
NEURODEVELOPMENTAL THERAPY AND UPPER-EXTREMITY INHIBITIVE CASTING FOR CHILDREN WITH CEREBRAL PALSY

Mary Law
David Cadman
Peter Rosenbaum
Stephen Walter
Dianne Russell
Carol DeMatteo

The child with cerebral palsy demonstrates inadequate integration of primitive reflexes and changes in muscle tone, which lead to abnormal movement patterns. These have a significant effect on the development of motor skills, and on self-care, education, employment and leisure (Eisenberg *et al.* 1984). To date there has been little methodologically rigorous research into the types of therapy that might improve these children's function.

Occupational therapy for children with cerebral palsy uses task analysis and activities to facilitate independence in movement, self-care, play and leisure (Canada: Department of National Health and Welfare and Canadian Association of Occupational Therapists 1983). One type widely practised is neurodevelopmental therapy (NDT). A technique using upper-extremity casting has been advocated by Sussman and Cusick (1979). It has been suggested that the cast, in combination with regular or intensive NDT, will lead to increased range of motion, and improved quality of movement and hand function (Duncan and Mott 1983).

The movements of a child with cerebral palsy are characterized by stereotypical patterns in flexion and extension, asymmetrical movement and the use of primitive reflexes to achieve voluntary reach and grasp (Bly 1983). The philosophy of NDT is that movements can

be learned, that normal postural reactions are necessary for normal movement, that these postural reactions are mostly automatic, and that the child and parents should play an active part in therapy (Bobath 1980). In NDT, the therapist uses movement and handling to alter tone and to facilitate normal movement patterns and postural reactions, while abnormal tone and reflex activity is inhibited. As voluntary control increases, the therapist decreases the amount of handling and challenges the child to attain more functional postures and activities against gravity.

Proponents of NDT claim that children who receive intensive NDT in the early years achieve greater independence. In six comparative studies of the efficacy of NDT for children with cerebral palsy, NDT was compared with no therapy (Wright and Nicholson 1973), traditional therapy (Carlsen 1975, Scherzer *et al.* 1976, Sommerfeld 1981), infant stimulation (Palmer *et al.* 1988) and Vojta therapy (D'Avignon *et al.* 1981). The results were mixed, with three demonstrating no difference (Wright and Nicholson 1973, Scherzer *et al.* 1976, Sommerfeld 1981), one supporting NDT (Carlsen 1975) and two supporting alternative interventions (D'Avignon *et al.* 1981, Palmer *et al.* 1988).

There are a number of methodological

problems with these studies. Except for that by Palmer and colleagues, inclusion criteria were heterogeneous, including all types and distributions of cerebral palsy, and the prognostic variability of different types of cerebral palsy was not considered. In only three studies were the children in each group comparable for prognostic risk factors such as chronological age, developmental age, and type and severity of cerebral palsy (Carlsen 1975, Sommerfeld 1981, Palmer *et al.* 1988).

Random assignment of subjects was used in four studies (Wright and Nicholson 1973, Carlsen 1975, Sommerfeld 1981, Palmer *et al.* 1988), of which only the Carlsen study found a statistically significant difference in favour of NDT. In addition, sample sizes were small and no power calculations were reported. The clinical manoeuvres were poorly defined in all studies. Intervention aimed at improving function in every area, not simply hand function.

For inhibitive casting, a cast is applied over a specific joint, such as the wrist or ankle, while it is in a functional, tone-inhibiting posture. Subsequently the cast is bivalved and worn for limited periods during the day and during therapy, allowing the limb muscles to work and become stronger and more functional.

There are biomechanical and neurophysiological explanations for the effect of casting. The biomechanical explanation emphasizes the effect of casting on muscle and joint position. Inhibitive casting in the correct position is thought to reduce soft-tissue contractures which develop secondarily to spasticity because of changes in muscle length (Tardieu *et al.* 1982). Gossman *et al.* (1982) reported that a muscle forced into passive length change will alter biomechanically, anatomically and physiologically. They suggest that changes in shortened spastic muscles may be due more to anatomical length changes than to neurophysiological changes, and that applying casts or splints in a lengthened position should add sarcomeres to the muscle fibre and stretch the connective tissue elements. The neurophysiological explanation stresses the effects that the cast may have on the neurophysiological components of

cerebral palsy, such as spasticity and abnormal reflexes (Hayes and Burns 1970, Sussman and Cusick 1979). Inhibitive casting may reduce cutaneous input and spasticity by providing neutral warmth and even cutaneous pressure.

The majority of research to date has studied the effects of casting on the lower limb. In one of three small studies of the upper limb, Mills (1984) reported a significant increase in range of motion after bivalved casting of the ankle, wrist and elbow joints of eight adults with head injuries. Two case studies also reported increased range of motion after casting to reduce elbow flexor spasticity in an adult stroke patient and a child with cerebral palsy (King 1982, Smith and Harris 1985).

The purpose of the randomized clinical trial reported here was to study the effect of intensive NDT and casting, separately and in combination, on hand function, upper-extremity quality of movement and range of motion of children with spastic cerebral palsy.

Method

Study design

A two-by-two factorial design was employed to study two levels of each intervention factor. Factorial studies are efficient in determining the effect of two or more interventions simultaneously (Winer 1971); also combined interventions are often more representative of clinical practice than designs varying only one factor. The sample size was calculated at 16 subjects per cell—64 in total—using an alpha level of 0.05 and a power of 80 per cent, with two-tailed tests of significance. It was increased by 15 per cent to allow for drop-outs, resulting in a projected size of 19 per cell, or a total of 76 children. It was recognized that the design had adequate power for determining the main effects of intensive NDT and casting separately, but less power to evaluate the specific, combined effect of intensive NDT plus casting (Winer 1971); the sample size needed for the latter was prohibitive.

Sample

Children were selected from those attending three treatment centres in

Ontario, Canada. Since these centres serve all physically disabled children in their geographical areas, the study is population-based. Inclusion and exclusion criteria are listed in Table 1. Children with severe developmental disability were excluded because their hand function was unlikely to improve because of their cognitive disability, rather than their physical disability. Of the 97 children who met the inclusion criteria, the parents of 79 consented to their children's participation. Six children left the study immediately after randomization and before therapy started, and were not included in further analysis. Therefore 73 children completed the study.

Intervention

Each child was graded by age (young: 18 months to 3 years 11 months; old: four to eight years) and hand function severity, according to the Peabody Fine Motor Scales (Folio *et al.* 1983). After randomization, children were assigned to one of the four intervention groups, using a randomization design with blocks of four.

Quantity of therapy was the major difference between the six-month programmes of regular and intensive therapy. Children receiving intensive NDT were to receive 45 minutes therapy twice weekly, plus a 30-minute daily programme at home. This represented a substantial increase over normal programming. Children receiving regular NDT attended therapy for a maximum of once a week and a minimum of once a month, plus a 15-minute programme at home three times a week. Before the trial began, all occupational therapists in the study attended a training workshop on the guidelines for therapy and the use of inhibitive casting. Although the principles of intervention were similar for all children, each child's programme was dictated by their unique clinical needs. A complete record of therapy attendances and goals was kept by each therapist.

Home programmes consisted of specific NDT therapy activities. Children randomized to the casting groups received an upper-extremity inhibitive cast, bivalved and worn for at least four hours a day. They were short-arm fibreglass casts, extending from below the elbow to the

TABLE 1
Inclusion and exclusion criteria

Inclusion criteria	
	Spastic cerebral palsy (hemiplegic or quadriplegic)
	Spasticity of wrist and hand
	Parent able to attend therapy
	Age 18 months to eight years
Exclusion criteria	
	Skin sensitivity to casting material
	Fixed, permanent wrist contracture
	Upper-extremity surgery planned during intervention period
	Severe developmental disability

palm of the hand, immobilizing the wrist from neutral to 10° extension. The thumb and fingers were not included. Parents kept records of the home programme and the lengths of time the casts were worn. Records were also kept of other types of intervention received during the six months of intervention so that their effects could be evaluated.

Measurement of outcome

Outcomes were assessed by an evaluator, blind to the children's status at commencement, after six months of therapy and nine-months follow-up. All children received regular occupational therapy during the follow-up period (*i.e.* six to nine months). The outcome measures were the Peabody Fine Motor Scales (Folio *et al.* 1983), a standardized measure of hand function; the Quality of Upper Extremity Skills Test (QUEST); and range of motion at the wrist. The QUEST measures the quality of upper-extremity movement; it was developed for this trial and designed to measure changes effected by therapy that are clinically important but not immediately represented by change in skill levels on other standardized tests. Items included are dissociated movements, grasp, weight-bearing and protective extension, as well as a section for free play. Before commencing the study, evaluation of the QUEST showed inter-rater reliability (intraclass correlation) to be 0.93. Using a sample of 40 children, the correlation of the QUEST with the Peabody Fine Motor Scale was 0.78 and with therapists' judgments of hand function was 0.63. The correlation between

TABLE II
Description of study sample

	Intensive NDT plus cast		Regular NDT plus cast		Intensive NDT		Regular NDT		Total	
	N	%	N	%	N	%	N	%	N	%
Gender										
Female	13	18	10	14	10	14	11	15	44	61
Male	6	8	7	10	8	11	7	10	28	39
CP distribution										
Quadriplegia	12	17	11	15	11	15	10	14	44	61
Hemiplegia	7	10	6	8	7	10	8	11	28	39
Years therapy before study										
>2	17	24	15	20	17	24	17	24	66	92
<2	2	3	2	3	1	1	1	1	6	8
Cognitive ability										
Below average	10	14	7	10	6	8	8	11	31	43
Average	9	13	10	14	12	16	10	14	41	57
Total sample	19	26	17	24	18	25	18	25	72	100

changes for 10 children measured on the QUEST and the Peabody Fine Motor Scale was 0.73.

Analysis

The General Linear Model regression programme (Statistical Analysis Systems 1979) was used for the main analysis. Changes in scores from baseline to six or nine months later were used as the dependent variable, and dummy variables were used as independent variables to define the contrasts of interest between intervention groups. The six-month analysis was designed to examine the immediate effects of the intervention(s), while the nine-month analysis was designed to examine the long-term effects. All groups received at least regular NDT, so the analysis of casting results examined the effect of casting in the presence of this. Additional covariates (age, hand function severity and treatment centre) which might confound the intervention effects were included in the model as further independent variables.

Intervention effects were assessed conditionally, after adjustment for covariates. Similarly, each intervention factor (NDT and cast) was evaluated after adjustment for the effect of the other; this was necessary because the numbers of children randomized to each study group were not all equal, so the two intervention effects could not be estimated completely

independently. The conditional tests used give conservative significance levels.

Results

Demographics and therapy consistency

Demographic information is summarized in Table II. 73 children completed the study, although one nine-month assessment was omitted because of consistently missed appointments. The four intervention groups were equivalent in age, hand-function severity, cerebral palsy distribution and maternal education.

Data from the parents' and therapists' log books were extracted by a trained occupational therapist. The goals set most frequently included weight-bearing, reaching and grasping, rotation, bilateral co-ordination and upper-extremity dissociation; these are very consistent with the practice of NDT. Information from parents' log books indicated that the casts were worn for an average of 3.05 (range 0.38 to 7.34) hours a day. 66 per cent of the parents completed all or some of the home programme more than 75 per cent of the time.

The average number of therapy attendances was almost three times higher for the intensive NDT groups, averaging 29 (once weekly), compared with 11 for the regular NDT groups. The potential number of attendances during the six-month period was 48, so a number of children did not attend twice weekly.

TABLE III
Six- and nine-month outcomes by treatment group

Treatment group	Baseline	6 months	9 months	Change (0-6)	Change (0-9)
<i>Peabody Fine Motor Scales: age equivalent in months (SD)</i>					
Intensive NDT plus cast	30.3 (13.2)	35.4 (13.9)	38.1 (12.3)	5.26	6.33
Intensive NDT	25.0 (17.5)	28.1 (18.4)	27.8 (18.8)	3.11	3.24
Regular NDT plus cast	30.6 (18.4)	33.7 (20.1)	32.8 (19.7)	3.05	2.44
Regular NDT	27.3 (20.3)	30.8 (21.3)	32.3 (21.8)	3.44	4.94
Contrasts: Intensive NDT vs. regular NDT			<i>F</i> 0.19 <i>p</i> (0-6) 0.66	<i>F</i> 0.24 <i>p</i> (0-9) 0.63	
Cast vs. no cast			0.49 0.49	0.03 0.87	
Intensive NDT plus cast vs. other groups			0.88 0.35	1.47 0.23	
<i>Quality of upper-extremity skills test: percentage score (SD)</i>					
Intensive NDT plus cast	61.9 (21.9)	66.8 (23.0)	69.2 (17.4)	4.89	4.10
Intensive NDT	47.1 (26.4)	47.9 (26.8)	47.2 (26.4)	0.80	1.55
Regular NDT plus cast	43.9 (25.7)	50.9 (25.7)	48.8 (26.8)	7.02	6.11
Regular NDT	45.8 (29.6)	47.2 (28.9)	47.3 (28.9)	1.34	1.47
Contrasts: Intensive NDT vs. regular NDT			<i>F</i> 0.30 <i>p</i> (0-6) 0.59	<i>F</i> 0.05 <i>p</i> (0-9) 0.82	
Cast vs. no cast			4.83 0.03	2.76 0.10	
Intensive NDT plus cast vs. other groups			0.42 0.52	0.41 0.52	

Hand function

Analysis of the results for hand function, measured with the Peabody scales, revealed no statistically significant or clinically important differences after six or nine months between intensive or regular NDT, nor between casting and no-casting groups (Table III). Since the pattern for the total raw score was the same as the age-equivalent change, the scores are reported as changes in age-equivalent months. The group receiving intensive NDT plus casting exceeded the results of the other three groups at both the six- and nine-month assessments. After six months the intensive NDT plus casting group changed by 5.3 months, compared with a mean of 3.2 months for the other three groups ($p=0.35$), while after nine months the intensive NDT plus casting group had changed by 6.3 months, compared with 3.5 months ($p=0.23$).

Quality of movement

Quality of movement, measured by the QUEST, was significantly higher after six

months for the groups using casts ($p=0.03$). This difference decreased between the six- and nine-month assessments ($p=0.10$). There were no statistically significant differences between those given intensive and regular NDT, nor between intensive NDT plus casting and the other three groups.

Range of motion

Range of wrist motion was analysed by examining the differences between the casted and uncasted arms of the children randomized to the casting groups. There was a statistically significant increase in wrist extension ($p=0.02$) for the casted arm compared with the uncasted arm.

Influence of other variables

To generate hypotheses for future research, multiple regression, using a backward elimination procedure, was used to evaluate the contribution of the intervention group and other important variables to the six- and nine-month Peabody and QUEST scores. Variables were selected based on a univariate

analysis of their relationship to the results. The following variables were not entered into either regression because of weak univariate relationships: maternal education level, family income, and therapist's ratings of a child's intelligence and parents' compliance.

For the Peabody results, parents' estimate of their understanding, comfort and compliance with the home programme ($p=0.02$) and the age of the child ($p=0.001$) contributed significantly to explaining the score changes. Children who were younger and whose parents estimated their own compliance as high had better outcomes. To ensure that randomization had been successful in equally distributing parents who complied with home programmes, intervention effects were also analysed after covariate adjustment for parent compliance ratings: the results did not change.

The following variables did not contribute as much to the regression equation: hand function severity ($p=0.35$), years therapy received previously ($p=0.95$), gender ($p=0.37$), attendances ($p=0.25$) and cerebral palsy distribution ($p=0.19$). For the QUEST results, the only variable which contributed significantly to the regression equation was intervention group ($p=0.04$).

Discussion

The results of this study indicate that casting, together with at least regular NDT, significantly improves quality of upper-extremity movement and wrist extension. The difference decreased slightly after the casts had been removed for three months, suggesting that the effects of casting decrease over time. This result supports the biomechanical reason for casting, that changes after casting occur because of the alteration in muscle length effected by the cast. Tardieu *et al.* (1982) and Watts *et al.* (1986) found a similar decrease in effect after the cast was removed. Our results support the need for long-term casting in order to maintain changes in quality of movement and range of motion. The addition of extra therapy for the casted group or intensive therapy alone did not improve quality of upper-extremity movement.

In this study there were no immediate

or long-term beneficial effects of intensive therapy or casting in improving hand function. The results suggest that intensive therapy and casting together improve hand function more than either intensive therapy alone or casting with regular therapy. During the six-month therapy period, the intensive NDT plus casting group changed at almost a normal developmental rate (5.3 months), compared with one-half that for the other groups (3.2 months). Between the six- and nine-month assessments, the intensive therapy plus casting group continued to improve slightly (an over-all change of 6.3 months), while the other three groups remained the same. A child may benefit from a short period of intensive therapy in combination with casting, in order to translate changes in quality of movement from casting into changes in hand function.

The results for the intensive therapy plus casting group are not conclusive, however. While the differences between groups—2.1 months initially and 2.8 months at nine-month assessment—are clinically important, they were not statistically significant. A reason for the lack of statistical significance was the decreased power to examine this interactive effect, compared with the power for tests of intervention main effects, owing to the low number of subjects (18) in the intensive therapy plus casting group. A *post hoc* power analysis revealed that the power for this sample size was 45 per cent. We are now doing further research to examine the effect of intensive NDT plus casting in children under four years of age.

The intensive NDT groups attended therapy once weekly on average, in comparison with the prescribed attendance of twice weekly. There was a large range of attendance rates in the intensive therapy groups, with some children attending only 20 times and others over 40 times. For the great majority of children, absences were scattered over the entire six-month period, for reasons equally distributed between child's illness, parents' inability to attend, and therapist's cancelling because of illness, continuing education or other duties. The pattern of attendances provides information about the practical

implementation of intensive therapy. It may be very difficult for parents to attend twice weekly when they have other young children, are employed or are busy with other activities. It is possible that the differences in outcomes between the intervention groups would have been larger if the attendance rate had been higher. However, it is important to note that the intensive therapy groups maintained a 3:1 ratio for attendance over the regular therapy groups.

The children in the study were graded before randomization on two variables: age and severity of hand function. Age was an important predictor variable, with children under four years performing better than those over four. Developmentally, these younger children are changing more quickly. An important question is whether there is a difference between intervention groups within this younger age-group. Although the small numbers can only be used hypothetically, the results of this study indicate that within the younger group, children who had intensive therapy plus casting changed more than the other groups.

Severity of hand function was not a significant covariate, but parent compliance was important as a predictor variable. Children whose parents felt comfortable with and were able to complete the home programme made more gains in hand function over the six-month intervention period, so it seems that parents were important in promoting their child's development and function. Knowledge of the demonstrated value of their participation could be very helpful to parents of disabled children, who often may feel that they cannot do much to help their child. In addition, active participation of parents is an integral part of NDT.

The results of this study indicate areas which require further exploration: the apparent combined effect of intensive NDT and casting in the younger group of children; and the factors related to change

after intervention, to determine whether age and parent compliance are the most important factors. The results indicate that casting combined with at least regular NDT improves the quality of upper-extremity movement and wrist extension. There is no evidence that additional NDT, without casting, improves the quality of upper-extremity movement or hand function. Other important mediating variables in this study were age and parent compliance. These results suggest that therapists should encourage parent compliance and recommend this kind of intervention when children are young.

Accepted for publication 20th November 1990.

Acknowledgements

The authors acknowledge the effort and support of the occupational therapists, children and parents at the following children's treatment centres: Children's Developmental Rehabilitation Program, Chedoke-McMaster Hospitals, Hamilton, Canada; Erinoak, Mississauga, Canada; The Rotary Centre, Kitchener and Cambridge, Canada; and Lansdowne Children's Centre, Brantford, Canada. They also appreciate the excellent study co-ordination in the centres by Susan Harvey, Susan McCaw, Nancy Pollock and Coleen Toal. This study was supported by a grant (01699) from the Ontario Ministry of Health, Ontario, Canada. Scotchcast casting material was provided by 3M of Canada. Mary Law holds a Career Scientist Award from the Ontario Ministry of Health. Stephen Walter holds a National Health Scientist Award from Health and Welfare Canada.

Authors' Appointments

*Mary Law, M.Sc., O.T.(C), School of Occupational Therapy and Physiotherapy and Department of Clinical Epidemiology and Biostatistics, McMaster University; Occupational Therapy Department, Chedoke-McMaster Hospitals.
David Cadman, M.Sc., M.D., F.R.C.P., Private Practice.
Peter Rosenbaum, M.D., F.R.C.P., Department of Clinical Epidemiology and Biostatistics and Department of Paediatrics, McMaster University.
Stephen Walter, Ph.D.;
Diane Russell, M.Sc.;
Department of Clinical Epidemiology and Biostatistics, McMaster University.
Carol DeMatteo, M.Sc., School of Occupational Therapy and Physiotherapy, McMaster University; Occupational Therapy Department, Chedoke-McMaster Hospitals.

*Correspondence to first author at Room 28, Building 74, Chedoke Campus, School of Occupational Therapy and Physiotherapy, Faculty of Health Sciences, McMaster University, 1200 Main Street West, Hamilton, Ontario, Canada L8N 3Z5.

SUMMARY

The purpose of this research was to study the effect of intensive neurodevelopmental therapy (NDT) and upper-extremity inhibitive casting, separately or in combination, on hand function, quality of upper-extremity movement and range of motion of 73 children with spastic cerebral palsy aged 18 months to eight years. There was no significant difference between intensive or regular therapy and casting or no casting for hand function, between intensive and regular NDT, or between intensive

NDT plus casting and the other groups for quality of movement and range of motion. Casting led to increased quality of movement and wrist extension after six months. Casting with NDT improved the quality of upper-extremity movement and range of motion. There appear to be no immediate benefits from intensive therapy alone.

RÉSUMÉ

Traitement neuro-développemental et plâtres inhibiteurs des extrémités supérieures chez l'enfant IMC
Le but de cette recherche était d'étudier les effets d'un traitement neurodéveloppemental intensif (NDT) et de plâtres inhibiteurs des extrémités supérieures, isolément ou en association, sur les fonctions de la main, la qualité du mouvement de l'extrémité supérieure et l'étendue des mouvements chez 73 enfants IMC âgés de 18 mois à huit ans. Il n'y eut pas de différence significative sur la fonction des main entre le traitement intensif ou habituel et l'existence ou non de plâtres, entre NDT intensif ou habituel et l'existence ou non de plâtres, entre NDT intensif et plâtres et les autres groupes pour la qualité et l'étendue du mouvement. Le plâtre permet une qualité accrue de mouvement et d'extension de poignet après six mois. Les plâtres avec NDT accroissent la qualité des mouvements des extrémités supérieures et l'étendu du mouvement. Il ne semble pas y avoir de bénéfices immédiats à partir du traitement intensif isolé.

ZUSAMMENFASSUNG

Entwicklungsneurologische Therapie und Gipsbehandlung der oberen Extremität bei Kindern mit Cerebralparese: Ergebnisse eines klinischen Versuchs
Das Ziel dieser Arbeit war es, den Einfluß einer intensiven entwicklungsneurologischen Therapie (NDT) und einer Gipsbehandlung der oberen Extremität, allein oder in Kombination, auf die Handfunktion, die Qualität der Bewegung im Bereich der oberen Extremität und den Beweglichkeitsgrad bei 73 Kindern mit spastischer Cerebralparese im Alter zwischen 18 Monaten und acht Jahren zu untersuchen. Für die Handfunktion fand sich kein signifikanter Unterschied zwischen intensiver oder regulärer Therapie, mit oder ohne Gipsbehandlung, und für die Bewegungsqualität und den Beweglichkeitsgrad fand sich zwischen intensiver und regulärer NDT oder zwischen intensiver NDT plus Gipsbehandlung und anderen Gruppen ebenfalls keiner. Die Gipsbehandlung führte nach sechs Monaten zu einer verbesserten Bewegungsqualität und Extension im Handgelenk. Gipsbehandlung mit NDT verbesserte die Bewegungsqualität der oberen Extremität und den Beweglichkeitsgrad. Mit der intensiven Therapie allein scheint man keine sofortigen Besserungen zu erzielen.

RESUMEN

Terapia neuroevolutiva y moldaje inhibitor de la extremidad superior en niños con parálisis cerebral. Resultados de un ensayo clínico
El propósito de este estudio fue el estudio del efecto de una terapia neuroevolutiva (TNE) y el moldaje inhibitor de la extremidad superior, por si solos o combinados, sobre la función de la mano, la cualidad del movimiento de la extremidad superior y la amplitud del movimiento, en 73 niños con parálisis cerebral espástica y la amplitud del movimiento, en 73 niños con parálisis cerebral espástica de edades desde 18 meses a ocho años. No había diferencia significativa entre una terapia intensiva o mediana y el moldeo o no de la función manual y entre una TNE intensiva y mediana, o entre una TNE intensiva con moldeo y los otros grupos, por lo que hace a la cualidad y amplitud de movimiento. El moldeo dio lugar a un aumento en la cualidad del movimiento y extensión de la muñeca pasados seis meses. El moldeo con TNE mejora la cualidad del movimiento de la extremidad superior y su amplitud de movimiento. No parece que se obtengan beneficios con sólo la terapia intensa.

References

- Bly, L. (1983) 'Neurodevelopmental therapy.' In Willard, H. S., Spackman, C. S. (Eds.) *Occupational Therapy, 6th Edn.* Philadelphia: Lippincott.
- Bobath, K. (1980) *A Neurophysiological Basis for the Treatment of Cerebral Palsy. Clinics in Developmental Medicine, No. 75.* London: S.I.M.P. with Heinemann Medical; Philadelphia: Lippincott.
- Canada: Department of National Health and Welfare and Canadian Association of Occupational Therapists (1983) *Guidelines for the Client-centred Practice of Occupational Therapy (H39-33/1983E).* Ottawa: Department of National Health and Welfare.
- Carlsen, P. N. (1975) 'Comparison of two occupational therapy approaches for treating the young cerebral-palsied child.' *American Journal of Occupational Therapy, 29*, 267-272.
- D'Avignon, M., Norén, L., Arman, T. (1981) 'Early physiotherapy ad modum Vojta or Bobath in infants with suspected neuromotor disturbance.' *Neuropediatrics, 12*, 232-241.
- Duncan, W. R., Mott, D. H. (1983) 'Foot reflexes and the use of the inhibitive cast.' *Foot and Ankle, 34*, 145-148.
- Eisenberg, M. G., Sutkin, L. C., Jansen, M. A. (1984) *Chronic Disability in Childhood.* New York: Springer.
- Folio, R., Fewell, R., DuBose, R. F. (1983) *Peabody Developmental Motor Scales.* Toronto: Teaching Resources Co.
- Gossman, M. R., Sahrman, S. A., Rose, S. J. (1982) 'Review of length-associated changes in muscle.' *Physical Therapy, 62*, 1799-1808.
- Hayes, N. K., Burns, Y. P. (1970) 'Discussion on the use of weight-bearing plasters in the reduction of hypertonicity.' *Australian Journal of Physiotherapy, 26*, 108-117.
- King, T. I. (1982) 'Plaster splinting as a means of reducing elbow flexor spasticity: a case study.'

- American Journal of Occupational Therapy*, 36, 671-673.
- Mills, V. (1984) 'Electromyographic results of inhibitory splinting.' *Physical Therapy*, 64, 190-193.
- Palmer, F. B., Shapiro, B. K., Wachtel, R. C., Allen, M. C., Hiller, J. E., Harryman, S. E., Mosher, B. S., Meinert, C. L., Capute, A. J. (1988) 'The effects of physical therapy on cerebral palsy: a controlled trial in infants with spastic diplegia.' *New England Journal of Medicine*, 318, 803-808.
- Scherzer, A. L., Mike, V., Olson, J. (1976) 'Physical therapy as a determinant of change in the cerebral palsied infant.' *Pediatrics*, 58, 47-51.
- Smith, L. H., Harris, S. R. (1985) 'Upper extremity inhibitive casting for a child with cerebral palsy.' *Physical and Occupational Therapy in Pediatrics*, 5, 71-79.
- Sommerfeld, D., Fraser, B. A., Hensinger, R. N., Beresford, C. U. (1981) 'Evaluation of physical therapy service for severely mentally impaired students with cerebral palsy.' *Physical Therapy*, 61, 338-344.
- Statistical Analysis Systems (1979) *SAS Users Guide*. High Point, NC: Statistical Analysis Systems.
- Sussman, M. D. (1983) 'Casting as an adjunct to neurodevelopmental therapy for cerebral palsy.' *Developmental Medicine and Child Neurology*, 25, 804-805.
- Cusick, B. (1979) 'Preliminary report: the role of short leg tone-reducing casts as an adjunct to physical therapy for patients with cerebral palsy.' *Johns Hopkins Medical Journal*, 145, 112-114.
- Tardieu, G., Tardieu, C., Colbeau-Justin, P., Lespargot, A. (1982) 'Muscle hypoextensibility in children with cerebral palsy. II: Therapeutic implications.' *Archives of Physical Medicine and Rehabilitation*, 63, 103-107.
- Watt, J., Sims, D., Harckham, F., Schmidt, L., McMillan, A., Hamilton, J. (1986) 'A prospective study of inhibitive casting as an adjunct to physiotherapy for cerebral-palsied children.' *Developmental Medicine and Child Neurology*, 28, 480-488.
- Winer, B. J. (1971) *Statistical Principles in Experimental Design*, 2nd Edn. Toronto: McGraw Hill.
- Wright, T., Nicholson, J. (1973) 'Physiotherapy for the spastic child: an evaluation.' *Developmental Medicine and Child Neurology*, 15, 146-163.