Developmental gains in early intervention based on conductive education by young children with motor disorders

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The purpose of the study was to evaluate the developmental gains of 26 young children with cerebral palsy and three children with other disorders attending early intervention based on the principles of conductive education (NZCE) or community-based (CB). Conductive education was implemented by parents supervised by a conductor an average of 7.4 hours per week. Developmental skills were objectively measured in functional contexts at home and school before the child entered the programme and after 12 months. Skill gains by children with spastic quadriplegia, cerebral palsy and severe developmental delay who were not able to sit independently ($n=6$) who participated in NZCE were significantly greater ($p<0.001$) than skill gains by children with similar disabilities who participated in CB ($n=6$). Children with quadriplegic cerebral palsy, severe developmental delay, epilepsy and sensory disabilities ($n=7$) also achieved significant gains in functional skills in NZCE ($p<0.005$). Conductive education may benefit young children with motor dysfunction as well as concomitant disorders and severe developmental delay. Gains were not related to intensity, age, or a product of maturation, but may be related to changed patterns of maternal–child interactions.

Ziel der Studie war die Bewertung der Lern- und Entwicklungsfortschritte von 26 jüngeren Kindern mit Zerebralparese und 3 Kindern mit anderen Erkrankungen, die basierend auf den Grundsätzen der Konduktiven Förderung in Neuseeland (NZCE=New Zealand Conductive Education) bzw. im Rahmen der ambulanten Versorgung (CB=community-based) eine Frühbehandlung undförderung erhielten. Die CE wurde von den betroffenen Eltern unter der Anleitung einer Konduktorin durchschnittlich 7,4 Stunden pro Woche durchgeführt. Die Lern- und Entwicklungsfortschritte der Kinder wurden vor ihrer Aufnahme in das Förderungsprogramm und 12 Monate danach anhand von funktionsrelevanten, objektiven Kriterien im häuslichen und schulischen Umfeld gemessen. Die Lern- und Entwicklungsfortschritte waren bei tetraplegischen Kindern mit spastischer Zerebralparese und schweren Entwicklungsstörungen, die nicht alleine sitzen konnten ($n=6$), nach Teilnahme an der NZCE signifikant besser ($p<0,001$) als bei Kindern mit ähnlichen Behinderungen, die im Rahmen der CB therapiert wurden ($n=6$). Auch wurden bei tetraplegischen Kindern mit Zerebralparese, schweren Entwicklungsstörungen, Epilepsie und sensorischen Defiziten ($n=7$) signifikante Verbesserungen der funktionellen Fähigkeiten ($p<0,005$) unter NZCE erzielt. Jüngere Kinder mit gestörter Motorik sowie Begleiterkrankungen und schweren Entwicklungsstörungen können von NZCE profitieren. Die erzielten Fortschritte korrelierten nicht mit der Intensität der Therapie, dem Alter oder der zerebralen Reifung, könnten aber durch Änderungen im Verhaltensmuster bei der Interaktion zwischen Mutter und Kind bedingt sein.

La finalidad del estudio era evaluar los avances en el desarrollo de 26 niños pequeños con parálisis cerebral y 3 niños con otros trastornos sometidos a una intervención precoz basada en los principios de la Educación Conductiva (ECNZ) o basada en la comunidad (BC). La EC fue aplicada por los padres supervisados por un monitor durante un promedio de 7,4 horas a la semana. Las capacidades de desarrollo se midieron objetivamente en contextos funcionales en el domicilio y el colegio antes de que el niño se incorporara al programa y después de 12 meses. Los progresos en las capacidades de los niños con parálisis cerebral tetrapléjica espástica y un grave retraso del desarrollo que no eran capaces de permanecer sentados sin ayuda ($n=6$) y que participaron en la ECNZ fueron significativamente mayores ($p<0,001$) que los progresos de los niños con discapacidades similares que participaron en la BC ($n=6$). Los niños con parálisis cerebral tetrapléjica, retraso grave del desarrollo, epilepsia y discapacidades sensitivas ($n=7$) lograron también unos progresos significativos en las capacidades funcionales en la ECNZ ($p<0,005$). La ECNZ puede beneficiar a los niños pequeños con disfunción motora, así como con trastornos concomitantes y retraso grave del desarrollo. Los progresos no estuvieron relacionados con la intensidad, la edad o un producto de la maduración, aunque pueden guardar relación con una modificación de las pautas de las interacciones entre la madre y el hijo.

L'étude avait pour but d'évaluer les gains sur le plan du développement chez 26 jeunes enfants infirmes moteurs cérébraux et trois enfants atteints d'autres troubles participant à des programmes d'intervention précoce en Nouvelle-Zélande, basés sur les principes de l'éducation conductive (NZCE), ou à des programmes en milieu communautaire (CB). La CE était mise en pratique par les parents encadrés par un Conducteur pendant 7,4 heures par semaine en moyenne. L'amélioration des aptitudes a été mesurée objectivement dans des contextes fonctionnels à domicile et à l'école avant l'entrée de l'enfant dans le programme et au bout de 12 mois. Les gains en aptitudes des enfants atteints de tétraplégie spastique liée à une infirmité motrice cérébrale avec retard grave du développement ne pouvant pas se tenir assis indépendamment ($n=6$), participant à un programme NZCE, étaient sensi-

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blement plus importants ($p<0,001$) que ceux des enfants avec des troubles similaires prenant part à un programme CB ($n=6$). Les enfants IMC tétraplégiques, avec un retard important du développement, de l'épilepsie ou des déficiences sensorielles ($n=7$) ont également réalisé des gains significatifs sur le plan de la capacité fonctionnelle avec NZCE ($p<0,005$). NZCE peut bénéficier aux jeunes enfants atteints de déficit moteur ainsi que de troubles concomitants et d'un retard important du développement. Les gains n'étaient pas liés à l'intensité du programme ou à l'âge, ni le fruit de la maturation des sujets, mais il est possible qu'ils soient liés à une modification de l'interaction mère-enfant. ***International Journal of Rehabilitation Research*** **27:17–25 © 2004 Lippincott Williams & Wilkins.**

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Introduction

Literature reviews have reported that physical therapy, neurodevelopmental therapy, and developmental skill instruction may have little impact on children with cerebral palsy (Parry, 1992; Graves, 1995; Palmer, 1997; Adams & Synder, 1998; Barry, 2001). There are very few early intervention programmes specifically designed for children with cerebral palsy (Miller, 1992; Mahoney *et al.*, 2001) and these are on average less effective than for children with other types of disabilities (Shonkoff & Hauser-Cram, 1987; Turnbull, 1993). It has been hypothesized that the pervasive nature of cerebral palsy, the frequency of concomitant disabilities in vision, hearing, developmental delay and seizure disorders, difficulties in early diagnosis, the range of affected movements, variability in severity and types and its relatively low incidence may contribute to the complexity of designing effective early intervention (Graves, 1995; Harris, 1997).

Conductive education (CE) is designed specifically for children with motor disorders and should begin at a young age. Conductive education involves individual programmes designed and implemented by specially trained conductors (Kozma, 1995). Some CE studies have shown some improvements (e.g., Cottam *et al.*, 1985; Sigafoos *et al.*, 1993). Other studies have shown little or no improvement as compared with children attending other programmes (e.g., Heal, 1972; Hur & Cochrane, 1995; Hur, 1997; Bochner *et al.*, 1999).

The goal of CE is to improve the child's overall functioning (Kozma & Balough, 1995); however, studies have typically evaluated skills only in a single context, and not all skills have been related to functioning in natural contexts, although children with cerebral palsy may function better in natural contexts rather than in standard testing situations (Palmer, 1997). A comprehensive review by Darrah *et al.* (2003) concludes: 'In summary, the present literature base does not provide conclusive evidence either in support of or against CE as an intervention strategy' (p. 27).

It was the primary purpose of this study to investigate an early intervention programme in New Zealand based on the principles of CE (NZCE) by measuring the functional skills of young children with cerebral palsy in natural contexts over a 12-month period. Children with motor dysfunction concomitant with developmental delay, sensory deficits, and seizure disorders may not be suitable for CE (Bairstow *et al.*, 1991; Kozma & Balogh, 1995). Since such deficits often occur concomitantly with cerebral palsy (Miller, 1992), it was the second objective to investigate the impact of NZCE with children with such disabilities.

Method

Setting

Two of the nine NZCE programmes were involved: one was located in a public school in one city and the other was located in a purpose-adapted building in a second city.

Participants

All parents and children younger than the compulsory school-age (72 months) accepted into NZCE were invited to participate, following informed consent procedures approved by the University of Canterbury and the Health Board Ethics Committee. In city 1, there were no other programmes available, and all children with severe motor disorders who applied were accepted. In city 2, there were alternatives. Acceptance into the programme in the second city was determined independently by the conductor.

No children or families that were accepted into NZCE were excluded. Two children older than 72 months were accepted and offered the opportunity to participate even though they were school age. Twenty-nine children, 10 girls and 19 boys, aged 16 to 95 months, with motor disorders and their families participated. Twenty-three attended the NZCE and six did not: of these, three moved to cities where there was no NZCE; two lived too distant to commute and one did not have a family member who could work with the child on the basis

required. Six participated in community-based programmes (CB).

Motor disorders

Twenty-six of the 29 children had cerebral palsy: 17 (58.6%) children had spastic quadriplegia, four had other types of quadriplegia, three had hemiplegia, one had diplegia, one had an unspecified form of cerebral palsy, and three had other motor disorders (Table 1).

Concomitant disorders

Five children had epilepsy and were on medication for it, although parents reported that the children still had seizures. Six had vision problems and one child was considered to be deaf-blind.

Ambulatory status

Darrah *et al.* (2003) recommended that ambulatory status be described to improve studies of CE. In the present study, none of the participants was ambulatory. Participants were assessed during the pre-test on independent sitting to indicate motor status. Children who were able to sit independently for 15 seconds without support and without losing their balance are identified in Table 1. Ten of the 29 children were able to sit.

Treatment

NZCE

The programme comprised systematic task routines implemented each session, incorporating functional skill training: (a) coming into the centre routine, including potty training; (b) 'good morning/afternoon' routine involving social and communicative interactions; (c) plinth routine involving gross motor movement, object use, singing, and receptive and expressive communication activities, including social interaction; (d) snack/lunch and play routines involving eating and social interaction and potty training, and (e) 'saying goodbye and leaving' routines (see Farkas *et al.* 1993; Kozma, 1995).

Parents (occasionally relatives or volunteers) individually guided their child through each routine each session under the supervision of one Peto-trained conductor at each centre. Sessions averaged three hours duration and 5–10 children participated in each session. Children attended NZCE from one to five sessions per week (Table 1), with a mean of 2.47 sessions (7.4 hours) per week. Families received information about their child's disability, support from other parents, and guidelines for carrying out similar routines in their home.

Plinths, ladder-back chairs, and other CE type equipment were constructed locally. Instructional materials—toys, books, and etc.—were purchased locally and were those used in early childhood education programmes.

CB

For four families, CB consisted of weekly centre-based individual family support in a three-hour session, including speech-language therapists, physiotherapists, developmental therapists, occupational therapists, and social workers. Families were provided information, support,

Table 1 Characteristics and raw scores of participating children

Child	Sex	C.A. (mo.)	Programme	Sessions	Diagnoses	Sit ?	Pre-test	Post-Test	Gain
1-1	F	18	CB	NA	Spastic quadriplegia cerebral palsy	No	29	37	+8
1-2	M	26	CB	NA	Spastic quadriplegia cerebral palsy	No	40	51	+11
1-3	M	39	CB	3	Spastic quadriplegia cerebral palsy	No	25	26	+1
1-4	M	60	CB	5	Spastic quadriplegia cerebral palsy	No	48	54	+6
1-5	M	68	CB	4	Spastic quadriplegia cerebral palsy	No	30	27	−3
1-6	F	71	CB	5	Spastic quadriplegia cerebral palsy	No	42	33	−9
2-1	F	22	NZCE	3	Spastic quadriplegia cerebral palsy	No	27	37	+10
2-2	M	46	NZCE	2	Spastic quadriplegia cerebral palsy	No	20	44	+24
2-3	M	47	NZCE	2	Spastic quadriplegia cerebral palsy	No	35	59	+24
2-4	M	48	NZCE	3	Spastic quadriplegia cerebral palsy	No	21	48	+27
2-5	F	62	NZCE	5	Spastic quadriplegia cerebral palsy	No	22	42	+20
2-6	M	74	NZCE	5	Spastic quadriplegia cerebral palsy	No	75	92	+17
3-1	F	12	NZCE	1	Athetoid quadriplegia, epilepsy	No	19	47	+28
3-2	F	18	NZCE	2	Ataxic quadriplegia, epilepsy	No	33	48	+15
3-3	M	23	NZCE	2	Spastic quadriplegia cerebral palsy, impaired vision, epilepsy	No	43	91	+48
3-4	M	30	NZCE	2	Mixed type quadriplegia, epilepsy	No	30	59	+29
3-5	F	32	NZCE	2	Mixed type quadriplegia, epilepsy, blind, deaf	No	25	44	+19
3-6	M	35	NZCE	4	Spastic quadriplegia cerebral palsy, blind, epilepsy	No	7	22	+15
3-7	F	38	NZCE	4	Spastic quadriplegia, epilepsy, cortical blindness	No	20	31	+11
4-1	M	16	NZCE	1	Spastic hemiplegia	Yes	58	89	+31
4-2	F	20	NZCE	1	Spastic hemiplegia	Yes	57	90	+33
4-3	M	20	NZCE	2	Spastic hemiplegia	Yes	65	149	+84
4-4	F	23	NZCE	2	Hypotonia, impaired vision	Yes	41	57	+16
4-5	M	32	NZCE	2	Angelman syndrome	Yes	44	53	+9
4-6	M	40	NZCE	2	Spastic quadriplegia	Yes	97	125	+28
4-7	M	48	NZCE	3	Spastic hemiplegia	Yes	160	210	+50
4-8	M	63	NZCE	2	Cerebral palsy, vision impaired	Yes	64	73	+9
4-9	M	65	NZCE	3	Spastic quadriplegia	Yes	67	91	+24
4-10	M	95	NZCE	2	Sotos syndrome	Yes	131	157	+26

and guidelines for home programmes. Study children also attended sessions (three hours each) at local early childhood education programmes with a parent, aide, or volunteer (one-to-one). The session total for children in CB includes the centre-based programme and the early childhood centre sessions (Table 1).

Two families received support and guidelines for home-programmes from visiting district nurses and other specialists on a less frequent basis and these two children did not attend an early childhood centre.

Measurement

The Uniform Performance Assessment System [UPAS] (Haring *et al.*, 1981) was selected by parents and the researcher to objectively measure children's skills in functional contexts. The UPAS provides an objective standardised measure of development across a broad range of skills, with established reliability and validity and is designed to measure progress, unlike some other instruments (Vance *et al.*, 1999). Increased numbers of items per year increases sensitivity of measurement [*c.f.*, 46 items per developmental year, as compared with 31 in the *Developmental Profile II*] (Alpern *et al.*, 1986). The UPAS is designed to measure children's progress up to age six. The children in the present study were too old to use the Bayley scales of Infant and Toddler Development. The UPAS has been used in early intervention studies of children with cerebral palsy (e.g., Bricker & Sheehan, 1981; Strain & Odom, 1986). The Appendix shows the first 100 items, up to a developmental age of about 24 months. Criteria for passing items are functional outcomes of movement, not physiological properties of movement, as recommended for children with cerebral palsy by Harris (1993) and Bailey *et al.* (1999). Each item passed independently without physical prompts or assistance is equivalent to one point and the raw score is the sum.

The UPAS was administered at the beginning of the study (pre-test) and after 12 months (post-test). The UPAS items were administered in two settings at both assessments: the child's home and NZCE or Early Childhood Centre. An item was scored as 'passed' if the criteria were met in *both* settings. The UPAS was administered by trained assessors, and at the post-test, they were blind to pre-test assessments.

Reliability

Second assessors independently observed 25% of items on each assessment of each child. Median inter-assessor reliability per item was 90% (range 80–100%) on the pre-tests and 90.3% (range 70–100%) on the post-tests. Parents were present at the home assessments, and most parents were present during the school assessment. At the end of the study, parents received a letter explaining the scores, and describing the changes in skills. Parents were able to query and discuss any result.

Data analysis

Darrah *et al.* (2003) identified difficulties in published CE studies, including the lack of random assignment and control groups, small group size, and heterogeneity and under-reporting of the disabilities of study children. In this study, random assignment to treatment types was not considered an ethical process, as family considerations and choice of a particular programme must be honoured in light of the code of ethics for service provision in New Zealand. A control group was not possible, as all potential children were identified and none could be refused service or placed on a 'waiting list' or other tactic to establish a control group. The small numbers of subjects in the present study is a function of population density (less than 400,000 in the two cities combined). In acknowledgement of these issues, all raw data for each subject is given for transparency of analysis and interpretation, and children's characteristics were used to group scores for analysis. The groups were a construct for analysis only, and grouping did not affect the treatment procedures.

Group 1 (n 6) consisted of children accepted to NZCE who did not participate in NZCE aged from 18–71 months with spastic quadriplegia ('Spastic Quadriplegia CB'). None of the children could sit (Table 1). The mean developmental age was 7.33 months (range 5–10).

Six children for Group 2 were selected from children attending NZCE to match the age and disability status of children in Group 1 ('Spastic Quadriplegia NZCE'). They ranged in chronological age from 22–74 months and 4–20 months in developmental age (mean 7.59 months).

Group 3 (n 7) children all had quadriplegia and epilepsy ('Quadriplegia + Epilepsy NZCE), three also had a sensory impairment and one child had dual sensory impairment. They were not able to sit independently. They ranged in chronological age from 12–38 months (mean, 26.85 months) and developmental age from 2–9 months (mean 5.05 months).

Group 4 (n 10) comprised children aged 16–95 months with a range of motor disorders ('Mixed Disorders NZCE') who could sit independently (mean developmental age, 19.84 months, range 9–42).

Results

Pre-test scores varied and ending scores reflect the same variability (Table 1). Gain scores, which take into account the entering level, provide a more equable comparison of effects and were determined by subtracting the raw score at the first assessment from the raw score at the second

assessment (Table 1). A negative gain indicated that the child passed fewer items at the post-test, and a positive gain indicated that the child passed more items at the post-test.

Although groups were not randomly selected or assigned to treatment, and group sizes were quite small, inferential statistics may be useful in describing differences, as all of the raw data on which they are based have been presented. Means and standard deviations are shown in Table 2 and paired sample *t*-tests ($p > 0.01$ set) were calculated to provide additional information.

In the 'Spastic Quadriplegia CB' group, four of six children gained skills, while raw scores for two were lower. Score gains ranged from –9 to + 11 (Table 1). The effect of CB was evaluated by comparing pre-test and post-test means and these were not significantly different (*df* 5, *t* –0.795).

In the 'Spastic Quadriplegia NZCE' group, all children made gains (range + 10 to + 24). Only one child in this group gained less than the highest gaining child in the 'Natural Contrast' Group. The effect of NZCE is indicated by a significant difference between pre-post test means (*df* 5, *t* –8.09, $p > 0.001$).

In the 'Quadriplegia + Epilepsy NZCE' group, all children made gains (range + 11 to + 48). The effect of NZCE is indicated by a significant difference between pre-post test means (*df* 6, *t* –4.901, $p > 0.003$).

In the 'Mixed Disorders NZCE' group, all children made gains (range + 9 to + 84). The effect of NZCE is indicated by a significant difference between pre-post test means (*df* 6, *t* –4.409, $p > 0.002$).

Overall, all 23 children attending NZCE gained skills. Nineteen increased their score by more than the 11 points of the maximum gain in the 'Natural Contrast' group. A pre- post-test effect size of + 0.686 was calculated to ascertain the overall impact of NZCE for Groups 2, 3 and 4 (*n* 23) using the mean on the pre-test (50.75, SD 37.4) and the post-test (76.43, SD 46.15).

The relationship between gains and intensity of treatment was evaluated with a Pearson product moment correlation 0.115 (NS). The relationship between gains and chronological age produced a correlation of –0.208 (NS).

To determine if the rate of development was affected by NZCE, Proportional Change Indices, PCI, (Rosenberg *et al.*, 1987) were calculated (Table 2). All NZCE groups showed a PCI above 1.00, indicating a gain in developmental rate during the NZCE treatment, while the 'CB' group PCI was below 1.00, indicating a decline in developmental rate over the 12-month study.

The protocol by Bairstow *et al.* (1991) was used to calculate an 'age differential' by subtracting the pre-test chronological age from the developmental age (Table 2) to informally indicate severity of developmental delay. The differential for Groups 1, 2 and 3 may be characterised as indicating a level of severe developmental delay, and for Group 4 as falling within a moderate-to-mild level.

At the start of the study, there were no statistically significant differences in chronological age (*t* –0.243, NS), pre-test raw scores (*t* 0.249, NS) or developmental age scores (*t* –0.096, NS) between 'Spastic Quadriplegia CB' and 'Spastic Quadriplegia NZCE'. Average level of severity of disability did not differ. Thus, Groups 1 and 2 may be considered to be equivalent at the start of the study. However, the effect of NZCE is indicated by the significant differences in gains using an independent samples *t*-test (*t* –4.554, $p < 0.001$). An effect size calculation for NZCE was + 2.41.

Discussion

The results support the effectiveness of NZCE in facilitating the acquisition of skills measured in home

Table 2 Means (standard deviations) of pre-test to post-test (12 months) raw scores, developmental age, and change index by group.

Variable	Treatment			
	CB	NZCE		
	Group 1 (*n* 6) 'Spastic Quadriplegia'	Group 2 (*n* 6) 'Spastic Quadriplegia'	Group 3 (*n* 7) 'Quadriplegia + Epilepsy'	Group 4 (*n* 10) 'Mixed Disorders'
Chronological age	47.0 (22.5)	49.83 (17.5)	26.85 (9.49	42.2 (25.65)
Pre-test (raw score)	35.67 (8.95	33.33 (21.15)	25.28 (11.52)	78.4 (39.07)
Post-test (raw score)	38.0 (11.96)	53.67 (20.18)	48.85 (8.38)	109.4 (50.08)
Gain in raw score	2.33 (7.47)	20.33 (6.15)	23.57 (12.72)	31.0 (22.23)
Developmental age (pre-test)	7.33 (1.97)	7.59 (6.25)	5.05 (6.25)	19.84 (11.35)
Developmental age (post-test)	8.25 (2.79)	12.48 (6.57)	11.25 (6.69)	28.68 (13.29)
Age differential (pre-test)	(– 39.7)	(– 41.2)	(– 21.8)	(– 22.36)
Development rate* (pre-test)	0.16	0.15	0.19	0.47
Development rate* (post-test)	0.14	0.21	0.29	0.53
Development gain (PCI)+	0.88	1.40	1.53	1.13

*Development rate, developmental age/chronological age.+ PCI, Proportional Change Index (rate of development during intervention/rate of development before intervention).

and programme contexts by children with spastic quadriplegia and concomitant disorders. The individual results indicate every child gained skills during NZCE, and means and effect sizes support this interpretation.

It has been suggested that programme intensity may affect impact (Darrah *et al.*, 2003). However, in the present study, the number of sessions attended did not appear to have a significant impact on gains.

It has been suggested that the younger the age at which intervention is begun, the greater its impact (Kozma & Balough, 1995). However, in this study, there did not seem to be a relationship between age and NZCE gains. Bochner *et al.* (1999) concluded informally that children in the CE programmes in Australia gained skills at the same rate as could be expected in developmental progression. In the present study, PCI indicate that NZCE did have a positive impact on developmental rate. However, the developmental rate of children in the 'Spastic Quadriplegia NZCE' group did decline; a pattern which may be associated with typical patterns of development in children with cerebral palsy not receiving an appropriate intervention (Cogher *et al.*, 1992).

Children in the 'Quadriplegia + Epilepsy NZCE' group had impairments that may be grounds for exclusion from CE (*c.f.*, severe developmental delay, uncontrolled epilepsy, and visual deficits) (Bairstow *et al.*, 1991). Despite this, they gained a mean of 23.57 skills and showed positive changes in developmental rate. Each child also gained more than the children of Group 1. These results indicate that NZCE may be effective in facilitating skill acquisition for children with spastic quadriplegia and epilepsy who are not able to sit and thus, that NZCE may be effective for children who might not typically be considered for CE.

This study has several limitations typical of field-based studies in low population areas: it has no control group, random assignment was not used, and group sizes are small. These limitations have been addressed by the use of a natural field-based contrast group and by analysis appropriate to small *n* studies. However, these limitations indicate that no conclusive findings can result from this study.

The results of this study show generally more positive results for CE than do other studies. It is difficult to compare results with other studies because the length of time involved (12 months) is longer than most other studies (*c.f.*, Catanese *et al.*, 1995; Coleman *et al.*, 1995; Reddihough, 1998), children in the present study are younger and seemingly more disabled than children in the 12 month Birmingham study, (Hur, 1997; Hur & Cochrane, 1995). In addition, the characteristics of NZCE differ from the characteristics of the other CE programmes studied. It may be that the gains result from the specific characteristics of the children involved in conjunction with the special characteristics of NZCE. The NZCE incorporates features of effective early intervention services identified by Carta *et al.* (1991) and Horn (1997), including: (a) providing individualised teaching plans; (b) teaching practical skills required for future school and non-school environments; (c) prompting high levels of active engagement; (d) incorporating opportunities for repetitive use of skills in a functional context including social interaction and (e) parent administration of programmes.

However, there is an additional component that may have resulted in the gains. Studies have shown that parent training can improve parent–child interaction and relationships, and it is particularly changes in relationships that can affect child development (Mahoney *et al.*, 1998). In NZCE, parents learned new ways of interacting with their children as they worked with their children under the supervision of the conductor, and these are very likely to have transferred to the home setting. Parents have not worked as extensively with their children with similar levels of disability in other studies of CE, and, therefore, it is hypothesized that changed parent–child relationships affected the gains reported in this study. Changes in the parent–child relationship may have interacted with other variables, such as intensity, age, and severity of disability.

Further research should seek to identify characteristics of effective early intervention programmes for children with cerebral palsy, and to study the role of parent–child relationships in developmental gains in early intervention.

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Appendix

Uniform performance assessment system: description of first 100 items

Fine motor items (independent motor responses required to pass item)

1. Focuses eyes and concentrates on object.
2. Looks directly at face when being spoken to.
3. Eyes and head follow bright object back and forth in 90° arc.
4. Eyes and head follow bright object back and forth in 180° arc.
5. Reaches for object held 15 cm away.
6. Grasps object and holds it for three seconds.
7. Picks up object using a raking motion.
8. Picks up and hold an object in both hands simultaneously.
9. Picks up object using finger-thumb.
10. Passes object from one hand to the other.
11. Drops object into container with wrist supported on container.
12. Drops object into container without wrist supported.
13. Picks up tiny object using a pincer grasp.
14. Stacks blocks in three-block tower.
15. Picks up a ring and puts it on a cylindrical stick, three of five rings.
16. Picks up small wooden sticks and puts them in holes in a form board.
17. Scribbles with pen/pencil on paper, twice reversing direction.
18. Turns three pages of a book, one page at a time.

Cognitive items (independently performed, alternative responses permitted to pass items)

19. Imitates or discriminates two different actions.
20. Matches a block bridge to the model from a choice of three constructions.

21. Understands that three forms (circle, square, triangle) go into a form-board with matching cut-outs.
22. Imitates or matches continuous looping pencil stroke.
23. Matches five dissimilar objects to their identical pair.
24. Matches pictures of objects (three of six).
25. Matches coloured squares (three of six).

Receptive communication (independently performed, alternative response forms may be used)

26. Discriminates the words *doll* and *ball*.
27. Discriminates non-speech sounds.
28. Recognises communicative act.
29. Recognises own name.
30. Responds to word/gesture.
31. Responds to 'come here' by leaning toward, crawling, etc., or else responds in a way that indicates not wanting to go to the initiator.
32. Responds to direction to attend to object away from initiator.
33. Indicates two of five articles of clothing and two of five toys when label is communicated.
34. Responds to three different single action directions (must be able to physically do actions).

Speech production (independently performed, vocal/motor responses are required)

35. Indicates awareness of sound.
36. Turns to sound.
37. Spontaneously says vowel sounds.
38. Makes differential pleasurable and non pleasurable vocalisations.
39. Spontaneously says consonant sound.
40. Spontaneously says at least one repetitive consonant–vowel sound (ba ba, ma ma, ga ga).
41. Babbles with intonation and pauses of sentences.
42. Imitates non-speech sound (cough, click, car sound).

Expressive communication (independently performed, alternative responses are acceptable)

43. Imitates talk.
44. Communicates 'no'.
45. Imitates or discriminates two of four sounds (eye, ee, my, be).
46. Imitates or discriminates four of four sounds (eye, ee, my, be).
47. Responds 'bye-bye' to assessor.
48. Requests word/name/sign for objects.
49. Requests three different objects by name.

Self-help skills (independent motor action required)

50. Sucks liquid from a bottle.
51. Feeds self using fingers, hands.
52. Drinks from cup with good lip closure and little leakage, cup held by adult.
53. Drinks from cup with good lip closure, cup held by child.
54. Brings spoon with food on it to mouth.
55. Eats solid food with spoon.
56. Turns tap on and off.
57. Co-operates during dressing (e.g., holds still, extends arm, etc.).
58. Removes sock.
59. Removes arm from sleeve of cost.
60. Sits on toilet without resistance.

Social/group skills (independent, alternative motor action accepted)

61. Interacts appropriately with materials during group activities.
62. Interacts appropriately with materials during activities with an adult.
63. Interacts appropriately with materials when playing alone.
64. Spends time within three metres of another child or uses the same materials as another child, but spends less than 25% of time (in setting with other children present) engaged in co-operative play, contact, or communication with other child(ren).
65. Spends more than 25% of time engaged in co-operative play, contact, or communication with other child(ren).
66. Claims and defends a possession.

Gross motor (independent motor action is required)

67. Arms and legs move smoothly and with a wide-range of motions.
68. Lifts head 90° (centred, not turned or tilted) in midline for five seconds while on stomach.
69. Brings both hands together in midline while lying on back.
70. Centres head while lying on back.
71. Props self on elbows, forearms, hands, while on stomach so head and chest are up.
72. Rolls from back to stomach.
73. Controls head (no head lag) when pulled gently by wrists to sitting position.
74. Lifts head 7 cm from surface without tilting or turning while lying on back.
75. Reaches with right hand while propped prone on forearm, elbow.
76. Reaches with left hand while propped prone on forearm, elbow.
77. Sits for 15 seconds on table/floor, may support self with hands on own legs or table/floor.
78. Pivots on stomach (to reach an object).
79. Crawls for approximately four metres.
80. Moves from a prone position to a sitting position.
81. Briefly bears weight on legs with little support (assessor may hold hands or help balance).

82. Creeps with reciprocal movement for approximately four metres.
83. Stands for at least 30 seconds while holding onto a piece of furniture.
84. Pulls self from sitting or crawling position to a standing position, using a piece of furniture or an object (not a person) for support.
85. Lowers self from standing to sitting, holding on, without falling.
86. Takes three steps in each direction while holding on to a piece of furniture (cruises).
87. Walks at least six consecutive steps while two hands are held.
88. Walks at least six consecutive steps while one hand is held.
89. Stands without support for 30 seconds.
90. Walks at least six consecutive steps without support and without falling.
91. Walks at least 15 meters independently, starting and stopping easily, without falling.
92. Walks carrying object in arms for three metres without falling or dropping object.
93. Pushes a small chair to a directed position about three meters away.
94. Pivots 180° while standing, keeping one foot almost in place.
95. Squats without support.
96. Stoops to pick up object on the floor, without support.
97. Walks up a 30° incline without falling, no support.
98. Walks down a 30° incline without falling, no support.
99. Rolls a ball using both hands.
100. Walks up five steps with one foot leading, may hold on to a railing.