of both procedures.

The studies cited previously suggest that unilateral upper-extremity restraint can influence contralateral arm function. In a recent review of the literature on the forced-use paradigm, Russo (1995) emphasized the need for further study to substantiate its treatment effect. The purpose of this study was to determine the effect of restriction of the less-involved upper extremity on spontaneous use of the more-involved upper extremity in children with spastic cerebral palsy. The hypothesis was that such restriction would result in increased use of the more-involved upper extremity in children with cerebral palsy.

Method

A single-subject, ABA experimental design was used. The independent variable was the restriction of the less-involved hand, and the dependent variable was the spontaneous use of the more-involved hand.

Subjects

The subjects for this study were two children with cerebral palsy, as diagnosed by a physician, who met the following inclusion criteria adapted from Yasukawa (1990):

- **Age:** The child is between the ages of 15 months and 5 years because older children with cerebral palsy may have perceptually and psychologically dissociated themselves from their more-involved limb and may not be receptive to learning how to use it.
- **Voluntary control:** The child uses the more-involved extremity as a gross functional assist for active reach, weight bearing, bilateral tasks, and grasp and release of objects.
- **Sensation:** The child does not have major sensory deficits because this could limit the spontaneous use of the extremity.
- **Motivation and intelligence:** The child enjoys moving and exploring in the environment and exhibits no major behavioral or cognitive problems.
- **Realistic parents:** The child's parents are motivated to participate in the study and have realistic expectations about the results of the study.

In another single-case study, Yasukawa (1990) examined the effect of upper-extremity casting and forced use on arm function of a child with hemiplegic cerebral palsy. In the first phase, inhibitive casting was applied to the less-involved upper extremity. In the second phase, the less-involved extremity was restrained for 4 weeks in a short arm cast that incorporated the hand, arm, and thumb. In the third phase, a bivalved cast was worn on the more-involved upper extremity at night to maintain the length of elbow extension achieved in the first phase.
The subjects were recruited from the Pediatric Neurologic Clinic, Stan Cassidy Centre for Rehabilitation, Fredericton, New Brunswick, Canada.

Subject A was a 2-year-old girl whose right side was more involved than her left. She lived with her mother, father, and 9-month-old brother. She was receiving 30 min each of occupational therapy, physiotherapy, and speech therapy per week. She had little spontaneous use of the more-involved extremity and usually held it with the wrist locked in neutral position, elbow flexed, and the fingers tightly fisted.

Subject B was a 3-year-old boy whose left side was more involved than his right. He lived with his mother, father, and 4-year-old brother. He was receiving 30 min of physiotherapy per week and 30 min of occupational therapy every 2 weeks. He used his left hand very actively for functional tasks, but his main difficulty was with inhanded manipulation of objects.

**Procedure**

Written consent was obtained from the subjects’ parents. The parents were informed of the possible benefits of forced use and of the potential risks of wearing the splint on the less-involved upper extremity (i.e., frustration and irritability; skin breakdown; diminished protective extension reactions, which increase possibility of falling).

Data were collected over a 7-week period during which the subjects continued to attend their regular therapy sessions. The first 2 weeks were used to collect baseline measurement of the use of the more-involved arm. At the beginning of the third week, the less-involved upper extremity was fitted with a custom resting splint that extended from the junction of the proximal one third and distal two thirds of the forearm to 2 cm distal to the fingertips. The splint was made of turbocast microthermoplastic splinting material with hook-and-loop straps. The parents were instructed that the splint be worn for most of the waking hours for 3 weeks but could be removed for bathing, sleeping, and short rest periods during the day. The goal was to achieve a minimum of 8 hours of forced use per day by the end of the first week of the experimental phase. Weeks 3, 4, and 5 involved measurement of the subjects’ use of the more-involved arm while the less-involved arm was splinted. The splint was removed at the end of the fifth week, and the final 2 weeks of the study were used to measure the postspinting use of the more-involved upper extremity. After the 7-week period, the parents were given the splint to use as desired. A follow-up evaluation was done at 6 months after the initial baseline evaluation.

**Evaluation**

For single-case designs, it is important to use several evaluation techniques with repeated measures. In this study, three methods of evaluation were used.

**Videotape.** Specific upper-extremity behaviors were documented on videotape while the subject engaged in 15-min sessions of free play at the clinic three times during the prespinting and postspinting phases, five times during the spinting phase, and once at the 6-month follow-up. One additional 15-min videotaped session was completed during each phase in the subject’s home environment while the subject was engaged in free-play activities. The subject was placed on a mat with a variety of toys. After a 5-min period to become accustomed to the environment, recording was initiated. These videotapes were viewed independently by two of the researchers, who indicated on a checklist each time the subject exhibited a particular behavior. The data collection sheets also contained a section for the researchers to record notes about the quality of upper-extremity movement. For Subject A, use of her more-involved upper extremity during the following behaviors was documented:

- **Stabilization and weight bearing:** to bear weight, to get up from or down to the floor, and to move about
- **Grasp and release:** to place and close hand on an object or open hand to release the object from grasp
- **Sensory exploration:** to place hand on an object to receive tactile information about the object
- **Bimanual assist:** to use the object simultaneously with the less-involved hand (i.e., two-handed use)
- **Index finger use in isolation:** to exhibit isolated use of the index finger
- **Push and pull:** to push or pull an object
- **Communication and gesture:** to communicate with another person, such as pointing to a desired toy, or in gestural expression, such as hand clapping

For communication and gesture, a single behavior constituted the period between initiation and termination of the gesture. For all other behaviors, the behavior began when the subject placed the more-involved hand on the object being manipulated and ended when the hand was removed. Initial data collected for Subject B were on more advanced upper-extremity behaviors, including finger-to-palm translation, palm-to-finger translation, wrist rotation, and isolated finger use.

**The Peabody Developmental Fine Motor Scale (PDMS-F).** The PDMS-F (Folio & Fewell, 1983) was completed once during each phase of the experiment to document use of the more-involved extremity for fine motor tasks. This test has been standardized for use with children from birth to 7 years of age (DeMatteo et al., 1993). Palisano and Lydic (1984) reviewed the PDMS-F and stated that it was particularly well suited for evaluation of infants and
children with motor development disorders. The Fine Motor scale contains 112 items, with 6 or 8 items in each of 16 age levels. The scale is divided into four categories: grasp, eye-hand coordination, hand use, and manual dexterity. Each response is scored on a three-point scale (0 = unsuccessful performance, 1 = clear resemblance but item criterion not fully met, 2 = successful performance and criterion met).

For the initial baseline measurement of fine motor ability, the subject was assessed with the PDMS-F, beginning at a level identified to be manageable when using only the more-involved upper extremity. Evaluation proceeded backward down the scale until a level was reached where the subject received no scores of 0. Evaluation then proceeded forward on the scale from the highest previously tested level until a level was reached where the subject received no scores of 2. During the splinting and postsplinting retests, evaluation began at the level where previously no scores of 0 were recorded and continued forward until the subject reached a level with no scores of 2. During testing in all phases, the less-involved upper extremity was restrained in the splint.

**Daily log.** A daily log of hand use during a feeding task was completed by the parents from the beginning of the presplinting phase to the end of the postsplinting phase. Parents were asked to place 10 pieces of finger food in front of the subject on the high chair tray and to record in the log provided the number of pieces the subject put into his or her mouth with the more-involved hand within a 5-min period. The parents were asked to select two foods that the subject enjoyed and to alternate between them each day in order to prevent boredom with the task. During the presplinting and postsplinting phases, the splint was used to restrain the less-involved extremity in order to measure the use of only the more-involved extremity in completing the feeding task. (Throughout these phases the less-involved arm was not restrained for any other part of the day.) To complement the logs, the parents were asked to record qualitative observations of how the subject was using the more-involved extremity at home.

**Data Analysis**

Interrater reliability of the pooled frequency data for use of the more-involved upper extremity in all behaviors observed during the videotaped sessions was evaluated between two observers with Pearson correlation coefficients. The frequency data for each upper-extremity behavior were analyzed with the two-band standard deviation method to identify significant changes. If at least two consecutive observations in a phase fall outside of the 2 standard deviation band, a significant change in performance has occurred, with an alpha level set at .05 (Gottman & Leiblum, 1974). In addition, the qualitative notes made during the videotape analyses were perused for indications of perceived changes in quality of movement of the more-involved extremity.

The PDMS-F was scored with the criteria given in the test manual for the three-point scale. The raw scores were compared to determine changes in use of the more-involved extremity for fine motor task completion. Because of the limited number of repeated measures, analysis was limited to visual inspection.

**Results**

Subject A appeared to enjoy wearing the splint, wearing it for an average of 10 hr per day throughout the splinting phase of the study. She was cooperative with the study procedures and did not demonstrate irritation or frustration with the restraint. In contrast, Subject B did not adjust well to wearing the splint and was averaging only 4 hr of wearing time per day at the end of the first week of the splinting phase. When wearing the splint, he appeared irritated, withdrew from play activities, and would often remove the splint and hide it from his mother. Because of his adverse reaction to the splint, he was unable to meet the minimum criterion of 8 hr wearing time per day; hence, his participation in the study was terminated. Therefore, the results presented here are for Subject A.

**Videotaped Documentation of Specific Upper-Extremity Behaviors**

The interrater reliability correlation coefficients of the videotaped observations were .99 in the presplinting phase, .91 for the splinting phase, and .96 for the postsplinting phase. Findings of such high reliability reinforce the use of videotape analysis as an objective behavioral measure.

The subject's average use of her more-involved (right) upper extremity in the seven behaviors across phases is illustrated in Figure 1. The data generated from the videotaped sessions in the clinic and at home were pooled because there was little variability in performance in the two environments. At no point during the videotaping did the subject demonstrate isolated use of the right index finger. For five of the six other behaviors, she showed increased frequency of use from the presplinting to splinting phases. Simultaneous use of both hands (i.e., bimanual assist) decreased during the splinting phase but exceeded the baseline frequency in the postsplinting phase and at 6-month follow-up.

To ascertain the significance of the changes in use of the right upper extremity across phases, the two-band standard deviation method was used for each behavior except index finger use in isolation (see Figure 2). Significant improvements were found in the use of the more-involved extremity for grasp and release, sensory exploration, and push and pull from the presplinting to splinting phase and
Results of the PDMS-F generally supported the findings from the videotaped sessions. The subject was tested on 44 items from the PDMS-F over the course of the study. Table 1 shows the 18 items (41%) on which the subject demonstrated a change in performance. On these items, her total score increased by 9 points from the presplinting to the splinting phase, increased by 17 points from the splinting to postsplinting phase, and decreased at 6 months follow-up to a score similar to that obtained in the splinting phase.

**PDMS-F**

**General Observations**

During the splinting and postsplinting phases, there was less posturing in flexion and a decrease in the associated movements of the subject's more-involved extremity. She also appeared to be more aware of her more-involved hand, using her right arm more voluntarily and spontaneously for a greater variety of functional tasks. In the presplinting phase, the subject tended to use her mouth in conjunction with her left hand to manipulate objects. In the postsplinting phase, she often used her right hand as the assist for her left and often used whichever hand was closer to an object rather than reorienting her body to facilitate exclusive use of her left hand. Before splinting, the subject used only the left upper extremity when crawling and would drag the right upper extremity under her body. In the postsplinting phase, she was observed to bear weight through both upper extremities while crawling.

The mother’s observations corroborated our findings. She reported that the subject was able to use her spoon to feed herself with her right hand at mealtimes when wearing the splint and that she continued to prefer to spoon-feed with that hand after the splint was removed. Additionally, the mother reported that not only did the subject use both upper extremities for crawling, but also began to pull herself to standing with the right hand. These behaviors persisted to the follow-up phase. From the end of the postsplinting phase to the follow-up evaluation, the subject continued to wear the splint for approximately 90 min per day, and during splint wearing, the quality of grasp and release of the right hand “improved significantly,” according to her mother.

**Discussion**

The results of this single-case study suggest that restriction of the less-involved hand can lead to increased use and improved function of the more-involved hand in a child with spastic cerebral palsy. Compared with baseline

**Daily Log**

The subject was initially given O-shaped cereal for the daily feeding task, which she enjoyed crushing with her splint and made no attempt to eat. The finger foods were switched to soft foods (e.g., pieces of cheese) that she could not crush with her splint. After attempting to crush the food, she flexed forward and ate the cheese directly off the high chair tray with her mouth. If the pieces of finger food were moved away from her, she would pull them toward her with either her more-involved or less-involved hand and then flex forward to eat them directly off the tray. The subject did not use her more-involved extremity to bring finger foods to her mouth during the daily feeding task at any time during the study.
Figure 2. Two-band standard deviation method for calculating the significance of six behaviors videotaped during the 15-min free-play sessions. Values represent the mean number of observations recorded by two observers. The dashed lines represent the mean and the dotted lines the standard deviation of the frequency of behavior during the presplinting phase. The asterisk (*) indicates a significant change from baseline at $p \leq .05$. 
evaluations, the subject used the right upper extremity with increased frequency and for a greater diversity of purposes during the splinting, postsplinting, and follow-up evaluations. However, inspection of the data of individual behaviors shows inconsistency in this trend, underlining the importance of monitoring several behaviors and interpreting the results with caution. For example, the frequency of push and pull actually decreased across phases as the subject developed more advanced means of interacting with objects. The most frequently observed behavior involving the right hand during the free-play sessions in the presplinting phase was bimanual assist. During the splinting phase, however, the frequency of this behavior decreased, possibly because the subject had adjusted to the encumbrance imposed by the splint during this phase. In the postsplinting phase, when the splint was not worn except during data collection, and at follow-up, when the splint was worn an average of 90 min per day, use of bimanual assist increased.

Inconsistency in frequency of use of the right upper extremity in stabilization and weight bearing was also noted during the free-play sessions across phases. The extent of use decreased dramatically at follow-up despite a concomitant improvement in the quality of use of the right upper extremity during crawling and pulling to standing. On closer scrutiny of the follow-up evaluation, it became apparent that the subject was no longer using her right upper extremity for support in sitting (because of improved balance) and chose to sit, as opposed to crawl, during this session, hence, the lower score on stabilization and weight bearing. Significant improvements were seen in communication and gesture from the splinting to postsplinting phases. The possible contribution of maturation to the changes seen in the 6-month follow-up evaluation cannot be ascertained.

Thirteen of the 18 items on the PDMS-F in which improvement was noted involved grasping an object, suggesting the subject's development of a functional grasp with her more-involved hand. The use of this hand was becoming more purposeful, and the subject was developing voluntary control of its movement to follow instructions and commands. General observations made by both the mother at home and the researchers at the clinic were consistent with these findings.

Unfortunately, the task selected to log daily—picking up a small piece of finger food with the more-involved hand and bringing it to the mouth—was inappropriate for this subject. Choosing a task that was motivating and challenging, yet not too demanding, was difficult. A behavior that would normally be expected for nondominant hand function, such as a task using the more-involved hand as an assist rather than as the prime mover, may have been a better choice for tracking function over time. However, to our surprise, the mother reported progressively increased use of the more-involved hand for a dominant hand function—spoon-feeding—which continued at follow-up.

Our findings are consistent with previous research that has suggested that a 2-week to 4-week period of forced use was sufficient to observe an effect on the involved upper extremity (Ostendorf & Wolf, 1981; Taub et al., 1993; Wolf et al., 1989; Yasukawa, 1990). Restriction of one extremity is unnatural, and wearing a restraint for longer than necessary could possibly lead to development of learned nonuse of the less-involved extremity in a person with bilateral involvement. Nevertheless, greater carryover of gains might have been demonstrated at the follow-up evaluation had the wearing time exceeded 90.

Table 1
Changes in Performance on the Peabody Development Fine Motor Scale Across Phases

<table>
<thead>
<tr>
<th>Task</th>
<th>Preplinting (2 Weeks)</th>
<th>Splinting (3 Weeks)</th>
<th>Postsplinting (2 Weeks)</th>
<th>Six-Month Follow-Up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grasping rattle</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Activating arms</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Grasping voluntarily</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Securing paper</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>1</td>
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<tr>
<td>Grasping precariously</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Lifting cup</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Grasping: radial-palmar</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Rotating wrist</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Grasping: ulnar-palmar</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Reaching cubes</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Grasping: raking</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Removing peg</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Grasping: thumb-finger</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Grasping: raking radial</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Grasping: inferior pincer</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Manipulating paper</td>
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<td>0</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Removing ring</td>
<td>0</td>
<td>3</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Poking finger</td>
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<td>0</td>
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<td><strong>Total</strong></td>
<td><strong>5</strong></td>
<td><strong>14</strong></td>
<td><strong>31</strong></td>
<td><strong>16</strong></td>
</tr>
</tbody>
</table>
min a day after the postsplinting phase.

The results are also compatible with the findings of Yasukawa (1990), who found that forced use after inhibitive casting improved the ability of a child with hemiplegic cerebral palsy to use her more-involved extremity. Although the present study demonstrated that forced use alone was sufficient to influence the performance of the more-involved extremity, further study is needed to determine whether the addition of inhibitive casting would enhance this result. It is possible that inhibitive casting would reduce tone in the spastic upper extremity, making it easier for the child to use that extremity in the forced-use situation.

The observed decrease in associated reactions in this study was also reported by Nwaobi (1987), who restricted the more-involved extremity of a child with athetoid cerebral palsy to decrease the involuntary movements of the less-involved extremity. Both studies showed that decreasing these involuntary movements was associated with better voluntary control of the unrestricted extremity.

Although Subject B was unable to comply with the protocol, his participation proved invaluable in helping us to formulate suggestions regarding selection criteria, protocol, and evaluation procedures for implementing forced-use techniques in clinical practice. A 2-day to 3-day trial period of splint wear is recommended to identify those children whose intolerance is likely to preclude compliance with the wearing schedule. For children with higher functional abilities, use of a bivalved fiberglass cast or a splint with straps that are difficult to unfasten should be considered.

For evaluation purposes, a baseline videotaped session is helpful to identify, on an individual basis, functional limitations and behaviors appropriate to monitoring change in function. (The behaviors tracked for Subject A could only be used with clients who demonstrate poor grasp and release and little spontaneous use of the more-involved upper extremity.) Additionally, the PDMS-F may not be appropriate for evaluation of older children or children who are functioning at a higher level because of the emphasis on bimanual tasks at the upper end of the scale. If the PDMS-F is to be used for evaluating children who are higher functioning, then the splint should be removed during testing to permit bimanual activities. Finally, the setting of functional goals must be carefully considered.

One of the goals of the forced-use paradigm is to reinforce the cortical pathways for more normal movement patterns of the more-involved extremity. By encouraging use of that extremity in activities that would normally be carried out by the dominant hand (e.g., writing), unnatural patterns of movement may be reinforced.

Limitations

Although the single-case design enabled us to examine the effects of forced use carefully and with considerable detail, it limits the generalizability of the results to a larger population. A randomized trial involving a larger and more diverse group of subjects is needed to determine the effects of the forced-use technique on children who are functioning at higher or lower levels than the subject who completed this study. Use of a control group is critical in determining which changes in function may be attributable to the intervention and which are secondary to the ongoing process of motor development and to other therapeutic interventions.

Conclusion

Forced use of the more-involved (right) upper extremity with a splint on the less-involved upper extremity for 3 weeks and strict adherence to a wearing schedule was achieved in a child with spastic cerebral palsy. This intervention was associated with improvement in stabilization and weight bearing, grasp and release, sensory exploration, push and pull, and communication and gesture with the more-involved extremity. There was also a decrease in associated reactions and less flexor tone, with a concomitant improvement in voluntary motor control of the right upper extremity. These results suggest that restriction of hand use in the less-involved hand can increase use of the more-involved hand in a child with spastic cerebral palsy. Although the results of this single-case design are encouraging, further research with a randomized, controlled design is necessary to determine the efficacy of the forced-use technique with a larger population.

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