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Effects of Vestibular Stimulation on Motor Development of Cerebral-palsied Children

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Introduction

Despite the dominant rôle that physical therapy has come to assume in rehabilitation programs designed for the cerebral-palsied child, surprisingly few studies have evaluated its effectiveness. In his presidential address to the American Academy for Cerebral Palsy, Mead (1968) commented on '. . the palpable lack of any adequate or competent research into the treatment of cerebral palsy'. In support of this claim, Wright and Nicholson (1973) surveyed the literature between 1940 and 1971 and found that, of 33 papers on the subject, eight merely stated the need for research into the effectiveness of physical therapy, in nine others physical therapy was confounded with other treatment programs, a further eight employed inadequate sample sizes, and in the remaining eight studies the effects of therapy were not evaluated relative to a control group.

Several methodological requirements need to be met within a research program designed to evaluate behavioral gains consequent upon physical therapy, or indeed any other mode of treatment. These requirements are basic; without them the results of the research are likely to be ambiguous. For therapy to be considered effective, it must produce gains in target measures which can be attributed to the specific intervention rather than to other causes. In evaluating therapy, it is necessary to ensure that (1) subjects who received treatment (experimental group) are compared with others not exposed to the therapy (controls); (2) the group samples are large enough to demonstrate statistically that gains attributed to therapy are not simply chance effects; (3) the population under investigation is clearly defined in order to identify whether effects attributable to treatment are specific to variables such as diagnostic category, age, the severity of the pre-existing condition, and history of prior treatment; (4) objective assessment techniques with known reliability are used to measure performance; (5) performance is assessed before as well as during therapy, and follow-up data are obtained to determine whether there is persistence in therapeutic gain; (6) evaluation is undertaken relative to a multiple baseline to establish whether therapy has specific or general consequences; and (7) blind methodology is employed, the person assessing pre- and post-treatment capabilities being unaware of the assignment of individuals to the experimental or

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control groups.

We have been able to locate in the literature only six studies that have compared the treatment group with a control group in assessing whether physical therapy administered to cerebral-palsied children produces gains in motor performance. In one such study, Paine (1962) followed up 177 patients from a population known to a hospital over the period from 1930 to 1950. He compared 103 patients who had received treatment with the other 74 who had not but the two groups were not matched initially and they probably differed in many respects other than treatment. Paine cast doubt on the universal effectiveness of physical therapy for the cerebral palsied, since many of those who had had no treatment attained the same level of motor competence as those given treatment. Wright and Nicholson (1973) similarly questioned whether gains result from physical therapy. They allocated 47 children at random to treatment and control groups, and reported that gains in function occurring over one year were simply those that would be expected on a maturational basis.

Carlsen (1975) compared the effects of facilitation and functional therapies, but the results are difficult to interpret since only 12 children were tested and blind methodology was not employed. The results reported by Ayres (1977) have limited generality because of the children studied, the training and the task she employed. Learning-disabled children who demonstrated involuntary motion of a choreoathetoid quality in the fingers during arm extension were given sensory integrative therapy. Although they showed greater improvement in eye-hand co-ordination than control children, the difference was not statistically significant.

Two studies have reported performance gains attributable to physical therapy. Scherzer *et al.* (1976) divided 22 infants aged under 18 months into an experimental group receiving active movement and positioning therapy and a control group given passive motion exercises confined to the major joint areas. More infants in the experimental group were reported as showing 'definite improvement' in motor and social development, but the gross level at which measures were analysed limits the comparison that can be made.

Some forms of physical therapy involve spinning the cerebral-palsied child. Clark *et al.* (1977) demonstrated that the motor competence of developmentally normal infants can be improved by controlled vestibular stimulation. In examining the therapeutic consequences of this technique, Chee *et al.* (1978) compared behavioral measures between 12 cerebral-palsied children exposed to 16 sessions of horizontal and vertical stimulation of the semicircular canal over a four-week period, and 11 cerebral-palsied children in two control groups. Blind methodology was used to assess performance. The children receiving vestibular stimulation exhibited greater improvement in reflexes and gross motor skills than the control children, but the study did not consider whether these gains persisted after therapy had ceased.

The present research was undertaken following the report by Clark *et al.* (1977) that motor development of the normal infant can be enhanced by vestibular stimulation. As in the study by Chee *et al.* (1978), cerebral-palsied children were allocated either to a group given systematic vestibular stimulation or to a control group not given vestibular stimulation. Blind methodology was used to measure the motor competence of the children before and immediately after the period of therapy, and again three months later. Since the present research was undertaken before publication of the study by Chee *et al.* (1978), the two studies differ in procedural aspects. However, the concern in both cases was to establish whether vestibular stimulation improves the motor behavior of cerebral-palsied children. The present study, like that undertaken by Chee *et al.* (1978), meets many of the design criteria outlined earlier. Whereas Chee and colleagues found that vestibular stimulation enhanced the motor skills of cerebral-palsied children, the present study did not.

Method

Children

Twenty cerebral-palsied children covering most diagnostic categories and ranging in age from eight months to 56 months were recruited through the Spastic Society of Victoria. Parents gave written consent for the participation of children in the study. All children were in good physical health and without a history of recurrent seizures.

Procedure

Each child was initially assessed on the Bayley Infant Development Scales (Bayley 1969). Two psychologists, two physiotherapists and an occupational therapist classified the items in the scales to form three groupings: gross motor, fine motor and eye-hand co-ordination. These indices were used in addition to the conventional mental and psychomotor development scores. The 20 children were then matched into pairs on the basis of chronological age, psychomotor development score, mental development score, and diagnostic category as established from medical files. Two blind children formed one pair, and two other pairs were matched on the basis of diagnostic category. Other pairings that could have been made using this criterion would have matched children who were markedly different in terms of their behavioral capabilities, but since the interest was in behavioral gains attributable to therapy, greater emphasis was given to psychomotor development scores and mental development scores in assigning these children to pairs. Within each pair, random selection was used to determine which child would receive vestibular stimulation. Characteristics of the matched pairs are presented in Table 1.

The children given therapy received 16 sessions of vestibular stimulation over four weeks; two sessions separated by 30 minutes were given on each of two days during each week. A session comprised 10 spins in a hand-operated rotating chair, fitted with a velocity indicator and located in a darkened room. Each spin involved a rapid one- to three-second angular acceleration, a one-minute period of rotation at 100°/sec (16·7rpm), and an impulsive stop in less than one second. For two spins (one clockwise, one counter-clockwise), the child was seated upright with the head tilted forward by 30°. The child was then placed in a right-side lying position for four spins (two clockwise, two counter-clockwise), with the side-lying position reversed for alternate spins. This procedure was then repeated with the child in a left side-lying position. The positioning of the child during rotation was controlled by either seating the child on an adult's lap or placing the child in a carry basket with pillow support. The children in the control group were handled in the treatment room for the same length of time as the treatment sessions lasted, but they did not receive vestibular stimulation. Over the period of the program all the children continued with normal management, except that vestibular stimulation was *not deliberately provided outside* treatment sessions.

The experimental and control children were retested on the Bayley Infant Development Scales in the week following

TABLE I
Characteristics of matched treatment (T) and control (C) children

Group	*No.*	*Sex*	*Chron. age (mths)*	*Pre-test scores PD†*	*MD*	*Diagnosis*
T	1	M	58	48	146	Ataxia
C	2	M	51	49	154	Diplegia
T	3	F	50	47	159	Hemiplegia
C	4	F	42	44	154	Quadraplegia
T	5	M	34	43	107	Ataxia
C	6	M	25	58	124	Diplegia
T	7	F	32	62	140	Hemiplegia
C	8	M	34	62	147	Hemiplegia
T	9	M	21	37	59	Hypotonia (blind)
C	10	F	20	34	57	Hemiplegia (blind)
T	11	M	8	25	79	Diplegia
C	12	F	18	43	114	Ataxia
T	13	F	17	38	78	Hypotonia
C	14	M	23	36	114	Spastic
T	15	F	49	15	77	Athetoid
C	16	M	52	15	59	Athetoid
T	17	F	49	31	66	Hypotonia
C	18	F	52	32	90	Athetoid
T	19	F	46	92	44	Spastic
C	20	M	26	93	45	Hypotonia

†PD = psychomotor development score; MD = mental development score.

completion of treatment, and also three months later. The experimenter undertaking these assessments did not participate in the therapy program, and he did not know to which group each child had been assigned.

Results

The means and standard deviations of pre-treatment, post-treatment, and follow-up measures for the goup receiving vestibular stimulation are shown in Table II, together with measures obtained at comparable times from control children. Values are given separately for the five indices (physical development, mental development, gross motor skills, fine motor skills, eye-hand co-ordination) derived from scores on the Bayley Infant Development Scales. It was not necessary to transform these measures to accord with the Law of Initial Values (Wilder 1967), since change scores were correlated significantly with pre-test measures only for the control group on physical development and gross motor skill. The data were amenable to parametric statistical analysis, since the assumption of homogeneity of variance was met for each measure.

Separate analyses of variance were undertaken to establish whether developmental performance as assessed by the five indices differed according to whether children had received vestibular stimulation, and varied over the three occasions of measurement. As shown in Table III, the two groups did not differ significantly in terms of scores on any of the indices, either when group differences were considered as a main effect or in interaction with time of measurement. In contrast, for all indices there was significant improvement in mean performance over the 18

TABLE II

Means and standard deviations of pre-treatment, post-treatment and follow-up scores for treatment and control groups

Group		Pre-treatment					Post-treatment					Follow-up				
		PD†	*MD*	*GM*	*FM*	*EH*	*PD*	*MD*	*GM*	*FM*	*EH*	*PD*	*MD*	*GM*	*FM*	*EH*
Treatment	Mean	37·4	100·3	48·6	41·2	39·3	39·7	106·0	50·8	45·3	43·2	43·7	115·7	54·2	51·6	50·7
(N=10)	SD	12·753	34·06	12·04	21·66	23·07	12·56	33·76	12·88	20·64	22·29	10·35	31·03	10·235	19·027	17·094
Control	Mean	40·6	110·6	52·4	48·5	47·9	43·7	115·3	55·0	51·4	51·0	47·0	121·2	57·9	55·1	54·6
(N=10)	SD	13·04	34·01	12·635	22·31	22·14	14·74	34·55	14·49	22·66	22·83	14·39	34·79	14·93	22·147	22·936

†PD = psychomotor development; MD = mental development; GM = gross motor; FM = fine motor; EH = eye-hand co-ordination.

TABLE III

Summary of analysis of variance for treatment and control groups

		Dependent variables									
		PD†		*MD*		*GM*		*FM*		*EH*	
Source	*df*	*MS*	*F*	*MS*	*F*	*MS*	*F*	*MS*	*F*	*MS*	*F*
Between groups											
Treatment/control (A)	1	183·75	0·3309	1050·06	0·281226	228·156	0·4189	476·016	0·31445	686·828	0·4235
Error	18	555·291		3733·87		544·602		1513·8		1621·93	
Within groups											
Pre/post/follow-up (B)	2	203·117	32·9576*	856·281	58·3069*	154·953	19·917*	365·0	38·4667*	416·516	35·8373*
A × B	2	0·9492	0·15402	32·0313	2·18111	0·34375	0·04418	18·8672	1·98838	31·6172	2·72037
Error	36	6·16298		14·6858		7·77995		9·48872		11·6224	

†PD = psychomotor development; MD = mental development; GM = gross motor; FM = fine motor; EH = eye-hand co-ordination.
*$p < 0{\cdot}001$.

weeks between the first and third assessment sessions.

Discussion

The results show that although the motor performance of cerebral-palsied children improved over the period of study, none of the gains could be attributed to the therapeutic intervention under investigation. Controlled vestibular stimulation was not found to accelerate motor development of cerebral-palsied children. The improvement in motor competence that occurred over the 18 weeks between the first and the third assessments was thus either primarily maturational or induced by experiences other than those given by design to experimental but not to control children.

Any study failing to demonstrate that therapy is effective is open to objections that the deficiency lay in the specific program employed rather than in the therapy itself, that therapy continued for too short a period of time, or that the sample under test included unsuitable cases. However, the present results are in direct contrast to the report by Chee *et al.* (1978) that vestibular stimulation induces gains in motor function. It is difficult to establish any basis for the discrepancy between the two sets of results. The conditions of stimulation seem comparable between the two studies, similar sample sizes were used, children from a range of diagnostic categories were tested, the age-range and the levels of initial competence seem similar, objective tests were used to measure motor performance, both studies employed a blind assessment methodology, and the effectiveness of therapy was evaluated by comparing a treated group with a control group.

One possible explanation for the failure to replicate the findings reported by Chee and colleagues could be the difficulty experienced in matching the present sample. Although children were randomly assigned to either the experimental or control groups, it was not possible to obtain perfectly matched pairs in terms of initial performance scores, age or clinical diagnostic category. This was due mainly to the limited sample of cerebral-palsied children available for testing (from centers within a city with a population in excess of two million) and the wide variability in degree of impairment characteristic of the disorder. Chee and colleagues, on the other hand, gave no details of their matched sample, and it remains uncertain whether pairs were closely matched on all variables, including age and diagnostic category.

A second factor which could account for the conflict in results is the objective test instruments used to assess motor performance. In the Chee *et al.* study a 'modified' Motor Skills Test described by Kantner *et al.* (1976) was used to measure gross motor skills, and the Reflex Test was employed to assess 17 reflexes on a 1- to 4-point scale. In comparison, the present study employed the Bayley Scales of Infant Development to determine gross motor, fine motor and eye-hand co-ordination skills. The objective tests used in the present study were sensitive enough to reflect significant maturational gains for both experimental and control groups across all measures, but no such data were shown by Chee and colleagues. In fact the changes they reported in test scores for the combined control group ranged from an improvement of 6·13 per cent to a decline of 13·79 per cent, although it must be remembered their study did not incorporate follow-up assessment.

In addition to gains in reflex development and gross motor skills, Chee and colleagues found improvements in fine motor and social/emotional behavior. Unfortunately these findings were based on subjective interview reports and only the qualitative data for the treated children were documented. Therefore not only is it impossible to compare treatment and control groups, but the gross nature of the assessment precludes the possibility of a deterioration in the behavior under examination.

A final point to be considered when attempting to account for the failure of the present study to show significant improvement in motor development is the therapy history of the children—a variable not controlled for in either of the studies. At present there is major emphasis on early intervention programs for the cerebral-palsied child, many of which incorporate some degree of vestibular stimulation. It was not possible with the present sample to determine accurately the quantity or quality of stimulation the child may have received prior to the start of the treatment regime, and it could be that the Chee *et al.* sample may not have been exposed to the same degree of vestibular stimulation prior to the study, and therefore the children were more likely to respond to such intervention.

Although a number of researchers attribute improved motor development following vestibular stimulation to an enhanced interaction between the vestibulo-ocular and vestibulo-spinal systems (Kantner *et al.* 1976, Clark *et al.* 1977, Chee *et al.* 1978) neither the Chee *et al.* study nor the present research included in its design a state measure of vestibular functioning. It was evident from observations made during and after treatment sessions that cerebral-palsied children vary in their response to vestibular stimulation in terms of post-rotary nystagmus and individual tolerance. While some children enjoyed the spinning and displayed self-stimulatory head shaking, others became irritable or drowsy. It remains to be determined whether a relationship exists between the nature of response and duration of post-rotatory nystagmus, age, or diagnostic category.

The present experiment has added a negative result to evidence bearing on the question of whether the motor skills of the cerebral-palsied child can be improved by physical therapy. Our intention has been not simply to report data, but also to outline methodological criteria that must be met in order for research to be able to evaluate the effectiveness of treatment. Although there is urgent need to assess the effectiveness of therapy programs, evaluations which are methodologically deficient are of no value since they do not yield data that are open to unequivocal interpretation. The conflict between our results and those of Chee and colleagues leaves open the question of the efficacy of vestibular stimulation in promoting motor development of cerebral-palsied chidren. Future research concerned with this issue might profitably consider the influence of variables such as vestibular function, age, diagnostic category, and the therapeutic history of the child.

AUTHORS' APPOINTMENTS
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SUMMARY

Twenty cerebral-palsied children ranging in age from eight to 56 months and covering most diagnostic categories were allocated to a treatment group or to a control group after having been matched into pairs. Those in the treatment group received 16 sessions of controlled vestibular stimulation over a four-week period, while the control children

did not. Motor function was measured one week and 18 weeks after treatment, and the same gains were found for the control and experimental groups. These results conflict with a recent report that vestibular stimulation is an effective therapy for cerebral-palsied children.

RÉSUMÉ

Les effets de la stimulation vestibulaire sur le développement moteur des IMC

20 IMC âgés de huit à 56 mois et présentant l'une ou l'autre des principales formes d'IMC on été divisés en un groupe de traitement et un groupe contrôle aprés avoir été appariés. Le groupe de traitement bénéficia de 16 séances de stimulation vestibulaire contrôlée sur une période de quatre semaines, tandis que le groupe contrôle n'en bénéficiait pas. Les fonctions motrices furent mesurées une semaine et 18 semaines après le traitement et les mêmes progrès ont été trouvés dans le groupe contrôle et expérimental. Ces résultats contredisent un article récent qui voyait dans la stimulation vestibulaire un traitement efficace de l'IMC.

ZUSAMMENFASSUNG

Der Einfluß vestibulärer Stimulation auf die motorische Entwicklung von cerebralparetischen Kindern

20 cerebralparetische Kinder im Alter zwischen acht und 56 Monaten aus fast allen diagnostischen Bereichen wurden paarweise aufgeteilt und dann jeweils das eine einer Behandlungsgruppe und das andere einer Kontrollgruppe zugeordnet. Die Kinder der Behandlungsgruppe erhielten in 16 Sitzungen über einen Zeitraum von vier Wochen kontrollierte vestibuläre Stimulationen, während die Kontrollkinder nicht stimuliert wurden. Nach einer Woche und nach 18 Wochen wurden die motorischen Funktionen geprüft und man fand bei der Kontrollgruppe sowie bei der Behandlungsgruppe diese ben Ergebnisse. Diese Ergebnisse stehen im Widerspruch zu einem kürzlich erschienenem Bericht, in dem die vestibuläre Stimulation als effektive Therapie bei cerebralparetischen Kindern beschrieben wird.

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